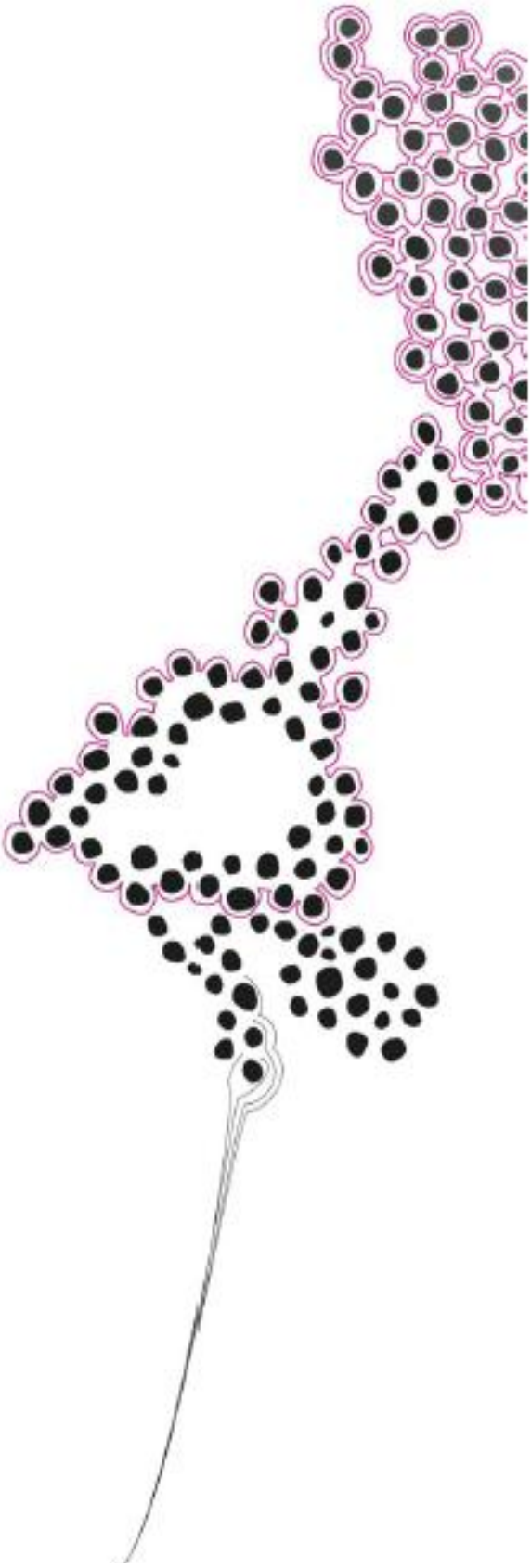


Bachelor Assignment

Learning from games by pretesting

Instructor: ***Dr. H. H. Leemkuil***

2nd Instructor: ***Dr. H. van der Meij***

University of Twente

Faculty of Behavioral Sciences

Bachelor thesis: Psychology

Kevin Kruse

UNIVERSITEIT TWENTE.

Table of Contents

Abstract

The importance of Game-Based Learning has increased in the last decade. In order to improve the embedding of support devices, different research approaches address both, the cognitive and the affective aspects of learning. This research examines the effect of a pretest on the learning gains in a Game-Based Learning environment. In other words, this research aims to improve learning with serious games. Previous research has shown that a pretest positively influences learning of students in a usual textbook situation. The hypothesis is that a pretest also positively influences learning in a digital game environment. This learning effect of participants as part of this research is measured by making use of different tools. The declarative knowledge of the participants is measured by a carefully designed posttest. However, the game performance also provides relevant information to examine the learning effect. Moreover, the affective state of the respondents is also measured in order to evaluate its effects on the learning situation. Consistent with the hypothesis, the pretest improves the effectiveness of learning with a serious game significantly. Regarding the affective aspect of learning in this experiment, the interest of the participants towards the learning task increased significantly. Furthermore, their anxiety decreased significantly. However, the game performance is not related to an increased learning effect in this research. The theoretical framework is discussed and advice for further research is given.

Abstract in Dutch

De rol van Game-Based Learning is groter geworden in de laatste decennia. Om de implementatie van ondersteuning in computergames nog effectiever te maken, houden zich verschillende onderzoeken met dit onderwerp bezig. Daarbij hebben onderzoekers de cognitieve als ook de affectieve aspecten van leren benadrukt. In dit onderzoek wordt het effect van een pretest op het leereffect van proefpersonen in een Game-Based Learning omgeving gemeten. Het doel van dit onderzoek is het leren met serious games beter te maken. Onderzoek heeft aangetoond dat het leren door een pretest bevorderd kan worden in een onderwijs situatie met boeken. De hypothese is dat een pretest ook in een digitale omgeving het leereffect positief kan beïnvloeden. Het leereffect van de respondenten van dit onderzoek wordt op verschillende niveaus gemeten. De descriptieve kennis van de respondenten wordt gemeten door een zelf creëerde posttest. Daarboven is de spelprestatie van de respondenten ook een belangrijke maat voor het leren om te meten. Bovendien wordt de motivatie om te leren gemeten bij de respondenten om een mogelijk effect op het leren te evalueren. Consistent met de hypothese bevorderd de pretest de effectiviteit van leren met serious games op een significante manier. Wat betreft de motivatie van de respondenten is de interesse tegenover de taak significant groter geworden. Daarboven heeft de angst tegenover de taak significant afgenomen. Daarentegen heeft de spelprestatie geen relatie met het leereffect van de respondenten. Het theoretisch kader wordt introduceert en advies voor verder onderzoek wordt besproken.

