

# ZooQuest: A mobile game-based learning application for fifth graders

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Final version: December 16, 2011

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# ZooQuest: A mobile game-based learning application for fifth graders

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## ABSTRACT

Motivation is considered one of the most important aspects in learning. Mobile game-based learning applications offer learning opportunities to keep the learner engaged and motivated. This study examined ZooQuest, a mobile game that supported fifth graders in the process of learning English as a second language. ZooQuest embedded the Mobile English Learning (MEL) application and was compared to MEL as a standalone application. Two groups were compared in a quasi experimental pre- and posttest design. The first group had English lessons at school, used the MEL application at the zoo and used the MEL application at home for 2 weeks. The second group solely used the ZooQuest application at home for 2 weeks. Fifth graders that used the ZooQuest application spent more time on learning at home than fifth graders that used the MEL application and obtained significant better learning results on the posttest than they did on the pretest. The ZooQuest application demonstrated its benefits in the practice of language learning outside school.

*Keywords:* mobile learning, serious games, motivation

## 1. INTRODUCTION

The study *Mobile English Learning: an evidence-based study with fifth graders* by Sandberg et al. (2011) has demonstrated that fifth graders are motivated to learn with a mobile application on voluntary basis. This application, the MEL application, was used outside the usual learning environment of the student and led to better results in the practice of English language learning. Sandberg et al. (2011) concluded that formal learning at school can be enhanced by informal mobile learning, outside school. Mobile learning brings new technology into the classroom where the learner “takes advantage of the learning opportunities offered by mobile technologies” (O’Malley et al., 2003). Mobile learning supports the learning process and fosters a learning approach which uses different types of learning activities (Savill-Smith, Attewell & Tribal, 2006).

The MEL application demonstrated its benefits in the process of language learning, however, within 15 days of monitoring, the number of students using the application decreased, as well as the average playtime per student. The study by Sandberg et al. (2011) did not examine why the students used the application less and less over time and whether they would be motivated over a longer period of time. To strengthen the practice of informal learning with a mobile application, learners must be motivated. A mobile application in the style of a serious game can offer learning opportunities to keep the learner engaged and motivated. Serious games are concerned with the use of games for purposes other than mere entertainment or fun and are

applied in various fields such as defense, education, engineering and health care (Susi, Johannesson & Backlund, 2007). To narrow the scope, the concept of digital game-based learning (DGBL) will be used, which integrates education, learning and games. Prensky (2001) states that digital game-based learning is successful due to 2 factors: game motivation, which seduces the learner into the game and secondly, the learning methodology, which is fast, effective and ‘un-school-like’. Both factors should be considered in a digital game-based learning environment.

This study is based on the suggestion by Sandberg et al. (2011) to improve the Mobile English Learning application. In this study, additional game characteristics are added to the MEL application in order to create a richer and more engaging application. Therefore we first explore which game characteristics foster motivation. Secondly, we will improve the MEL application with relevant game characteristics to support English language learning at the level of primary school. Thirdly, we will compare the learning results of two conditions. The first condition is derived from the initial MEL-experiment and concerns a group of students that took English lessons at school, used the MEL application at the zoo, and used the MEL application at home for 2 weeks. Condition 1 is compared to condition 2. This condition concerns a group of students that solely used the enhanced MEL application, the ZooQuest application, at home for 2 weeks. Our study examines whether the ZooQuest application leads to more student motivation and better learning results than the MEL application.

The remainder of this paper is organized as follows: Section 2 discusses the theoretical background of this study. Section 3 provides the problem statement and section 4 the methodology of this study. Section 5 presents the results derived from the experiment with the ZooQuest application. Finally, the discussion and conclusions of this study are reported in Section 6.

## 2. THEORETICAL BACKGROUND

### 2.1 Motivation and Learning

An engaging and motivating game-based learning environment is submissive to its design; creating instruction should be done on sound motivational precepts. To understand how instruction, design and motivation are related, we need to focus on earlier developed principles in the literature. Our first consideration is the ARCS Model of Motivational Design, which was originally coined by Keller twenty-nine years ago (Keller, 1983). In the words of Keller, the ARCS model is “a problem solving approach to designing the motivational aspects of learning environments to stimulate and sustain students’ motivation to learn”

(Keller, 2006). ARCS contains four categories of motivational variables: Attention, Relevance, Confidence and Satisfaction. *Attention* enables learners to engage in a deeper level of curiosity and interest while variation helps to sustain these principles. *Relevance* connects learning content with the learners interests, learning style and motives. *Confidence* helps the learner to establish positive expectations to successfully achieve in his/her task. Paras & Bizzochi (2005) explain that learners are motivated when challenge is balanced, so that achieving success is neither too easy nor too difficult. *Satisfaction* refers to positive feelings of the learner, regarding his/her own learning effort. Keller explains that when a learner receives recognition and evidence of success, this will foster intrinsic feelings of satisfaction (Keller, 2000).

Dempsey, Johnsons & Burke (1998) used the ARCS model in the development of an ARCS gaming scale which measured the components and degree of motivation as a result of playing computer games. The ARCS Gaming Scale correlated with accepted computer game principles, however, it provided limited support to measure *attention* and *interest*.

In 1987, Malone & Lepper (1987) proposed a taxonomy of intrinsic motivations for learning. This taxonomy can be used for designing instructional environments. Forms of intrinsic motivation are induced through competition, cooperation, recognition, challenge, curiosity, control and fantasy and can be incorporated within a game-based learning environment or other instructional environments.

## 2.2 Game Characteristics

A game-based learning environment depends on its structural design that is formed by different game characteristics. The identification and formulation of game characteristics has been the subject of debate since the early 80's. According to Malone (1981), challenge, fantasy, complexity and control contribute to the engagement and fun in games. In *Digital Game Based Learning*, Prensky (2001) elaborates on 6 structural elements that can be used in order to create a fun and engaging game environment: rules, objectives, results/feedback, challenge, social interaction and storyline. Johnston & Felix (2003) suggest that dynamic visuals, rules, goals and interaction are essential game characteristics.

