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CHAPTER 4

MOBILE GAME-BASED LEARNING AND STUDENTS' GAME ACTIVITIES

Insights into the relation between what students are doing during a game and the outcomes of playing a game are lacking because research on this topic is scarce. Therefore, in this study, students' game activities while they play the game *No Credit, Game Over* (NCGO) are described and related to their motivation to learn, perceived learning outcomes, and game performance. Moreover, effects of playing NCGO on students' self-reported motivation and learning outcomes are examined. In NCGO, students use their tablets to combine virtual information regarding debts with assigned tasks in urban spaces. Information was gathered from 181 students who completed questionnaires concerning their game activities, motivation to learn and learning outcomes. The data analysis showed that some game activities are related to motivation to learn, learning outcomes and team game performance. The extent to which the students were engaged with the game characters appeared to be negatively related to perceived learning outcomes and motivation to learn.

1. INTRODUCTION

Mobile learning can be a promising way to improve students' learning achievements, school motivation and subject-matter interests (Furió, Juan, Seguí, & Vivó, 2015; Hsu & Ching, 2013; Shin, Sutherland, Norris & Soloway, 2012; Sung, Chang & Liu, 2016). Mobile learning in schools is mostly applied in environmental education or out-of-class schooling (Chiang et al., 2015). This type of mobile learning has been made possible by the addition of equipment to mobile devices, such as wireless network connections, cameras, RFID readers and GPS (Jeng, Wu, Haung, Tan, & Yang, 2010), which expand learning with games from the screen to learning in a mixed-reality environment by using urban spaces as a game board. These types of games are called mobile location-based games or urban games when they are played in an urban environment (De Souza e Silva & Hjorth, 2009).

Game-based learning, including learning with mobile games, can be beneficial for both students' learning outcomes and their motivation (e.g., Jabbar & Felicia, 2015; Wouters, Van Nimwegen, Van Oostendorp, & Van der Spek, 2013). Enabled by technological developments, mobile game-based learning is emerging, and it fits with students' personal worlds. However, much information remains to be discovered regarding the processes that play a role in mobile game-based learning (Iten & Petko, 2016). Insights into the relation between what students are doing during a game and the outcomes of playing a game are currently lacking because research on this topic is scarce. The present study is a case study that examines the activities of

students while they play a game and how these activities relate to their motivation to learn, perceived learning outcomes, and game performance.

2. MOBILE GAME-BASED LEARNING

Mobile game-based learning can be different from traditional game-based learning if the game is being played on a handheld device and includes the environment outside the classroom. Studies on mobile game-based learning mostly focus on the usability of these games or on motivational and learning effects (Rubino, Barberis, Xhem-bulla, & Malnati, 2015; Squire & Jan, 2007; Klopfer & Squire, 2008). Wake (2013) stated there was a research gap between convictions that mobile games can facilitate learning and an understanding of the role these games have for learning and what their role in education is (Wake, 2013, p. 9). In his dissertation project, he developed, deployed and researched a mobile location-based game for teaching and learning history called *Premierløytnant Bielke*. He concluded that learning by playing mobile location-based games was a motivating and engaging way to learn. However, he also noted some constraints of current pedagogical practices, such as for instance working in class hours of 45 minutes and that a ten hour intervention is probably difficult to realize. Not many studies on location-based games go beyond the effects on learning or motivation and also investigate why students become motivated to learn or why these effects are lacking by examining the game process. Gurbibye, Wake, and Wasson (2014) studied what students do during game play of *Premierløytnant Bielke* and found that there is sometimes a contradiction in the educational game they researched. Winning the game was about using as little time as possible and resulting in that sometimes learning opportunities were missed as students would not take time to dwell and reflect upon historical surroundings. Ardito, Costabile, De Angeli, and Lanzilotti (2012) found a similar result. They examined students' game experiences with an emphasis on how students explored the mobile excursion game *Explore!*, integrated information from real and virtual sources and acquired knowledge on archaeology and life in Roman times. The game creates an augmented reality environment that is based on 3D models of places and objects and uses contextual sounds to enrich the physical environment. *Explore!* was designed to stimulate students' interest in archaeological sites and to facilitate history learning during site visits. The students explored the environment in small groups and needed to identify meaningful places in an archaeological site to solve the game's mission. Two second-year middle school classes played two versions of *Explore!*, one with contextual sounds and one without. In a between-subjects design, the authors reported positive experiences with both versions of the game, but unexpectedly, the 3D reconstructions of places and objects in their original state were often ignored by the students. The students explained that their first goal was to win, and due to time pressure, they skipped the 3D reconstructions, which decreased their opportunity to learn about the objects and places in their original state. So the desire to win the game can have negative effects on learning, but this does not necessarily have to be the case. For example, Admiraal, Huizenga, Akkerman, and Ten Dam (2011) studied the game process of *Frequency 1550*, a mobile city game concerning medieval