Introduction

Research in the field of Game-Based learning has revealed contradicting results in the last decade (Wouters, Nimwegen, Oostendorp, & van der Spek, 2013). The main purpose of these studies was to prove that Game-Based Learning would address both aspects of learning, which are of affective and cognitive nature. However, as there are previous findings of researchers that give evidence that the cognitive aspect of learning can be more effective using game-based learning, the affective dimension was not proven to be superior to traditional learning methods (Wouters et al., 2013). Regarding the great potential of Game-Based Learning in educational structures, there is no doubt that its importance has increased and will be even more so in the future (Wu, Hsiao, Wu, Lin, & Huang, 2012). Research from Robertson & Howells (2008) assumes that Game-Based Learning will enforce the development of several cognitive abilities like reasoning skills or problem solving strategies, if the game environment is correspondingly designed. In addition, research from Naicker, Amory, Vincent, & Adams (1999) reveals that playing games is a significant facilitator for the social and mental development of a human being. Important for educational structures is the fact that Game-Based Learning can foster the acquisition of knowledge compared with traditional teaching methods (Leemkuil & De Jong, 2012). On the other hand, Leemkuil & De Jong (2012) found that there are certain unresolved issues like the right use of instructional support in Game-Based learning. These unresolved issues need to be further investigated in order to increase the effectiveness of Game-Based Learning as an educational method. Addressing these issues in order to improve the effectiveness of Game-Based Learning will require some basic understanding of the cognitive and motivational factors of learning in general and how they are related to the digital environment. Therefore, general definitions of serious games and learning will be introduced.

Wouters et al. (2013) define serious games in terms of being interactive, are being set by some agreed rules and will eventually lead to certain constraints. Moreover, a serious game is directed towards a certain goal and it will provide feedback in terms of game score or changes in the game world. In addition, a serious game often also features a competitive aspect, for example comparison of performances with the computer or another player.

The core of Game-Based learning is discussed in the following passage. Research from Schrader & Bastiaens (2012) indicates that learning in a digital environment takes place in terms of discovery-, experiential or problem-based learning. Discovery learning describes the

active discovery of a player in an environment that aims to understand the basic principles of a game (Woolfolk, Hughes, & Walkup, 2013). This active learning typically works through the use of inductive reasoning, resulting in an acquisition of basic knowledge (Woolfolk et al., 2013). Furthermore, discovery learning is based on a constructivist theoretical framework. In a constructivist's belief, the learner subjectively transforms the object that is to be learnt into his own reality. As a result, an adaptation in the game environment can change the interaction, understanding and interpretation of the game (Wu et al., 2012). Experiential learning also depends on inquiry learning but is based on the learning theory of humanism. In experiential learning, the learner does not depend on a teacher but learns through the meaning-making process of his own direct experience. Knowledge is therefore continuously gained through the personal and environmental experiences of the learner (Wu et al., 2012). In problem-based learning, the learner has more control over his learning progress. In addition, the learner acquires new knowledge only as necessary step for solving authentic or ill-structured problems (Wu et al., 2012). Altogether, discovery-, experiential- and problem-based learning heavily demand on the working memory capacity (Schrader & Bastiaens, 2012). In order to reduce this heavy demand on the working memory and support the learner, some form of support is required. Usually, this support is embedded in the virtual gaming environment not only in order to improve the learning gains made, but also to reduce the cognitive load and increase the virtual presence of the player. Virtual presence describes a subjective emotion-related state in which a player is deepened into a virtual activity using technological devices (Schrader & Bastiaens, 2012). Research of Schrader & Bastiaens (2012) emphasizes that virtual presence is positively associated to the learning succes in computer games. In order to foster this virtual presence by the participants of this research, all measurements take place in a digital environment.

As mentioned before, learners need some form of support to aid their learning progress. There are different approaches that vary in their effectiveness in providing actual support for the learner. Instructional support often comes in the form of hints, explanations of game procedure, advice or feedback. These forms of instructional support are based on experiential or discovery learning strategies to facilitate Game-Based Learning. Since Humanism and Constructivism both stress the importance of learner-centered education, those support devices are based on a suitable theoretical framework (Wu et al., 2012). Research from Schrader & Bastiaens (2012) states their view that the learner needs to be supported in the selection of relevant information.

Until now, the opportunities to support the learner in the digital environment as well as the connection to suitable learning theories have been introduced. The next step is to describe problems that occur in supporting the learner. So it is important to state where the problems are in Game-Based Learning and what possibilities arise to solute these problems. In order to measure the learning effect, participants need to verbalize their knowledge explicitly. But research of Leemkuil & De Jong (2012) revealed that using Game-Based Learning, most participants rather implicitly learn and have problems to verbalize the learned material. Moreover, research of Leemkuil & De Jong (2012) found no relation between the game performance and learning effect of a player, what might have to do with the problem of verbalizing knowledge. In general, games often provide too much information for the player experiencing it, causing a cognitive overload (Schrader & Bastiaens, 2012). Therefore, formalizing requirements and prioritization criteria for the selection of relevant information for the player in Game-Based Learning is necessary (Schrader & Bastiaens, 2012). Another problem is that players often behave reactive during a game, that means they only try to solve existing problems rather than prevent problems that are likely to occur in future (Leemkuil & De Jong, 2012). Moreover, being reactive during a computer game implies that players think passively. As a result, the learners are unaware of upcoming problems, because of focusing on existing problems (Leemkuil & De Jong, 2012). But in order to enforce the descriptive knowledge of the player, it is important to actively think about upcoming problems and possible solutions before they occur (Leemkuil & De Jong, 2012). Therefore, players need to act proactively instead of reactively during a game. However, these features are important when using instructional support in order to enforce learning of a player.

The opportunities of Game-Based Learning are emphasized in the research of Pivec & Pivec (2011). They point out that if the environment in computer games is designed appropriately, they can train a variety of cognitive abilities like working memory, reasoning, or problem solving. These cognitive abilities are all highly associated with academic success. Moreover, the differences in game design will also affect the motivation of the player, as some computer games are more entertaining and engaging than others (Pivec & Pivec, 2011).