Clearly, the same game characteristics are found in various studies, however, they are described differently, which causes variation and diffusion in their descriptions. Based on a thorough literature study, Garris, Ahlers & Driskell (2002) attempt to categorize game characteristics in terms of 6 broad dimensions: fantasy, rules/goals, sensory stimuli, challenge, mystery and control. Moreover, Garris et al. (2002) state that "any type of game can be described by these 6 dimensions". The dimensions are explained by the following descriptors:

### 2.2.1 Fantasy

Fantasy refers to an imaginary context or environment, typical mental images of nonexistent physical or social situations. Fantasy can be described as a game characteristic

as well as a compelling motivational factor. Malone & Lepper (1987) state that learning content is remembered better when embedded within a fantasy context. Rieber (1996) describes the relation between the learning content and the fantasy as endogenous fantasy; when the fantasy is interesting, the content becomes interesting. Kenny & Gunter (2007) support the idea of endogenous fantasy and argue that games that embed a fantasy context are more engaging than games that do not invoke the player's imagination. Kenny & Gunter (2007) suggest that a proper developed game immerses the player both into the learning content and the fantasy context; this closely parallels a constructivist approach where the learner becomes actively engaged in the construction of his or her own knowledge.

Typical fantasy-based role-playing games require the player to adopt different roles or personalities. In 'Savannah', a mobile game by Facer et al. (2004), children managed a game character in order to act and think as a lion. The game offered strategic decision-making and encouraged children to empathize with their game character.

### 2.2.2 Rules/Goals

Prensky (2001) typifies a game as organized play or rule-based play. Game activity consists of rules because without rules, the game would be free play, not a game. Rules are incorporated in a game and set the limit to what is wrong or right, ok and not ok, fair and unfair. Typically all players should have the same chance of success. Rules also impose limits, constraints and/or boundaries within a game; they describe the goal structure of a game. The player must follow and understand the rules to reach one or multiple goals. Locke & Latham (1990) state that clear, specific and challenging goals lead to better task performance than goals that are easy or vague. The findings by Locke & Latham (1990) were used in the development of Goal Setting theory which is now generally accepted among motivation theories.

Another important concept is goal-feedback on progress towards goals. Goal-feedback allows the player to measure progress against the goals and informs the player which steps need to be taken in order to reach the goals. High goal commitment, which is provoked by challenging goals, leads to an increase in effort and performance. Kiili (2005) suggests to add positive feedback loops to the game. This means the player gets rewarded by positive feedback during play in order to keep the game fun and engaging.

### 2.2.3 Sensory Stimuli

Garris et al. (2002) explain sensory stimuli as "dramatic or novel visual and auditory stimuli". Sound effects, music and dynamic graphics can enhance the motivational appeal of a game. Paras & Bizzochi (2005) suggest to use compelling graphics, sound and physical interaction to help the player enter the game. This suggestion is based on the spatial arrangement and properties of digital environments which immerse the player into the game (Murray, 1997). When the player immerses him- or herself into the game, he or she fully participates with the game world, which means that stimuli outside this world are less relevant to the player.

#### 2.2.4 Challenge

The idea of providing an optimal level of challenge for the player was originally coined by Malone & Lepper (1987). In *Things That Make Us Smart*, Donald Norman (1993) elaborates on the mandatory requirements of a learning environment. Norman suggests that a learning environment should “provide a continual feeling of challenge that is neither so difficult as to create a sense of hopelessness and frustration, nor so easy as to produce boredom”. Adding uncertain goal attainment (ambiguity and uncertain outcome) increases challenge within the game (Garris et al., 2002). Prensky (2001) suggests to balance a game by keeping the level of challenge in synch with the players skill and progress.

#### 2.2.5 Mystery

Garris et al. (2002) define a distinction between *mystery*, a feature of the game, and *curiosity*, which is an emotion related to the player. Garris et al. (2002) state that mystery evokes curiosity and use the study of Berlyne (1960) to describe the concept; “mystery is enhanced by the incongruity of information, complexity, novelty, surprise and violation of expectations”. Role-playing games or *adventure games* stimulate curiosity by involving the fulfillment of mysterious quests and the exploration of unknown worlds. For example, MobileGame by Schwabe & Göth (2005) offered a ‘hide and seek’ role-playing game in which players had to find each other across the campus of the university of Koblenz. MobileGame supported exploration, cooperative learning and play within a mixed reality environment.

#### 2.2.6 Control

Control is the ability to purposefully direct, suppress, regulate, command or change something. Garris et al. (2002) reflect on learning environments that make a distinction between learner control and program control. Program control means that the learning environment, or instructional environment, controls all forms of instruction. With learner control, the learner controls most of the instruction, which evokes a sense of personal control. Providing learner control leads to increased motivation and better learning results (Cordova & Lepper, 1996).

#### 2.2.7 Narrative

Another game dimension is narrative. Dickey (2006) suggests that narrative in game design is a method to develop engaging, interactive learning environments although using narrative in games is not a guaranteed model for success. In a recent study that focuses on engagement strategies & instructional design, Dickey (2005) points out that there is an ongoing debate whether narrative should be integrated in games or not. According to Bringsjord (2001) a strong narrative can successfully trigger more engaging & immersive gameplay. Dickey (2006) elaborates on Malone’s (1981) findings on intrinsic fantasy and clarifies that narrative in fantasy can serve as a cognitive framework for problem solving.

However, Juul (1998) argues that interaction is central to the game, not narrative. According to Juul (1998), games and

narrative are different phenomena that contradict each other and cannot be realized at the same time. Juul (1998) argues that narrative consists of linear and fixed sequences while games are interactive and non-linear with elements that can be combined again and again. Actions of the player interfere and alter the nature of linear narrative. Narratives often vary in speed (in which they are told) while games are fixed speed and real time. Despite these conflicts, games and narrative can still be combined. One strategy is to branch storylines where player actions affect storyline and outcomes (Rouse, 2001). A second strategy is to keep the narrative line intact while allowing the player to access various components of the story in any order of choice (Rouse, 2001).