Amsterdam. In particular, they investigated the game activities of student teams and their effects on team game performance and student learning outcomes. The game was used in history classes and played by 216 secondary school students, most of whom were 13 years old. The game was played in groups of four students, who had to complete assigned tasks. Two students navigated the city by using a medieval map of the city and completed the assignments. The other two students stayed behind in a room with computers and searched for information, collected the completed assignment and guided the city students with the use of a contemporary city map that displayed the location of the city teams. The study showed that when the students were more engaged in competition, they learned more about the medieval history of Amsterdam. Furthermore, when the students were less distracted by solving technological problems, team performance was better, and they learned more. The other distractive activity, navigating, had a significant negative effect on team game performance.

Hwang and Chang (2015) had a more specific focus than Admiraal et al. (2011) and Ardito et al. (2012) and examined whether competition in mobile game-based learning mattered for learning. They designed a peer competition-based mobile learning system for conducting and learning from local cultural activities. In this system, there was a board game interface with a map where 'each location on the map is associated with a real-world learning target with a set of relevant questions' (p.4). During a field trip, two fifth-grade classes that used the mobile game-based learning system were compared: one class with peer competition and one class without competition. The students in the peer competition-based approach were more motivated to learn and had a more positive learning attitude and local cultural identity (valuing local culture) than the student group without competition.

3. THE CASE: THE GAME OF NO CREDIT, GAME OVER

The game that was examined in the current study is a serious urban game called 'No Credit, Game Over' (NCGO) and was created by the '[ew32]' organization (<http://www.ew32.be/about/about-ew32-english-version/>). The game is designed to offer an interactive learning context about debt, and it is played in a city by using a tablet. The goal of the game is to decrease the amount of debt.

Secondary school students played the game in groups of two or three students (occasionally four). Each team was assigned a tablet in on this tablet information could be found about a specific character with a debt of €1,400. There were ten different characters, each with his/her own reasons for being in debt, such as frequently calling a boyfriend abroad or having a gambling addiction. To decrease their debt, the student teams needed to find ways to earn money and reduce expenses. They started the game by going into the city (in real life) to interview passers-by regarding their opinions of people in debt and advice to get out of debt and then went to visit organizations that could help. Organizations such as banks, job centres, unions and social organizations participated in the game. In every participating organization, one or more of the employees were informed that students may come to their organization. The organizations were indicated on a map on the tablet. The teams pre-

sented themselves with the name and background of their character. The teams also had to consider options to reduce their expenses while they walked through the city.

During the game, the game master offered the teams an additional option to change the amount of debt by calling one of the team members who pretended to be either a drug dealer or an employer. The drug dealer offered the teams a quick way to earn money by keeping a package in their apartment that contained soft drugs. The employer offered undeclared work with a higher wage than regular jobs. However, in both scenarios, the teams could get caught either with doing undeclared work or with possessing a drug package. If caught, the teams received a fine, which increased the debt. The actual score of a team was updated in real time and was accessible to the teams. The game was played in three stages; see Table 1.

Table 1. The three stages of the game No Credit, Game Over

Stage	Duration (minutes)	Description
Introduction	30	Introduction at the headquarters of the game
Play	120	Interview at the starting location in the city followed by visiting organizations and looking for options to save money
Debriefing	30	Discussing the scores and decisions at headquarters

The goal of the current study was to obtain insight concerning the relation between students' game activities in the NCGO mobile game and students' motivation to learn, perceived learning outcomes, and game performance. We also wanted to know if students' perceived learning outcomes and motivation to learn changed after playing the game. Accordingly, we formulated the following six research questions:

- 1) Do students' perceived knowledge of the subject of debt and perceived interest in the subject of debt change after playing the game?
- 2) Does students' character immersion explain the differences among students in their motivation to learn the subject of debt?
- 3) Do students' team game activities explain the differences among students in their motivation to learn the subject of debt?
- 4) Does students' character immersion explain the differences among students in their perceived learning outcomes?
- 5) Do students' team game activities explain the differences among students in their perceived learning outcomes?
- 6) Do students' team game activities explain the differences in team game performance?