This research aims to support learning of the participants by using a new approach in Game-Based Learning. Therefore, it is important to combine knowledge of other, previously-applied methods to reach this goal. The basic idea is to adapt an approach of a research finding of Pressley, Tanenbaum, McDaniel & Wood (1990) that took place at the University

of Western Ontario. In this study, one group of students had to answer a pretest questionnaire that contained questions about the topic that had to be learned. Then they read a chapter of a textbook. After the reading another questionnaire measured their knowledge of this chapter (Pressley et al., 1990). As a result, participants in the pretest condition outperformed the control group significantly in recall of material that was prequestioned (Pressley et al., 1990). In this research, the found cognitive factors that are able to support learning in instructional support will be used in a questionnaire in order to test if learning can be enhanced.

The research question of this study is whether the pretest is able to support the acquisition of descriptive knowledge of the participants, compared to a control group. The participants will play a computer game called Enercities, which requires them to build a sustainable city. The game Enercities has a potential positive side effect, informing participants about the possibilities of sustainability. After their game experience, the participants will fill in an additional questionnaire to examine the attained knowledge of the player. Furthermore, this research makes use of different tools of measurement for the learning of the participants. As already mentioned, a posttest measures the declarative knowledge of the learner. The game performance is measured by taking the actual game score and the reached game level. Naicker et al. (1999) emphasize in their research results that using computer games in education will intrinsically motivate players because it would stimulate their curiosity. In order to test whether this potential intrinsic motivation will also be found by the participants of this study, this research will make use of a motivational questionnaire. Since motivation also plays a role in learning, the motivation questionnaire by Rheinberg, Vollmeyer & Burns (2001) is used. This short questionnaire is developed to assess the current motivation in learning situations.

There lies great potential in Game-Based Learning to improve learning in educational structures. But still there are problems with the effectivity of different approaches. Also there are different opportunities to support learning by making use of Game-Based Learning. This research examines the effectiveness of a new approach to support learning. A pretest is used that aims to increase the awareness of the participants and aid them to select relevant information. As a result, the cognitive load of the learner should be decreased and the basic structure of the game should be understood more easily.

Alternative Hypothesis: Pretesting will lead to higher learning gains that are assessed by different measurements compared to the control group.

Null hypothesis: There will be no difference in learning gains between the two conditions

Alternative Hypothesis 2: The motivational state influences the learning effect.

Condition (1): Pretest + QCM + Gameplay + QCM + Posttest

Condition (2): QCM + Gameplay + QCM + Posttest

Participants

All respondents that participated in this research never played the game Enercities before. Otherwise some already attained knowledge of the game Enercities would bias the experiment. This is the only important requirement for the respondents to participate in this research. Also some general knowledge about using a computer is required in order to prevent participants from confusion. Most of the respondents are students of the University of Twente, some are friends that study abroad. Students of the University of Twente need to spend 15 hours as participant before they can graduate. As a result, their motivation to participate was to receive one hour credit. Friends participated in this research only for supporting the researcher. The age of the participants is ranged between 20 and 26. The participants were recruited regardless of their age and gender. Every participant had to fill in the informed consent in order to make sure they participate voluntarily. Altogether, 41 respondents participated in this research, 21 in the control group and 20 in the experimental group. All respondents were randomly allocated into the experimental- or control group. Moreover, 21 were male, and 19 were female respondents. From these 21 males, 13 were in the control group and 8 in the experimental. From the 19 females, 12 were in the experimental and 7 in the control group. In fact, all of the participants had German as native tongue, all of whom were randomly allocated to one of the two conditions.

Materials

The following materials are used in order to examine the research question: The game Enercities, a questionnaire to asses motivation in learning situations (Rheinberg et al., 2001), a self designed post-test that examines knowledge of the game and a self-designed pretest that contains four questions about the topic of sustainability and two strategic questions about how to play a computer game. The game Enercities is described more in detail in the following section.

In order to understand this new experiment situation properly, the pretest will be described in greater detail. The pretest contains questions about the important aspects of the game and also strategic questions about how to play a computer game. These questions are deliberately slightly suggestive in order to bring the respondents on the right trail. As a result, the pretest contains some essential information about the game Enercities, but it depends on the participant how the information is processed or weighted. Furthermore, it is not intended to score the pretest of the participants. The pretest simply intends to cognitively support and prepare the participants. There are four questions about the topic of the game and two strategic questions about how to play a computer game. All of the questions are related to sustainability, for example*:"Do you think that it is important to save oil and energy in the industry as well? Motivate your answer".* This test will be taken by the respondents before they will play a computer game and is therefore called pretest. In the mentioned pretest, the respondents need to verbalize background knowledge about the topic of the game as well as knowledge about how to play a computer game. These questions should help the respondents to think and act proactive in the game, as the verbalization of background knowledge requires active thinking about the topic. This cognitive involvement of a test situation possibly increases the concentration of the respondents. As a result, the selection of relevant information and awareness on the most important problems should be fostered. After playing the game, the participants need to verbalize their acquired knowledge in the posttest. Therefore, the pretest aims to support the player afterwards. The following sense is an example for a pretest question that prepares the participant not only for the game, but also for the posttest: *"Without money it is not possible to finance renewable energies and save resources. Therefore industry is an important part of a city to enable an economy. What is after your opinion important for the industry of the future?".* This example provides information that is necessary in the game, because it suggests that money is important in the game. Moreover, it suggests that industry is needed in order to generate money, which is necessary to know to answer the first posttest

question. The last aspect of this pretest question is that the participant needs to think further about a sustainable industry. A sustainable industry is fundamentally important to realize in the game in order to prevent the quick consumption of natural resources.