### 2.4 Constructivism

In modern learning theory, constructivism explains learning as an active process in which learners construct new ideas or concepts based upon their current and past knowledge. Constructivism emphasizes the importance of the learner being actively involved in the learning process which means total learner participation is expected. Another principle of constructivism is that learning is an active, social process with collaboration among learners (Duffy & Jonassen, 1992).

### 2.5 Flow Theory

It is known that games foster play. Games are designed to generate a positive effect in players (Kiili, 2005) and produce a state of flow. The flow state can be described as complete engagement, absorption or motivation (Csikszentmihalyi, 1990). According to Kiili (2005), a flow experience is “dependent on the interplay between the person, the task and the artifact”. The person-artifact-task (PAT) model originates from a study by Finneran (2003) in which the major components of human-computer-related activity are conceptualized. Kiili (2005) suggests to use the PAT components when designing an educational game. All challenges within the game should be related to the main task in order to create a flow experience. Kiili (2005) emphasizes that the challenges within the game should closely match the skill level of the player. The player may feel anxiety if the challenges are greater than the player’s skill level. In contrast, the player may feel bored if the challenge is lower than the player’s skill level. Thus, *flow* is derived from an optimal alignment between *challenge* and *skill*. It is obvious that when the player’s skill level increases the challenges should become more difficult in order to keep the player in a state of flow.

## 3. PROBLEM STATEMENT

The *Mobile English Learning* study by Sandberg et al. (2011) demonstrated the effectiveness of the MEL application in terms of learning English as a second language at the level of primary school. However, results derived from the MEL-experiment did not point out whether students would be motivated over a longer period of time. Furthermore, subsequent research could examine the strength of the learning effect. Hence, Sandberg et al. (2011) suggested to improve the ‘MEL application’ in three ways: 1) by adding additional game characteristics to create richer

and more engaging gameplay 2) by adding artificial intelligence to the application that adapts to the learning skill of the student and 3) to create a stronger didactic link between text, voice and images/video.

All three improvements are considered in the development of an enriched mobile language learning application: the MEL2 application. However, this study limits its scope by addressing only the first improvement. Additional game characteristics are added to the MEL application; this forms the ZooQuest application which is the predecessor of the MEL2 application. The following research questions are central to the design of the ZooQuest application:

*RQ1:* Does usage of the ZooQuest application lead to more motivation compared to usage of MEL application?<sup>1</sup>

*H0:* Students using the ZooQuest application do not spend significant more time on the application at home than students using the MEL application. *H1:* Students using the ZooQuest application spend significant more time on the application at home than students using the MEL application.

*RQ2:* Does usage of the ZooQuest application lead to better learning results compared to usage of the MEL application?

*H0:* Students using the ZooQuest application do not gain significant better learning results than students using the MEL application. *H1:* Students using the ZooQuest application gain significant better learning results than students using the MEL application.

## 4. METHOD

### 4.1 Experimental Design

A quasi-experimental pre- and posttest design was adopted since this type of design was used in the ‘*Mobile English Learning*’ study by Sandberg et al. (2011). Results from the initial MEL experiment needed to be comparable to the results of this study. The argument for a nonequivalent groups design is based on the fact that the schools kept the class structure intact, which prevented us from randomly assigning students to the conditions.

In this study, 2 groups of students were compared. Each group represented a specific condition. The first condition, a control condition, was derived from the initial MEL experiment. Condition 1 consisted of students that 1) took English lessons<sup>2</sup> at school and 2) used the MEL application at the zoo and 3) used the MEL application at home for 2 weeks. Condition 2 consisted of students that solely used the ZooQuest application at home for 2 weeks.

Before the students could use their mobile application at home, a pretest was conducted for both conditions. The pretest encompassed an English vocabulary test that measured passive and active English word knowledge of the

<sup>1</sup> Motivation is expressed as time spent on the application, however, the degree of motivation is also measured with the use of a questionnaire, see sections 4.5 & 5.

<sup>2</sup> English lessons comprehended a 2 week lesson plan with a general introduction on the 25 animals & various assignments. A more thorough description can be found in Sandberg et al. (2011).

students. Immediately after the pretest, a 2 week learning phase started in which the student could take the mobile application home. When the learning phase ended, the exact same test was conducted again as a posttest.

### 4.2 Participants & Theme

The study involved a total of 43 fifth graders (27 boys, 22 girls) from 2 different primary schools. Ages ranged from 8-10. Condition 1 consisted of 22 subjects. Condition 2 consisted of 21 subjects.

As stated, the pre- and posttest encompassed an English vocabulary test that measured passive and active English word knowledge of the student. For both the passive and active part, the learning theme *zoo animals* was selected because most children “are familiar with the names of zoo animals in their native language” and because “animals are a popular topic in early English programs” (Sandberg et al., 2011). In condition 1, the MEL application was used at the zoo, providing a meaningful context in addition to the learning contents.

### 4.3 Target Words

The test relied on 50 target words divided over 6 categories: words concerning animal names (*bison, gorilla*) animal habitat (*savannah, tropical forest*), animal food (*seeds, plankton*), animal characteristics (*beak, claws*), animal behavior (*to hunt, to lay eggs*) and abstract words (*predator, reptiles*). The target words were selected by linguists from the University of Utrecht and the University of Groningen in order to justify the didactic aspects of language learning.<sup>3</sup>

### 4.4 Test Procedure

During the pre- and posttest, all subjects were individually tested by an interviewer and an observer. The interviewer was interacting with the subject by showing pictures of animals and asking questions. The observer sat behind the subject and scored the subjects answers on both the active part and the passive part (fig. 1).



Figure 1: Passive part of the word knowledge test.