4. METHOD

4.1 Participants

The participants were 181 students who played the game in the Flemish city of Oostende. The students (66 males, 115 females) varied in age from 15 to 22 years. Most students (169) were in the fifth to seventh grades from four schools of secondary

education. The students played the game in teams (N=69 teams). The teachers of the students had signed their students up to play the game. Most of the teachers had their students play the game as a part of the secondary education subject PAV (Project Algemene Vaardigheden, literally translated: project general skills). This is an interdisciplinary subject/course that integrates learning contents of several subjects; financial literacy is one of the themes discussed in this context.

4.2 Procedures

The students completed a pre-game questionnaire when they entered the headquarters. The game was introduced by the game master, an employee of the organization. The students started the game by going to their appointed starting location in the city; then, they conducted an interview and worked on reducing their debt. Halfway through the game and at the end of it, each student team completed an online questionnaire regarding game activities as a team.

Immediately after the debriefing at headquarters, the students completed the post-game questionnaire.

A pilot study of the questionnaires was conducted with 24 secondary education students who had played the game approximately two weeks before. The information from this pilot study was used, along with the additional feedback of colleagues, to improve the questionnaires.

4.3 Students' game activities

Character immersion. Each student was assigned a character with a certain reason for being in debt. We wondered if during the game students would be immersed into the character and whether this would affect learning and motivation. Students' immersion with their character was measured by 7 items in the post-game questionnaire (e.g., 'I was able to imagine myself as my character well' and 'When playing the game, I felt like I was the character'). The items were answered on a four-point Likert scale with 1=*completely disagree* and 4=*completely agree*. The reliability in terms of Cronbach's alpha was .73, after 3 items were deleted and the Spearman-Brown correction for test length (to six items) was conducted. The mean score was 2.14 ($SD=0.62$, $N=177$).

4.4 Team game activities

Team game activities were measured during the playing of the game by an online questionnaire with nine 'activities' in which the students could be engaged (see Table 2 for an overview of the activities and their mean scores and standard deviations). We included activities that were part of the game, such as visiting organizations, as well as other activities, such as busy doing something other than the game. As students were supposed to work in teams and deliberate (with the rationale of being able to learn more this way), this was also an activity in the questionnaire. To see if students were engaged in competition we asked whether they looked at the

score. Each team of students rated on a five-point scale how often they had performed this activity in the past hour, with 1=*almost never* and 5=*almost the entire time*. The team game activities were measured at two moments. In general, there were no significant differences between the scores of the two time points, except for the activity ‘*We were looking to see whether we scored better than our fellow students*’ ($t(64)=-3.68$; $p<.001$), which had a higher score at time 2. The mean scores of times 1 and 2 together were used in further analyses.

Table 2. Team game activities

Activity	Time 1	Time 2	Mean time
	(<i>N</i> =65)	(<i>N</i> =69)	1 and 2 (<i>N</i> =69)
	Mean (<i>SD</i>)	Mean (<i>SD</i>)	Mean (<i>SD</i>)
We were busy thinking how to save money	3.76 (1.24)	3.87 (1.25)	3.80 (1.12)
We were imagining ourselves as our character	3.62 (1.21)	3.71 (1.29)	3.65 (1.18)
We were busy looking at the route	3.54 (1.31)	3.74 (1.27)	3.64 (1.22)
We were deliberating	4.68 (0.75)	4.56 (0.81)	4.62 (0.74)
We were looking up information on the internet	1.82 (1.21)	1.71 (1.18)	1.74 (1.08)
We were busy doing something other than the game	1.49 (0.94)	1.62 (1.03)	1.56 (0.86)
We had technical problems	1.91 (1.31)	1.86 (1.18)	1.90 (1.15)
We were looking to see whether we scored better than our fellow students	2.00 (1.38)	2.48 (1.52)	2.21 (1.31)
We were busy visiting organizations	3.91 (1.24)	3.88 (1.17)	3.89 (1.07)

4.5 Motivation to learn and perceived learning outcomes

Immediately before the start of the game and after the game, motivation to learn and perceived learning outcomes were measured by 15 questionnaire items. All items were answered on a four-point Likert scale with 1=*completely disagree* and 4=*completely agree*. After a principal component factor analysis with varimax rotation, three factors were extracted that explained 46% of the variance (rotated component matrix, included in the supplementary material). The reliability and descriptive statistics of these three factors are included in Table 3. Motivation to learn is operationalized as *interest in the subject of debt*. Perceived learning outcomes was originally operationalized as *knowledge about the subject of debt* and *conscious spending behaviour*. However, for the scale *conscious spending behaviour*, the alphas were unsatisfactory; therefore, this scale was excluded in further analyses, and perceived learning outcomes was operationalized only as *knowledge about the subject of debt*.