The posttest is designed in order to measure the obtained verbal knowledge about the game. It mainly consists of questions that afford knowledge about the basic structure of the game: **"***State three possibilities to increase the value of money".* Other questions are related to a typical game situation, for example a problem. The respondent is then asked how to solute this problem: **"***What went wrong in this example? State improvement possibilities".* In order to treat every respondent the same, a scoring pattern is developed and the scores on the posttest are standardized. The maximum score of the posttest is 25.

The motivational questionnaire designed by Rheinberg et al., (2001) consists of 18 items that are divided into 4 different constructs: Interest, Challenge, Anxiety and Probability of Success. Each of those constructs contribute to the current motivation to learn in relation to the described task. This is an example of an item that measures anxiety*:" I am a bit scared that I could embarrass myself here."* In this experiment, the motivational questionnaire has to be filled in before and after playing the game by all respondents. Therefore, it is possible to examine the difference in motivation to learn before and after the task.

The Game Enercities

The following section gives a brief description of the game Enercities. As Enercities is a browser game, it can be played on almost any computer with an internet connection. Moreover, the estimated time to reach all game goals is 25 minutes, after which the game stops. The goal of Enercities is to build a sustainable city with 200 inhabitants. The maximum score that can be reached is estimated around 450. There are different possibilities to play the game and reach 200 inhabitants, but in order to achieve a high game score only a sustainable, nature-oriented build will work to reach this goal. A sustainable city is a city that consumes the smallest amount of natural resources possible. Moreover, it provides itself with clean energy and is not dependent on, for example, coal-fired power plants. Furthermore, nature is supported with space for forests, parks or reservoirs in a sustainable city. Recycling or even cradle-to-cradle is the basic idea behind a sustainable city.

Figure 1 is implemented to get an impression how this sustainable build looks like.

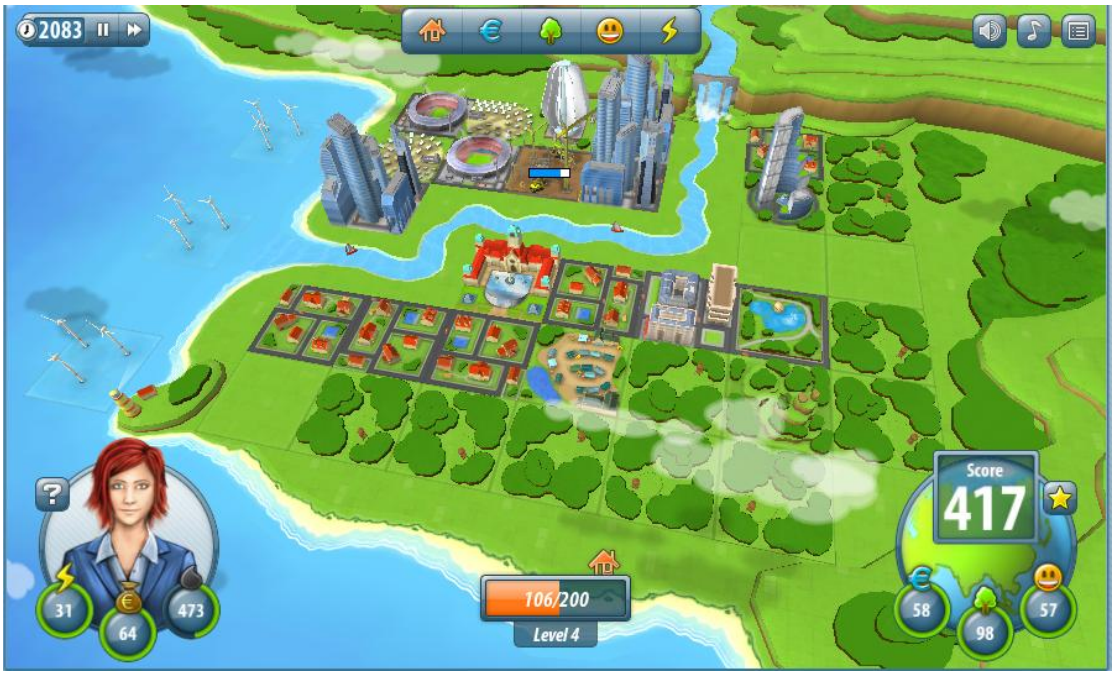


Figure 1. Screenshot Enercities

Figure 1 presents an example of the best possible way of playing the game. On the left side of the screen, the advisor is presented as well as the value of energy, money and amount of natural resources. At the beginning of the game, every player has the value of 1000 natural resources that decreases with the consumption of the buildings. It is not possible to increase this value and therefore important to prevent natural resources from quick consumption. On the right side of the screen, the current game score is displayed as well as finance-,

environment- and well-being points. In the middle on the screen is the amount of inhabitants displayed. The goal is to reach 200 inhabitants and each level is reached with earning a required amount of inhabitants. The Game is build up in 5 levels. Each consecutive level is reached with a certain amount of inhabitants. With reaching a new level, the player gets more space to build the city. In general, there are five important aspects in the game Enercities, these aspects are represented with 5 symbols at the top of the screen: inhabitants, finance sector, nature, well-being and energy. In order to reach a high game score, a player has to choose wisely to balance these aspects in the right way. Every symbol has different buildings that will enforce its particular score, for example, a stadium will increase the satisfaction of the inhabitants. Within each building are different upgrade possibilities that are important to be sustainable. For example improved insulation in suburban will decrease the amount of natural resources this building consumes. However, these upgrades are even more important in industrial facilities. Because natural resources are limited in the game, it is very important to decrease the amount of natural resources each buildings needs. Almost every participant faces the problem of exhausted resources in the game. Therefore it is important to be aware of this problem. Knol and de Vries (2011) point out in their article about the game Enercities that the learning goal of the game is to develop the player's attitude and awareness in respect to problems with resources and energy. The major aspects of the game are tested according to the questions in the post-test.