The test started with the active word knowledge part in which pictures of animals and animal features were shown. Students had to actively speak and answer while animal names and animal features were asked; “How do we call this animal?” [answer: bison], “How do we call this part of the animal?” [answer: fin], “What is the name for a baby

<sup>3</sup> For more information, visit <http://www.mobielengelsleren.nl/>

bison?” [answer: calf]). Each question was considered as an individual item. For the active part of the test, 23 items were selected and were scored as follows: 0 (incorrect), 1 (partially correct e.g. *monkey* instead of *chimpanzee*), 2 (correct). The elicitation of free speech and the activity of pointing and naming pictures are features derived from the Student Oral Proficiency Assessment (Thompson, Kenyon & Rhodes, 2002).

During the passive part, students were asked to point at picture cards, each card contained 4 pictures derived from the 6 categories of target words. Students had to point at the right picture to answer a question (e.g. “Can you point to the llama?”, “Where do you see an animal that has been washed up?”). For the passive part, 27 items were selected and were scored as follows: 0 (incorrect), 1 (correct). The test methodology for the passive part was adopted from the Peabody Picture Vocabulary Test (PPVT) which asks subjects to identify words based on series of pictures (Dunn & Dunn, 1997).

#### 4.5 Questionnaire

In addition to the pre- and posttest, a questionnaire was administered. We aimed for additional qualitative data in order to help us explain the quantitative results from the pre- and posttest.

The questionnaire was used with a select group of 4 test subjects from condition 2 and included 18 open-ended questions that assessed the subject’s motivation in relation to the game characteristics described by Garris et al. (2002). Questions were grouped in 6 sets, each set represented an individual game characteristic. For example, a question from the set ‘challenge’ referred to the underlying theoretical basis of goal progression (Prensky, 2001) e.g. “Did the game inform you which goals had to be completed?”. For this study, it was of importance which game characteristics would appeal most to the subjects and which game characteristics would appeal the least to the subjects.

#### 4.6 Smartphones

During the 2 week learning phase, subjects in both conditions received a personal smartphone with either the MEL application or the ZooQuest application. For condition 1, SIM-less Huawei Pulse phones were used, offering the Android 1.5 platform, GPS, a camera and 2 GB of internal storage. For condition 2, SIM-less Huawei Ideos phones were used, offering the same functionality as the Huawei Pulse except this type of phone ran on the Android 2.5 platform. Each smartphone logged game-actions (answers, scores and clicks) to separate csv files for the analyses of the gameplay.

#### 4.7 MEL Application

The MEL application represented a serious game in which 25 different animals were divided over 5 continents (Africa, Asia, North- and South-America, Oceania). Each continent contained 5 different animals. In the application, the subject had to choose a game mode. The first game mode focused on location based play and was used during the zoo visit of condition 1. In this mode, subjects were guided through the zoo via GPS, leading them to zoo animals that were

incorporated in the application. In the second game mode, subjects could randomly choose a continent. After selecting a continent, the MEL application loaded 5 animals that belonged to the corresponding continent. For each animal, one of the following mini-games started:

1. Jigsaw puzzle: a drag and drop puzzle game in which animal pictures had to be completed.
2. Memory: a game in which words and images (that represented the same object) had to be combined.
3. Multiple choice quiz: a game that asked 1 question at a time, providing 4 answers to pick from of which 1 was correct (fig. 2, left screen).
4. Spelling quiz: a game that asked 1 question at a time, providing 3 answers to pick from of which 1 was correct. Answers concerned words that were spelled differently (fig. 2, right screen).
5. Yes or no: a game that presented 1 picture with 1 question at a time, providing only a yes or no answer of which 1 was correct.

At the beginning of each mini-game, a video was played that contained all the learning content on the corresponding animal. For instance, if the game loaded the ‘Snowy Owl’, the following content was actively narrated in the video by a native English speaker:

“This is the Snowy Owl. It is a *predator* that *hunts* at night. It has great *eyesight* and can spot its prey in the dark. It flies high above the ground when it hunts. When it sees *prey*, it dives down and attacks it with its *sharp beak and claws*. Because the Snowy Owl has white feathers, it is hard for other animals to see it in the snow: this is called *camouflage*”.<sup>4</sup>

#### 4.8 ZooQuest Application

The ZooQuest application added an extra, surrounding game layer to the MEL application. Due to time restrictions, ZooQuest wasn’t programmed from scratch. Instead, open source Android game *Andor’s Trail*<sup>5</sup> was selected for adjustment because it had the most potential to facilitate the six game characteristics by Garris et al. (2002) and to immerse the player both into the learning content and the fantasy context (Kenny & Gunter, 2007). *Andor’s Trail* is a 2D RPG game that allows the player to control a game character from a bird’s eye view. As a player, you are situated in a fantasy world in which you battle monsters, gain experience, gain levels, solve quests, find treasures and gather equipment. Game characteristics from *Andor’s Trail* were reused in the ZooQuest application, other characteristics were removed (e.g. battling monsters).

ZooQuest represented a single-player, quest-driven RPG with a basic narrative. Within the game, the player took on the role of a zoo visitor named Jack (fig. 3, left screen). The main quest for Jack was to help zookeeper Jane (fig. 3, right screen) find 25 animals that escaped from their cage. Just as in the MEL application, the animals were divided over 5

<sup>4</sup> Words in italic were considered target words (see Section 4.3).

<sup>5</sup> Source: <http://code.google.com/p/andors-trail/>

continents (Africa, Asia, North- and South-America, Oceania), hence, the player could visit each continent in order to find the escaped animals.



Figure 2: The MEL application.

As soon as an animal was encountered (animals were moving at fixed areas), the player was able to ‘catch’ the animal by ‘touching’ it. If an animal was caught, the corresponding animal content would load from the MEL application. For instance, if a player tried to catch a bison, a mini-game from the MEL application was loaded that displayed a video and questions about the bison.