Table 3. Three factors regarding motivation and learning outcomes that were extracted from the factor analysis

Scale	No. of items	α pre	α post	Pre (N=180) Mean (SD)	Post (N=179) Mean (SD)	Example item
Interest in the subject of debt	5	.82	.85	2.80 (.65)	2.99 (.63)	I'm interested in the causes of debt
Knowledge about the subject of debt	3	.73	.77	2.23 (.67)	2.87 (.56)	I know which organizations can help me if I have debt
Conscious spending behaviour	6	.55	.57			I think hard before I borrow money

Note. The reported Cronbach's alphas are the alphas after the Spearman-Brown correction for test length to six items.

4.6 Team game performance

Each team started with a debt of €1,400 (a score of minus 1400). The goal was to get rid of the debt. During the game, the students had to send all of their choices (e.g., the job they chose, the options to save money and how much money this would be) to the game master. One group had to restart because of technical problems, and this score was not included in the analyses. At the end of the game, the average debt of the teams was increased to €1,665 (SD=€761); the highest score was a surplus of €273.59, and the lowest score was a debt of €3,062.68.

5. ANALYSES

To validate the self-reported data on game activities, the first author randomly chose a team of students to observe their game activities for each of the nine times that the game was played. The self-reported data from the students concerning their activities was mostly consistent with the researcher's observations, except for technical problems, which seemed to be over-represented in the self-reported data. This over-representation was caused by the students' broad interpretation of technical problems. They indicated having to switch between applications (for instance from the map to the character information) and not knowing what to find where as a technical problem.

To examine whether perceived knowledge of the subject of debt and perceived interest in the subject of debt changed after playing the game paired sample t-tests were performed.

To examine the relation between motivation to learn the subject and perceived learning outcomes (the dependent variables at the student level) and character immersion (the independent variable at the student level) as well as team game activities (the independent variables at the group level), multi-level regression analyses

were performed. For each of the dependent variables, two models were calculated, namely, one variance component model and one model with the student game activities. The pretest score was a predictor.

For the relation between team game activities and team game performance, a multiple regression analysis was performed because all of these variables are at the group level.

6. RESULTS

Students' perceived learning outcomes and motivation to learn There was a significant difference between knowledge of the subject of debt before playing the game ($M = 2.23$; $SD = 0.67$) and after playing the game ($M = 2.87$; $SD = 0.56$); $t(178) = -13.55$, $p = .000$; 95% CI $[-0.73, -0.55]$. Students' knowledge of the subject of debt was higher after playing the game than before.

There was also a significant difference between interest in the subject of debt before playing the game ($M = 2.79$; $SD = 0.64$) and after playing the game ($M = 2.98$; $SD = 0.63$); $t(178) = -5.48$, $p = .000$; 95% CI $[-0.26, -0.12]$. Students' interest in the subject of debt had increased after playing the game.

Student game activities and interest in the subject of debt. The pretest and posttest scores of *interest in the subject of debt* were significantly positively related (see Table 4). The individual student scores on *character immersion* showed a significant negative relation to motivation: when the students individually identified more with their character, their interest in the subject of debt was lower. Finally, a significant negative relation was found to the team game activity '*We were busy doing something other than the game*': when the students were more occupied doing something other than the game, they were less interested in the subject of debt.

Student game activities and knowledge about the subject of debt. The pretest and posttest scores were significantly positively related (see Table 4). The individual student score on *character immersion* was negatively related to the posttest score, which means that when the students identified more with their character, their score on self-reported knowledge about the subject was lower. Moreover, none of the team game activities were significantly related to the posttest scores concerning *knowledge about the subject of debt*.

Team game activities and team game performance. Team game performance was significantly related ($\alpha=0.05$, $N=68$) to two team game activities, specifically visiting organizations ($B= 329.43$, $s.e. 113.04$) and looking at the route ($B=-235.74$, $s.e. 95.09$). When the teams visited organizations more and looked at the route less, team game performance was higher.