Enercities is a suitable game for this research because it is widely unknown, rather short and not too difficult. Every participant faces the same situation and deals with the same problems. Moreover the amount of information this game provides is suitable for research as cognitive overload is unlikely to bias the results. In order to increase the validity and reliability of this research the respondents have been screened to not have any experience in advance with the game Enercities.

Procedure

In this section, the procedure of this research is described in detail. Before the respondents participate in this research, they have to fill in the informed consent that records that they participated voluntarily. In order to assure that every participant understands the task, they will be briefly informed about what they have to do. This introduction deals with the game Enercities, the questionnaires and possible questions of the respondents. Then, the respondents will receive the pretest or begin with the motivation questionnaire, depending on the condition they are in. In the experimental condition they receive the pretest which will take about 10 minutes and then follow the usual procedure. After filling in the short motivation questionnaire, each respondent is asked to play the game Enercities for 25 minutes. Then the respondents will fill in the motivation questionnaire for a second time. Finally the respondents will deal with the posttest in which their knowledge about the game is tested. In addition, important values are filled in the posttest, like the game score, achieved level, ID, age, and gender. There are no time limits for the participants except for the 25 minutes of playing the game Enercities. Generally it takes 45 minutes to take part in this experiment for the control condition and 55 minutes for the experimental condition. Each participant is randomly assigned to a condition in order to prevent this research from bias, they do not know in which condition they are. Moreover, a scoring pattern is developed in order to ensure that every posttest is scored equally.

In the execution of the experiment, every participant gets the same treatment. The only minor problems that occurred had to do with minor computer errors that could be fixed, that was with opening the tests with open office. In order to prevent the participants from problems with second languages, the pre- and posttest was accessible in English, Dutch and German. Moreover, in the game Enercities it is possible to choose the own language. In this experiment, there are two conditions: the control group and the experimental group. In the control group, the participants do not receive the pretest.

During the experiment the respondents need to be focused on their computer, all distractions have to be eliminated. Therefore, most of the participants took part in the experiment at the computer room of the “cubicus” at the University of Twente. However, as some participants did not have the time to come, the experiment was executed at their home computer. During all experiment sessions the researcher was present to control the environment and avoid for example talking between the respondents. As some respondents

were more familiar with computers and computer games than others, fewer explanations were necessary.

Analysis Plan

This section provides the analysis plan of this research and describes the different (statistical) methods that are used to analyze the hypothesis and also how these methods are used. In order to measure the "learning effect" of the respondents the posttest contains 10 questions about the basic structure of the game. To examine the correct posttest score of every respondent in a reliable way, this research makes use of a scoring pattern. Moreover, the frequencies of correct answers are standardized on the posttest. The procedure of standardization is to divide the actual score of the respondent through the possible high score and then multiply it by 10. For example: If a respondent scores 16 on the posttest, this score is divided through the highest possible score (25) and then multiplied by 10, resulting in a standardized score of 6.4. These standardized scores are then filled in SPSS. The other relevant measurement tools for "learning effect" are directly taken from the game: game performance and game level. Those measurements are also carried out in SPSS. In addition, all item scores from the motivational questionnaire are filled in SPSS and then computed to the four different constructs in SPSS: interest, challenge, anxiety and success. This was done for the motivational questionnaire that was filled in before and after the game.

Firstly, a 5 number summary was conducted and the outliners were eliminated using this analysis (n=1). This clear outliner is shown in figure 2. Then, an independent t-test is used to examine if there are different effects between the conditions on the posttest variable. Therefore, condition is the independent- and posttest the dependent variable. It is expected that the posttest scores are significantly higher in the experimental group, compared to the control group. A boxplot is used to make the distinctions between the experimental- and control group more visible. In addition, a Spearman Correlation Coefficient between game score and posttest is used to examine the relation between the game score and the "learning effect". Moreover, the same Spearman Correlation Coefficient is used to describe the relation between game level and posttest score.

In order to examine the differences between the motivational questionnaire for and after the game, a paired sample t-test is used. Furthermore, the four constructs of the motivational questionnaire are computed to differential scores, subtracting the scores before the game from the scores after the game. These differential scores are examined with simple linear regression.

Results

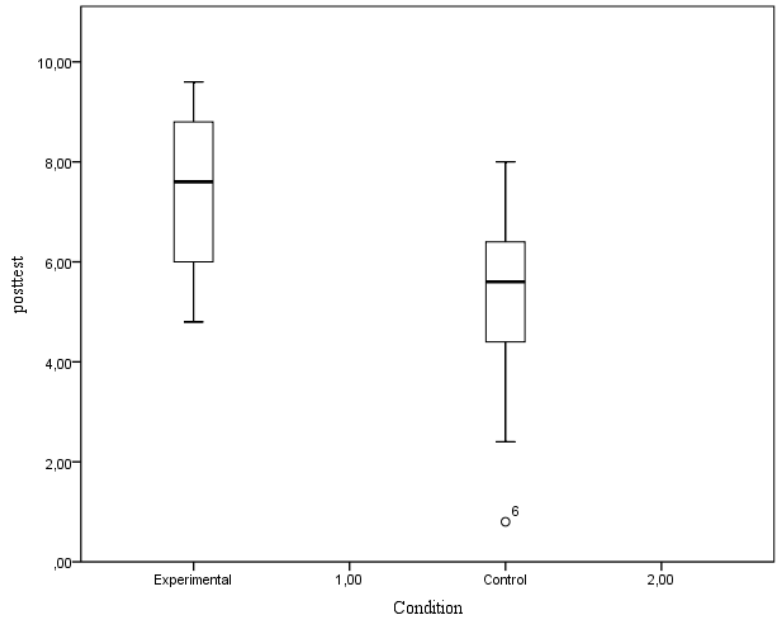
This section focuses on the results of the statistical methods that are described in the last paragraph. Beginning with information about the descriptives, table 1 shows the differences in mean and standard deviation between the experimental and the control group. The values of the standard deviation are not significantly different but the mean score on the posttest is 1.9 points higher in the experimental group compared with the control group. This indicates a statistically significant difference that is well documented by the independent sample t-test $t(38) = 3.739$, $p < .001$. Moreover, the 95% confidence interval reveals that respondents in the population of the experimental group scored between 0.871 and 2.973 higher on the posttest with a 95% reliability. In order to make these numbers visible, figure 2 presents a boxplot diagramme with the deleted outliner.