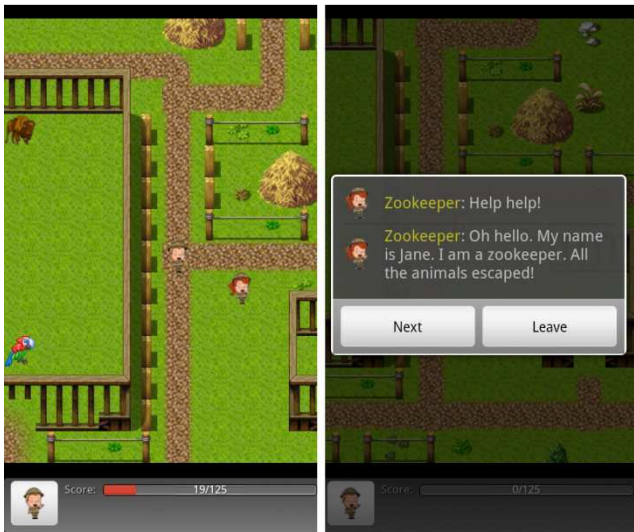


Figure 3: The ZooQuest application.

When a mini-game was finished, two states of the game changed: 1) the player was rewarded a medal, based on the number of correct answers in the mini-game, and 2) if the player scored at least 3 correct answers in the mini-game, the corresponding animal in ZooQuest was sent to its cage. Players could achieve a maximum of 5 points in each MEL mini-game. Points were equal to the  $N$  of correct answers and medals were rewarded as follows: 0 points = stone medal, 1-3 points = bronze medal, 4 points = silver medal, 5 points = gold medal. Players could retrieve an overview of the animals they caught and the medals they obtained (fig. 4, right screen). Game progress could be retrieved via the game progress bar in the main screen (fig. 4, left screen).

Encaged animals could be ‘touched’ again, this action restarted their corresponding mini-game. We encouraged the player to ‘retouch’ a caught animal by adding an additional ‘double gold medal’. This medal could be achieved if a player answered all mini-game questions correctly, but only if a gold medal was already achieved. Mini-game answers were put in random order. This prevented the player from pressing answers in a fixed order. In the jigsaw and memory mini-game, the player started with a maximum amount of points. For each incorrect action, 1 point was deducted from the maximum amount of points.

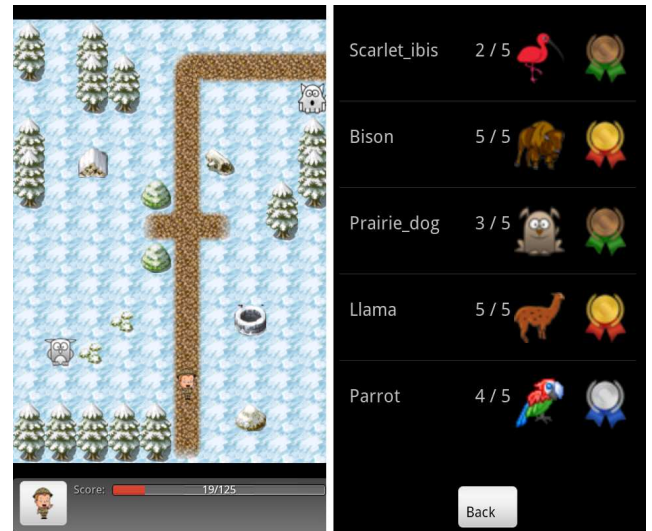


Figure 4: The ZooQuest application.

If we reflect on the six game characteristics by Garris et al. (2002), our major design decisions are summarized as follows: the MEL learning contents were embedded and contextualized within the fantasy setting of ZooQuest. A narrative was added in order to explain the goals of the game. The learner could choose how to control his/her game character by finding continents and animals in any order. In this way, the learner controlled most of the instruction (learner control). We tried to evoke curiosity by challenging the player with exploration of unknown continents. We also challenged the player with a major quest to find all the animals. Sensory stimuli were evoked by dynamic graphics, sounds and physical interaction. Medals were added in order to provide positive feedback loops during play.

#### 4.9 Data Analysis

The within-subjects data for both conditions were analyzed with a dependent samples  $t$ -test. For the between subjects data analysis, a reliability correction was conducted for the passive and active pretest scores in order to reduce pretest measurement error. The adjustment was made with the following formula:  $X_{adj} = \bar{X} + r(X - \bar{X})$  where  $r$  is reliability,  $X_{adj}$  is the adjusted pretest value and  $\bar{X}$  the original pretest value (Trochim, 2006). Between-subjects data were analyzed with 2 one-way multivariate analyses. In the first multivariate analysis, gain scores from the passive and active word knowledge test were used as dependent variables, condition as fixed factor and the adjusted passive and active pretest scores as covariates. In the second multivariate analysis, the total amount learning time (in hrs) was added as additional covariate. To investigate if both conditions differed in MEL application usage at home (in

hrs), an independent samples *t*-test was conducted with condition as grouping variable and ‘MEL-time’ as test variable<sup>6</sup>. Significance levels of .05 were used in all cases.

## 5. RESULTS

General results for both conditions are listed in table 1. Internal consistency of the scales was computed with Cronbach's alpha reliability analysis. Results are listed in table 2. An  $\alpha \geq .6$  is considered questionable and an  $\alpha \geq .7$  is considered acceptable (George & Mallery, 2003), for subsequent analyses all pre- and posttest items were used.