Table 4: Multilevel regression analysis with the dependent variables of interest in the subject of debt and subject knowledge

	Model 0 interest in the subject of debt	Model 1 interest in the subject of debt	Model 0 subject knowledge	Model 1 subject knowledge
	Variance components	Final	Variance components	Final
	<i>N</i> =179	<i>N</i> =167	<i>N</i> =179	<i>N</i> =167
	<i>B</i> (s.e.)	<i>B</i> (s.e.)	<i>B</i> (s.e.)	<i>B</i> (s.e.)
<i>Fixed effects variables at the student level</i>				
Pretest		0.68 (0.05)		0.34 (0.06)
Character immersion		-0.18 (0.06)		-0.17 (0.06)
<i>Fixed effects variables at the team level</i>				
We were busy thinking how to save money		0.06 (0.04)		0.08 (0.05)
We were imagining ourselves as our character		0.00 (0.04)		0.05 (0.05)
We were busy looking at the route		0.02 (0.04)		-0.03 (0.04)
We were deliberating		0.03 (0.06)		-0.08 (0.06)
We were looking up information on the internet		0.03 (0.04)		0.03 (0.04)
We were busy doing something other than the game		-0.09 (0.04)		0.00 (0.05)
We had technical problems		0.06 (0.03)		0.02 (0.04)
We were looking to see whether we scored better than our fellow students		-0.00 (0.03)		0.05 (0.03)
We were busy visiting organizations		-0.07 (0.05)		0.02 (0.04)
<i>Random effects</i>				
Level 2 (group) $\sigma^2_{u_{0j}}$	0.00 (0.00)	0.00 (0.00)	0.09 (0.07)	0.00 (0.00)
Level 1 (student) $\sigma^2_{e_{0ij}}$	0.40 (0.04)	0.16 (0.01)	0.22 (0.07)	0.21 (0.02)
2*log likelihood	341.90	165.83	297.57	214.22

Note. *N*=number of students included in the model; 's.e.'=standard error. Significant fixed effects (with $\alpha=0.05$) are printed in bold.

7. DISCUSSION

To provide insight into the relation between students' game activities and the game's outcomes, we examined whether students' character immersion and team game activities were related to motivation to learn, perceived learning outcomes and team game performance. Also, we wanted to know if after playing the game students' perceived learning outcomes and motivation to learn had changed.

Both the scores on perceived learning outcomes and on motivation to learn were higher after playing the game than before. We are not sure whether this is due to the game, as we do not have a control group. However, the time between pretest and posttest was only a few hours and not much more than the game has happened in these hours. It is also possible that students might have given socially desirable answers, but there were no clues for this when comparing observations with questionnaires.

For both perceived learning outcomes and motivation to learn, character immersion was a significant predictor but unexpectedly, a negative one. Considering the importance of roles and characters in game design and role-playing in game-based learning (Dickey, 2007; Souter & Hitchens, 2016), this result merits further research.

For perceived learning outcomes, none of the team game activities were significantly related. Other researchers (Admiraal et al., 2011; Ardito et al., 2012; Hwang & Chang, 2015) have found relations between game activities during the game and learning outcomes, for instance for competition. Students' knowledge about debt was higher after playing the game, but it might be that in this game the students may have learned the most during the debriefing phase. This phase is understood as an important phase in game-based learning for student learning (Ardito et al., 2012). In the current study, game activities were measured only during the game. Maybe if the posttest had taken place before the debriefing relations with the game activities would have been different.

For motivation to learn, the only significant relation was to the team game activity '*We were busy doing something other than the game*'. This outcome does not raise questions, as it seems logical that students who are not interested in the subject of debt spend more time doing something other than a game about debt as students who are interested in debt. Two team game activities were related to team game performance, namely, visiting organizations and looking at the route. Visiting organizations was positively related to team performance, so a good way to get rid of the debt. We would have thought that probably being busy thinking how to save money might have this effect as well, but it did not. Maybe because the saving options reduce the debts by smaller amount than visiting organizations (finding a job makes a larger difference than saving on groceries) and also busy thinking about it does not necessarily mean that students were succeeding in saving. Looking at the route showed a negative relation to game performance. It might be that some students had trouble reading the map and took a lot of time traveling from one organization to another and as visiting organizations contributed to game performance, being able to visit less organizations due to looking at the route might be an explanation for why this activity negatively influenced team game performance.

7.1 Limitations and future research

Our study has shown that some student game activities in mobile location-based games are related to game outcomes. In our study, we measured team game activities by surveying students through an online questionnaire on a tablet that students shared. One possible route for future research is to measure students' game activities in more detail and at an individual level. In this way, more varied insight into student activities can be established. Measuring these activities in more detail may be accomplished by using GPS logs, for example, to examine exactly which organizations students visit and when. With detailed insight into students' game activities at individual and group levels, we expect to find more relations between game activities and game outcomes.