Table 1. *Mean and Standard Deviation of the posttest score*

Condition	Mean	SD
Experimental	7.34	1.62
Control	5.44	1.6

Note. SD=Standard Deviation

Figure 2. boxplot for condition *x* and posttest *y*



The following analysis deals with the relation between the posttest scores and the game performance and achieved game level as other potential tools to describe learning in this game-based learning experiment. Regarding the resulting Spearman Correlation Coefficients, both measurements reveal to have no significant correlation with the posttest scores (Game level $r = .81$, $p = .309$; Game performance $r = .112$, $p = .245$).

Table 2. *Mean and Standard Deviation of the game score*

Condition	Mean	SD
Experimental	163.85	12.84
Control	144.95	13.77

Note. SD = Standard Deviation

Table 3. *Mean and Standard Deviation of the game level*

Condition	Mean	SD
Experimental	3.75	.64
Control	3.65	.67

Note. SD = Standard Deviation

Concerning the motivational questionnaires, the simple linear regression of the computed differential scores reveals that the variation in the posttest scores cannot be explained by the differential scores between the two motivational questionnaires on all constructs. That means that if the respondent had a higher score on interest or challenge or anxiety or success in the motivational score, this same respondent is not likely to have a significant higher or lower score in the posttest.

Regarding the difference between the constructs of the motivational questionnaire for and after the game, interest increased significantly- ($t(39)$ = -2.079, p = .022) and anxiety decreased significantly ($t(39)$ = 2.487, p = .0085) after playing the game. The constructs challenge (t(39) = -.799, p = .215) and success (t(39) = .028, p = .489) did not change significantly after playing the game. Table 4 presents the mean and the standard deviation of the motivation before- and after the game per condition.

Table 4. *Mean and Standard Deviation of the Questionnaire to asses Current Motivation*

QCM	Control Mean	Experimental Mean	Control SD	Experimental SD
QCM-before				
Anxiety	16.15	16.2	7.3	6.81
Challenge	19.8	18.1	4.69	4.55
Interest	24.3	21	6.48	5.68
Succes	18.6	19.4	6.46	4.53
QCM-after				
Anxiey	14.6	14.1	9.1	6.39
Challenge	20.65	18	5.55	3.9
Interest	24.75	23.8	8.51	6.47
Succes	18	19.95	6.6	4.62

Note. SD = Standard Deviation

Conclusion

This section deals with the conclusion of the statistical information that was described in the last paragraph. In order to disprove the null hypothesis this research made use of an experiment in which 41 respondents participated. The statistical information that was gathered in this experiment reveals that the "learning effect" that is documented by the posttest score is significantly greater when respondents receive a pretest compared to respondents receiving no pretest. Therefore the null hypothesis has to be rejected and the alternative hypothesis that "Pretesting will lead to higher learning gains compared to the control group", can be confirmed.

The other tools of measurement for "learning effect" in a game-based learning environment, game performance and achieved level, did not reveal any correlations with the posttest. Furthermore, the motivational questionnaire also could not explain the variances in the posttest. However, there was no significant difference between the experimental and the control group on the motivational questionnaire. This result indicates that the alternative hypothesis 2 has to be dismissed. In table 4 it can be seen that there is no significant difference in motivation before- and after playing the game between the two conditions.

Discussion

In this section the results of the experiment will be discussed. Moreover the connections between the statistical results and the method will be connected to the theoretical framework the experiment was built on. Furthermore, this section deals with the problems that arose from the specific method and procedure used and the resulting implications for further research. The aim of this research was to test in an experiment whether the learning effect can be increased by use of a pretest in a game-based learning environment. The learning effect is determined by a posttest where declarative knowledge is tested. Therefore, the experimental group was compared to the control group were the respondents followed the same procedure except of the pretest. The results showed that there is evidence that the pretest enhanced the amount of verbal knowledge about the game Enercities in the experimental group. This result

confirms the research of Pressley et al. (1990), were a pretest fostered the acquisition of knowledge in a college on an exam about a textbook. As there were no other studies that made use of this sort of experiment in a Game-Based Learning situation, the results of this study may encourage more research on this topic. Regarding the small sample size of 41 respondents, the external validity of this research is not high enough to generalize. However, every participant followed the same procedure. Therefore the internal validity of the experiment is estimated to be high. The only problem that arose was with participants that had no Microsoft Word on their computer, three participants in the experimental condition needed to fill in the questionnaire with open office, where it looked slightly different.

As mentioned in the introduction, all measurements took place in a digital environment. Therefore, the virtual presence should be fostered, as proposed by research of Schrader & Bastiaens (2012). Another point is the motivation of the respondents, which was assessed by the questionnaire of Rheinberg et al. (2001). Although there was no correlation found with learning effect, two constructs differed after playing the game. The interest towards the task increased significantly by the respondents and their anxiety decreased significantly. The reason therefore might be simply fun during the game. Afterwards, the participants might know some important facts about the game that decreased their anxiety of the task. This result is inconsistent with the results of Wouters et al. (2013) where no influence on motivation was found. Because the pretest was taken before the motivational questionnaire, it can be assumed that this influenced the motivation of the participants in the experimental condition. However, this was not the case. Before playing the game there remain no significant differences on motivation between the experimental and the control group.