**Table 1: General results**

Cond.	N	Passive items		Max = 26	
		Pretest	Posttest	Mean	Std. dev.
1	22	10.64	3.14	15.96	4.45
2	20	12.05	3.49	13.7	3.01

Cond.	N	Active items		Max = 46	
		Pretest	Posttest	Mean	Std. dev.
1	22	5.10	4.00	26.91	8.90
2	20	8.15	4.60	14.85	6.51

**Table 2: Reliability analysis**

	Part	Cases	$\alpha$	N of items
Pretest	Passive	42	.60	27
	Active	42	.70	23
Posttest	Passive	42	.71	27
	Active	42	.86	23

The dependent samples *t*-test explains that both groups scored significantly higher on the posttest than they did on the pretest (condition 1, passive:  $t(21) = -6.57, p = .000$ , active:  $t(21) = -11.21, p = .000$ ; condition 2, passive:  $t(19) = -2.65, p = .016$ , active:  $t(19) = -5.31, p = .000$ ). In the first one-way multivariate analysis (with gain scores from the passive and active word knowledge test as dependent variables and the adjusted passive and active pretest scores as covariates), a main overall effect for condition was found (Pillai's trace,  $F(2) = 15.52, p < .000$ , partial  $\eta^2 = .46$ , observed power = .999). Pairwise comparisons (with Bonferroni correction for multiple comparisons) of both conditions were made comparing results from the passive and active word knowledge test. Condition 1 outperformed condition 2 in passive ( $M = 3.94, p < .003$ ) and active ( $M = 15.39, p < .000$ ) word knowledge.

However, a significant effect for the total amount of learning time (in hrs) was found,  $t(40) = -7.53, p = .000$ , with condition 1 having a larger total amount of learning time ( $M = 8.1$ ) than condition 2 ( $M = 4.38$ ). Thus, in the second one-way multivariate analysis, the total amount learning time was added as additional covariate, as learning time significantly correlated with the passive ( $r(42) = .33, p < .031$ ) and active ( $r(42) = .47, p < .002$ ) word knowledge posttest scores. Again, a main overall effect for condition

was found (Pillai's trace,  $F(2) = 7.92, p < .001$ , partial  $\eta^2 = .306$ , observed power = .937). Again, pairwise comparisons (with Bonferroni correction for multiple comparisons) of both conditions were made comparing results from the passive and active word knowledge test. Again, condition 1 outperformed condition 2 in active ( $M = 14.61, p < .000$ ) word knowledge. However, there was no significant effect ( $M = 2.09, p = .222$ ) between the conditions in comparing the results from the passive word knowledge test.

### 5.1 MEL-Time Differences

The total amount of learning time differed for both conditions. For condition 1, learning time consisted of 1) English lessons at school 2) learning with the MEL application at the zoo 3) learning with the MEL application at home. For condition 2, learning time solely consisted of learning with the ZooQuest application at home, where learning time was split into ‘MEL-time’, the actual time the subjects were in the MEL environment and ‘ZooQuest-time’, the actual time the subjects were in the ZooQuest environment since ZooQuest represented an additional, surrounding game layer to the MEL application. To investigate if both conditions differed in ‘MEL-time’ at home, an independent samples *t*-test was conducted. There was a significant effect for ‘MEL-time’ at home,  $t(50) = 2.95, p < .005$ , in which condition 2 spent more ‘MEL-time’ at home ( $M = 2.79$ ) than condition 1 ( $M = 1.7$ ).

### 5.2 Further Exploration

Additional analyses were made in order to explore the data more thoroughly. First, a comparison was made between subjects from condition 2 that had the highest/lowest gain scores on the posttest for both passive and active word knowledge. Subjects with gain scores 1 standard deviation lower than the average were considered subjects with the lowest gain scores and subjects with gain scores 1 standard deviation higher than the average were considered subjects with the highest gain scores. For the passive part of the test, subjects ( $N = 3$ ) with the lowest gain scores spent an average of 3.1 hrs on learning (1.7 hrs MEL-time, 1.2 hrs ZooQuest-time) and subjects ( $N = 3$ ) with the highest gain scores spent an average of 3.4 hrs on learning (2.2 hrs MEL-time, 1.2 hrs ZooQuest-time). For the active part of the test, subjects ( $N = 3$ ) with the lowest gain scores spent an average of 6.1 hrs on learning (3.8 hrs MEL-time, 2.3 hrs ZooQuest-time) and subjects ( $N = 3$ ) with the highest gain scores spent an average of 4.6 hrs on learning (2.9 hrs MEL-time, 1.7 hrs ZooQuest-time).

In a second analysis the ZooQuest scores were considered. Subjects could gather 25 medals by finding the 25 animals within the game. A gold medal rewarded the player with 5 points, hence the maximum gamescore a player could achieve was  $25 \times 5 = 125$ . Subjects in condition 2 achieved an average gamescore of 103.2 ( $SD = 13.7$ ) after playing the game for a first time (fig. 5). Approximately half of the subjects played the game again, scoring an average gamescore of 83.9 ( $SD = 30, N = 11$ ).

<sup>6</sup> See section 5.1.

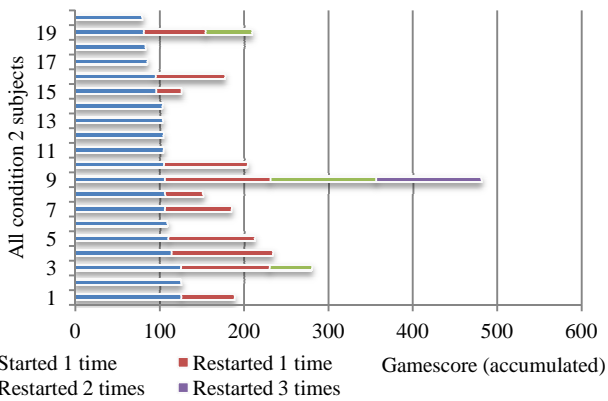


Figure 5: Gamescores by all condition 2 subjects.

Only 3 subjects restarted the game 2 times (avg. gamescore = 76.6,  $SD = 41.9$ ) and 1 subject restarted the game 3 times (gamescore = 125). There was a significant effect for gamescore,  $t(18) = -5.19, p < .000$ , with subjects restarting the game twice or more receiving higher scores ( $M = 211, SD = 62.2$ ) than subjects that restarted the game once ( $M = 99, SD = 14.6$ ). There was no difference in gain scores on both word knowledge tests when subjects that restarted the game once were compared to subjects that restarted the game twice or more (active,  $t(18) = .253, p < .803$ ; passive,  $t(18) = -.032, p < .974$ ).