Regarding the theoretical context of this experiment, pretesting can be compared to other methods of instructional support like advice, hints or feedback. The pretest was designed on the same theoretical basis that aims to support the understanding of basic structures and principles in the game. The acquisition of knowledge is supported by the use of a pretest that combines semantic and strategic questions about the topic of the game that is used. The reason for this increased knowledge might be active formalizing of answers. Thereby, the learner might be cognitively prepared to learn. Moreover, as the questions are slightly suggestive, the learner is primed for the right content to learn. As a result, the learner can more easily select relevant information that is presented in the game. Eventually, the learner is supported to understand the basic principles and structures of the game. However, it can be assumed that pretesting involves the respondent emotionally stronger than other

forms of instructional support, because it provides an actual test situation. In test-situations, people develop some sort of pattern like in real exam situations. This pattern may help some people to focus better on the task. On the other hand, some learners may have trouble with this test-situation because of exam nerves. Maybe this is a reason for the decreased anxiety of the participants towards the task. Moreover, verbalizing their own thoughts needs more cognitive involvement than to just think active.

Another important aspect is the relation between the learning effect and the game performance of the respondents. Game performance was measured by the actual game score and the achieved game level. However, both game performance measurements revealed no relation with the posttest score which is described as the learning effect. This result is similar to the research of Leemkuil & De Jong (2012), where no significant correlation was found between game performances and learning effect. Regarding the motivation of the respondents, there were also no significant relations found between all theoretical constructs of the motivational questionnaire and the learning effect. That means that respondents were not more motivated to learn when they had a higher learning effect. At least, there was a difference between the two measurements of the motivational questionnaire before and after playing the game. After playing the game the interest of the respondents increased and their anxiety towards the task decreased.

For further research on this topic different constructs need to be measured. For the testing situation it may be important to know if there are people who actually suffer from exam anxiety, which leads to lower test scores. This anxiety of exam situations could be assessed by usage of a suited questionnaire. Moreover the general experience with computer games a respondent has needs to be examined. It is important to evaluate the effects of experience with computer games and relate it to the game performance and learning effect. As some people are seriously involved with computer games, they may have an advantage in recognizing the basic structures of a game. But this advanced experience could also lead to more implicit knowledge gain what may result in problems verbalizing this knowledge.

The goal of this research was to examine the difference in learning effect between a control group and an experimental group that made use of a pretest. The results on this topic reveal a quite clear perspective. The experimental group had a significant higher score on the posttest and therefore a higher learning gains than the control group. Therefore, it can be assumed that pretesting can help learners in the acquisition of knowledge in a Game-Based

Learning environment. However, all other measurements that were used in this research revealed no significant relations to the learning effect of the participants. As tools of measurements include the game performance of the learner, it can be assumed that this measurement is not related to the acquisition of knowledge in a Game-Based Learning environment.

References

Halpern, D. F., Millis, K., Graesser, A. C., Butler, H., Forsyth, C., & Cai, Z. (2012). Operation ARA: A computerized learning game that teaches critical thinking and scientific reasoning. *Elsevier: Thinking Skills and Creativity, 7*, 93-100.

Kaufman, D., & Asgari, M. (2004). Relationship among computer games, fantasy and learning. *35th Annual Conference of the International Simulation* (pp. 1-8). Burnaby, Canada: Faculty of Education Simon Fraser University.

Knol, E., & de Vries, P. W. (2011). Enercities, a serious game to stimulate sustainability and energy conservation. *eLearning Papers, 25*, 1-10.

Leemkuil, H., & De Jong, T. (2012). Adaptive advice in learning with a computer-based knowledge management simulation game. *Academy of Management Learning & Education*, 1-35.

Leutner, D. (1993). Guided discovery learning with computer based simulation games: effects of adaptive and non-adaptive instructional support. *Learning and Instruction, 3*, 113-132.

Naicker, K., Amory, A., Vincent, J., & Adams, C. (1999). The use of computer games as an educational tool: identification of appropriate game types and game elements. *British Journal of Educational Technology, 30*, 311-321.

Pivec, M., & Pivec, P. (2011). Lernen mit Computerspielen. *Bundesministerium fuer Wirtschaft, Familie und Jugend*, 1-62.

Pressley, M., Tanenbaum, R., McDaniel, M. A., & Wood, E. (1990). What happens when university students try to answer prequestions that accompany textbook material. *Contemporary Educational Psychology, 15*, 27-35.

Rheinberg, F., Vollmeyer, R., & Burns, B. D. (2001). A questionnaire to asses current motivation in learning situations. *Diagnostica, 47*, 57-66.

Robertson, J., & Howells, C. (2008). Computer game design: Opportunities for succesfull learning. *Computers & Education, 50*, 559-578. doi:10.1016/j.compedu.2007.09.020

Schrader, C., & Bastiaens, T. (2012). Learning in educational computer games for novices: The impact of support provision types on virtual presence, cognitive load and learning outcomes. *The International Review of Research in Open and Distance Learning, 3*, 207-227.

Woolfolk, A., Hughes, M., & Walkup, V. (2013). *Psychology in Education* (Vol. 2). England, London: Pearson.

Wouters, P., & Oostendorp, H. v. (2012). A meta analytic review of the role of instructional support in game-based learning. *Computers & Education, 58*, 1-40. doi:10.1016/j.compedu.2012.07.018

Wouters, P., Nimwegen, C. v., Oostendorp, H. v., & van der Spek, E. D. (2013). A Meta-analysis of the cognitive and motivational effects of serious games. *Journal of Educational Psychology*, 1-18. doi:10.1037/a0031311

Wu, W. H., Hsiao, H. C., Wu, P. L., Lin, C. H., & Huang, S. H. (2012). Investigating the learning-theory foundations of game-based learning: a meta-analysis. *Journal of Computer Assisted Learning, 28*, 265-279. doi:10.1111/j.1365-2729.2011.00437.x

Attachments

Pretest

ID:	Gender:	Score:

State three possibilities to save oil/gas and energy in the household:

Do you think that it is important to save oil and energy in the industry as well? Motivate your answer:

Which environmental factors influence the satisfaction of humans in a housing complex?

Without money it is not possible to finance renewable energies and save resources. Therefore industry is an important part of a city to enable an economy. What is after your opinion important for the industry of the future?

In a game problems often need to be solved. But sometimes it can be more effective to predict the development of problems and therefore avoid problems. Which problems need to be faced in the future concerning resources, environment and production of energy. State possibilities to avoid these problems:

In computer games are often a main goal and different sub-goals. What needs to be done for one goal may harm another goal. Thereby one has to wage. Can you state an example of such a situation? Combine this example with the background of a computer game in which you need to build a sustainable city.

Motivational Questionnaire

Participant Nr: _____

On this sheet you can rate your current attitude towards the described task. Please chose and mark the number that corresponds to your current attitude best.

	True						**Not true**
1. I like this kind of puzzles. (I)	1	2	3	4	5	6	7
2. I think I can cope with the difficulty of this task. (S)	1	2	3	4	5	6	7
3. Probably I will not succeed in the task. (S)	1	2	3	4	5	6	7
4. In the task, I like the role of the scientist, discovering new connections. (I)	1	2	3	4	5	6	7
5. I feel under pressure to perform well in the task. (A)	1	2	3	4	5	6	7
6. The task is a real challenge for me. (C)	1	2	3	4	5	6	7
7. After reading the task description I think the task is very	1	2	3	4	5	6	7

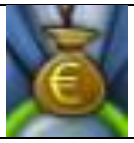
interesting. (I)							
8. I am keen to know how good I will perform in this task. (C)	1	2	3	4	5	6	7
9. I am a bit scared that I could embarrass myself here. (A)	1	2	3	4	5	6	7
10. I am strongly determined to try hard on this task. (C)	1	2	3	4	5	6	7
11. For task like this I don't need a reward, because they are fun. (I)	1	2	3	4	5	6	7
12. I would feel awkward, if I would fail at this task. (A)	1	2	3	4	5	6	7
13. I think everybody can succeed in this task. (S)	1	2	3	4	5	6	7
14. I think I will not succeed in this task. (S)	1	2	3	4	5	6	7
15. If I succeed in this task, I will be somewhat proud of my capability. (C)	1	2	3	4	5	6	7
16. When thinking of the task I feel a bit worried. (A)	1	2	3	4	5	6	7
17. I would work on such a task in my leisure time. (I)	1	2	3	4	5	6	7
18. The concrete performance requirements here lame me. (A)	1	2	3	4	5	6	7

(C): Challenge 4
(I): Interest 5
(S): Probability of success 4
(A): Anxiety 5

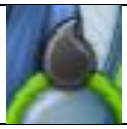
Posttest

ID:		Gender	☐ male ☐ female		
Score:		Level			

Question 1:

	**State three possibilities to increase the value of money:**
1:	
2:	
3:	

Question 2:

	**State three possibilities to increase the value of oil:**
1:	
2:	
3:	

Question 3:

	State two advantages and two disadvantages of this example:
Advantage1	
Advantage2	
Disadvantage1	
Disadvantage2	

Question 4:

	What went wrong in this example? State improvement possibilities:
1:	
2:	

3:	
4:	

Question 5:

	**What is this and why would you choose to build it?**
Answer:	
	Which disadvantage has it?
Answer:	

Question 6:

	It was already chosen for solar roofs (+1 oil and +1 energy) What would you choose next?
	a)  b) 
	c)  d) 
Antwort:	a) ☐ b) ☐ c) ☐ d) ☐
	Why do you think this upgrade is important?
Answer:	

Question 7:

	**State one advantage and one disadvantage of an atomic power plant:**
Advantage:	
Disadvantage	

Question 8:

	What went wrong in this example? Why do you think so?
Answer:	

Question 9:

	**State three possibilities to increase the value of satisfaction:**
1:	
2:	
3:	

Question 10:

	**State three possibilities to increase the value of energy:**
1:	
2:	
3:	

	Yes	No
Have you played this game before?	☐	☐
Did the pretest helped you to orient in the game?	☐	☐
Did the pretest influenced your way of playing the game?	☐	☐
Have you been frustrated at any time during the experiment?	☐	☐
Have you been motivated to participate?	☐	☐

Informed Consent

GEÏNFORMEERDE TOESTEMMING

GW.07.1

Ik, …….. (*naam proefpersoon)*

Stem toe mee te doen aan een onderzoek dat uitgevoerd wordt door

Kevin Kruse

Ik ben me ervan bewust dat deelname aan dit onderzoek geheel vrijwillig is. Ik kan mijn medewerking op elk tijdstip stopzetten en de gegevens verkregen uit dit onderzoek terugkrijgen, laten verwijderen uit de database, of laten vernietigen.

De volgende punten zijn aan mij uitgelegd:

1. Het doel van dit onderzoek is meer inzicht te krijgen in een computerspel. Deelname aan dit onderzoek zal meer inzicht geven in het bouwen van een stad.
2. Er zal mij gevraagd worden een computerspel te spelen. Het hele onderzoek zal ongeveer 50 minuten duren. Aan het einde van het onderzoek zal de onderzoeker uitleggen waar het onderzoek over ging.
3. Er behoort geen stress of ongemak voort te vloeien uit deelname aan dit onderzoek.
4. De gegevens verkregen uit dit onderzoek zullen anoniem verwerkt worden en kunnen daarom niet bekend gemaakt worden op een individueel identificeerbare manier.
5. De onderzoeker zal alle verdere vragen over dit onderzoek beantwoorden, nu of gedurende het verdere verloop van het onderzoek.

Handtekening onderzoeker: …… Datum: ……..

Handtekening proefpersoon: …… Datum: ……..