### 5.3 Questionnaires

The purpose of the group interview was to probe the ideas of the subjects about the game characteristics that were incorporated in the ZooQuest environment. As stated, it was of importance which game characteristics would appeal the most and the least to the subjects and how design, instruction and motivation were related to this. First, the subjects elaborated on the ZooQuest fantasy setting; we asked if ZooQuest resembled a fantasy setting or a real world setting. One subject replied: “To me, it was more of a fantasy world, the animals looked a bit strange and were really small”. Other subjects agreed that ZooQuest resembled a fantasy setting and argued that some phenomena did not match a real world setting: “The shark moved on the grass when it was caught”, “The jellyfish was situated on the bridge that is impossible”, “The eagle should not be placed in grass but in the mountains”. When we asked the subjects about their character (zoo visitor Jack) one child replied: “I preferred to choose between different character genders because I’m a girl”. Then, we asked if the rules of the game were clear and allowed for a wide range of permissible actions. It was notable that the subjects instantly replied: “Yes the rules were clear, however, the game should have been longer, it was very short”. One subject replied “I finished the game on the first day”. This is where the interview became partly unstructured because subjects wanted to share their game experiences: “Although I finished the game quickly, I wanted to play again because it was so much fun”. Subjects shared when and where they played ZooQuest: “I played the game when I woke up and went to bed”, “Usually I read before sleeping, however, last week I was playing ZooQuest because it allowed me to read some English”. Two subjects admitted they played ZooQuest until 3~4 AM in the morning: “When my mother sent me to bed, I kept on playing until 3:30 AM, however,

the same day I had to be at the hockey club at 7 AM”. We continued the interview by asking the subjects if they could easily track their progress toward desired goals. The children argued that it was unclear how many animals they had caught, or how many animals they still needed to catch. The subjects ‘solved’ this problem by counting the animals in the medal overview (fig. 4, right screen). Then, regarding the game characteristic ‘sensory stimuli’, we asked if the video/audio clips were appealing. Subjects replied that they liked the video clips, although they intended to skip the video clips: “I had a silver medal and wanted the gold medal (...) I already knew the video clip, so I didn’t watch for a third of fourth time”, “I skipped the videos most of the time”. When we asked if the subjects were curious to learn about the animals, mixed answers were given: “Yes, but just a bit”, “I thought it was more for fun”, “I wanted to learn a lot about the animals (...) I was curious about their living/eating habits”. Finally, we asked if they liked the game’s narrative, and whether this was a strong narrative. Again mixed answers were given: “I think the story was a bit simple”, “The story was nice but short”. Additional questions on game improvement are discussed in section 6.4.

### 5.4 Application Usage

Application usage was logged to each smartphone. For both conditions, the number of playing subjects decreased over time (fig. 6) with an average of 8 playing subjects for condition 1 and an average of 6 playing for condition 2<sup>7</sup>.

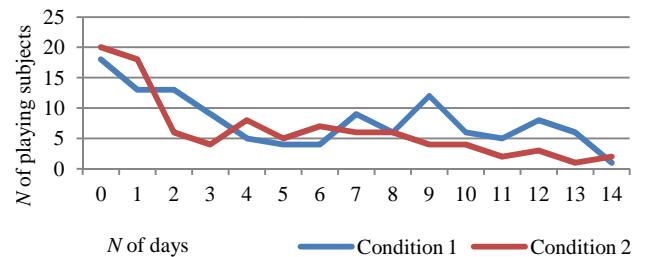


Figure 6: N of subjects using the mobile application per day.

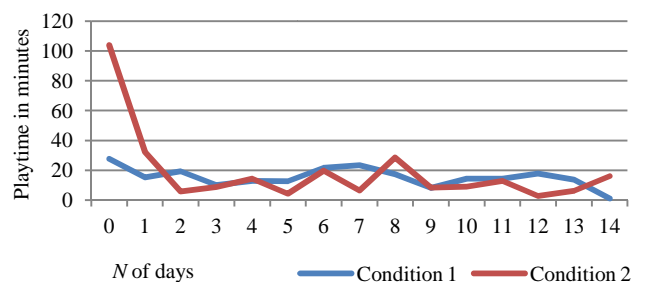


Figure 7: Average playtime per playing subject per day.

For condition 1, the average playtime per playing subject per day slowly decreased after the first day. For condition 2, the average playtime per playing subject per day decreased enormously after the first day (fig. 7). Subjects in condition 1 played an average of 15.3 min per day ( $SD = 6.5$ ). Subjects in condition 2 played an average of 18.6 min per day ( $SD = 25.1$ ).

<sup>7</sup> Both averages were rounded up.

## 6. DISCUSSION & CONCLUSION

### 6.1 Hypotheses

The first alternative hypothesis (*RQ1H1*) stated that students using the ZooQuest application spent significant more time on MEL than students using the MEL application. This hypothesis was met: there was a significant effect for ‘MEL-time’ at home in which condition 2 spent more ‘MEL-time’ at home than condition 1. This result suggests that the ZooQuest environment motivated the subjects to spend more time in the MEL-environment.

The second alternative hypothesis (*RQ2H1*) stated that students that used the ZooQuest application obtained significant better learning results than students that used the MEL application. This hypothesis is rejected in favor of its null-hypothesis (*RQ2H0*): condition 1 outperformed condition 2 on passive and active word knowledge. However, this result is partly due to the larger total amount of learning time for condition 1. Therefore, total learning time was considered as additional covariate. With this adjustment, condition 1 outperformed condition 2 on the active word knowledge posttest. For passive world knowledge, no significant effect was found. This finding indicates that the larger learning gains for condition 1 on the passive word knowledge test are mainly due to a larger amount of learning time.

For active word knowledge, condition 1 made tremendous progress due to English lessons at school, a factor that was absent for condition 2. During the lessons at school, subjects in condition 1 were actively engaged in speaking and pronouncing English words. The ZooQuest application however did not instruct the subjects to do the same at home. This finding opts for a combined learning approach in which children follow English lessons at school and use a mobile learning application at home.

### 6.2 Limitations

In the first additional analyses<sup>8</sup>, a comparison was made between subjects from condition 2 that had the highest/lowest gain scores on the posttest for both passive and active word knowledge. For the passive part of the test, subjects with the highest gain scores spent slightly more time on ZooQuest than subjects with the lowest gain scores. For the active part of the test, subjects with the highest gain score spent less time on ZooQuest than subjects with the lowest gain scores. This suggests there is no correlation between learning time and the learning gains for condition 2. However, when both conditions were considered, learning time correlated with the passive ( $r(42) = .33, p < .031$ ) and active ( $r(42) = .47, p < .002$ ) part of the word knowledge posttest. This result indicates a correlation between learning time and the learning gains for both conditions, although the correlations are rather weak positive correlations.

The findings reflect the first limitation of this study: learning time cannot be treated as a linear construct. An  $x$  amount of learning time in class is incomparable to a same  $x$  amount of learning time with a mobile learning application. The second limitation concerns learning competence: the relation

between learning time and learning gains is affected by learning skill differences of the subjects. This limitation adheres to the fact that subjects with the highest gain scores spent less time on ZooQuest than subjects with the lowest gain scores. Furthermore, the conditions were formed at 2 different primary schools that systematically differed on various variables. First, it was unclear to what extent schools differed in their English curricula. Secondly, it was unknown how both schools differed in educational quality.

### 6.3 ZooQuest

Experimentation with the ZooQuest application led to promising results, however, the number of subjects using the ZooQuest application decreased over time (fig. 6). Average playtime per playing subject per day also decreased over time (fig. 7). We were hoping to find an even amount of playtime/players over time but this wasn't the case. To explain this, we rely on the results from the questionnaires and game logs. It is notable that children in condition 2 played an average of 104 minutes at home the first day, whereas children in condition 1 (only) played an average of 28 minutes at home the first day. The drop of playtime, after the first day, concurs with the response of the subjects (condition 2).

When subjects played ZooQuest for a second time, the setting of the game was the same, which made gameplay less appealing. Hence, game characteristic *mystery* lost its attractive force, there was nothing ‘new’ to be discovered by the player after playing the game a second time. Also, the goals of the game did not change after restarting the game. Therefore, goals became less challenging which led to lower goal commitment, which led to a decrease in effort and performance (Locke & Latham, 1990). The game did not provide a continual feeling of challenge (Norman, 1993) and ‘challenge’ did not increase by uncertain goal attainment because the goals of the game did not change (Garris et al., 2002). Subjects felt bored over time because the level of challenge was lower than their skill level. Hence, we did not keep the subject in a state of flow (Csikszentmihalyi, 1990) because the alignment between challenge and skill wasn't optimal. Furthermore, ZooQuest did not provide a strong narrative. The story was “a bit simple” and “a bit short” according to the subjects.

### 6.4 Future work & Recommendations

Results of this study are used in the (future) follow-up study, *Mobile English Learning 2*, which synthesizes game characteristics from this study with intelligent tutoring principles. The *Mobile English Learning 2* study will represent a mobile game-based learning application that offers learning content at the individual skill level of the student. The application will also allow teachers to track individual learning performance of the students. Our game related recommendations are the following:

First, decide if the game should meet real world rules (‘a shark cannot be on the grass’, ‘a road affords walking’). When real world phenomena (e.g. animals, continents) are translated to a fantasy setting, game rules can break real world rules in order to make the game more engaging (‘it is funny when a shark is on the grass’). However, game rules

<sup>8</sup> See section 5.2.

can also match real world rules in order to keep the learning content (based on real world rules) related to the game's fantasy context. Secondly, when the game allows the player to control a game character, offer the player an option to choose between different 'personalities' so that the player can empathize/identify with his or her character. Thirdly, the game needs to incorporate proper goal-feedback. In ZooQuest, goal-feedback was poor because players did not immediately know how many animals were caught/needed to be caught. Furthermore, the game's narrative should be strong and extensive as it triggers more engaging and immersive gameplay (Bringsjord, 2001).

The most important recommendation concerns reward and game duration. In order to prevent children finishing the game too quick, a more advanced reward system should be adopted that takes the rehearsal of the learning contents into account. When we asked the subjects how the game could be improved a central idea rose: the player should receive awards that allow the player to receive new awards (e.g. by obtaining coins to unlock new continents or animals). If this reward loop is consolidated with the learning contents, the child's retention of the learning contents is expected to increase due to repetition which also counterbalances the forgetting curve as defined by Ebbinghaus (1913). A good example of an advanced reward system can be found in the World of Warcraft, a massive online role-playing game that adopts various reward paths. In Word of Warcraft, players are rewarded with gear, achievements, experience points, spells, abilities, new quests etc. Exploring new phenomena while constantly receiving positive rewards are perhaps the greatest motivators to keep the player playing.

## 6.5 Conclusion

The mobile game-based learning application ZooQuest was constructed for learning English at primary school level. Fifth graders that used the ZooQuest application spent more time on learning at home than the fifth graders from the initial study by Sandberg et al. (2011) and obtained better learning results on the posttest than they did on the pretest. The ZooQuest application demonstrated its benefits in terms of informal learning outside school and can serve as a basis for subsequent development and research.

## ACKNOWLEDGMENTS

We thank all the teachers and children from OBS de Bongerd/OBS de Boemerang for participating in this study. I would personally like to thank Jacobijn Sandberg and Marinus Maris for tutoring this study and for providing critical, constructive feedback. I would also like to thank Kees van den Broek, Miek Teunissen, Judith Schenkels, Pepijn Hoogendoorn, Ricus Smid, Lieuwe Rekker and Mathilde van Dijk for their help during the experiment. Special thanks go to Tiko Schep for his weekly support. This study was partly funded by Kennisnet.<sup>9</sup>

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