Learning History by Playing a Mobile City Game

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Abstract: Digital games seem to be excellent tools for facilitating and supporting situated learning. This unbinding of knowledge from a specific context fosters its transfer to new problems and new domains. Additionally, children's attitude towards computer games is the very attitude we would like all our learners to have. Therefore, it makes sense to try to merge the content of learning and the motivation of games.

The objectives of this paper are to generate insights into the practicalities and the effects of mobile game-based learning in secondary education on the development of pupils' engagement in learning (more specifically their motivation for the subject history), historical knowledge and collaborative skills. For this purpose we investigated a game called Frequency 1550. Frequency 1550 is a mobile city game in which pupils playfully acquire historical knowledge about the medieval city of Amsterdam. There have been two pilots concerning this game, one in 2005 and one in 2007. The first pilot was carried out with one class and evaluated on the usability of the game. For the second pilot the game has been redesigned, tested, implemented and evaluated. A quasi-experimental design is followed in which data have been gathered on the process of gaming and learning. Both quantitative and qualitative data have been gathered and analyzed. Twenty classes of some 25 pupils have participated in the pilot. Pupils from ten classes played the mobile history game while the other pupils were in the control condition and followed regular project-based lesson series. Learning effects, motivation and collaboration have been studied and analyzed in both quantitative and qualitative ways. The preliminary results show high motivated pupils playing, learning and working on the subject of medieval Amsterdam, even though there were problems with the technique and the assignments and pupils level did not always match.

Keywords: game-based learning, learning effects

1. Introduction: Game-based Learning

Computer and games can let student experience ways of learning that stress immersion in a practice, supported by structures that lead to expertise, professional-like skills, and innovative thinking (Shaffer & Gee 2006). Children learn prior to and outside school, at home or elsewhere, technical languages, skills and knowledge. But today, children have to be able to produce and not just consume, to make knowledge and not just receive it. We like Shaffers (2004, 2006a, 2006b) approach to learning, which is about having pupils do things that matter in the world by immersing them in rigorous professional practices of innovation. In this approach, pupil do things that are meaningful to them and to society, supported all along the way by structure, leading to expertise, professional-like skills, and ability to innovate.

Digital games appear to be excellent tools for facilitating and supporting meaningful learning of pupils, merging out-of-school and in-school learning (Prensky 2003; Shaffer et al. 2005). Gee (2005) lists a number principles of learning or practices to be built in digital pedagogy characterizing game-based learning. These principles of learning are clustered into three sections: principles which have to do with the empowerment of the learner, features of the learning task as a problem-solving task, and aspects of the learning process as a process of understanding (see Table 1).

These principles of game-based learning will be effectuated in the design and the evaluation of educational practices using mobile games in secondary education.

Table 1: Characteristics of game-based learning

	Principles	Description
Empowered learners	Co-design	Learners feel like active agents (producers) and not just passive recipients (consumers). Players should feel a real sense of agency and control as they are the ones who make things happen.
	Customize	Different styles of learning work better for different learners. Learners have to be able to make decisions about how their learning will work, but should be encouraged to try new styles as well.
	Identity	Learners take on a new identity they value and in which they become heavily invested. Players either inherit a strongly formed and appealing character or they get to build a character from the ground up.
	Distributed knowledge	Learners feel expanded and empowered when they can manipulate powerful tools in intricate ways that extend their area of effectiveness.
Problem solving	Well-order problems	The problems learners face early should be well designed to lead them to hypotheses that work well, not just on these problems, but as aspects of the solutions of later, harder problems, as well.
	Pleasantly frustrating	Learning works best when new challenges are pleasantly frustrating in the sense of being felt by learners to be at the outer edge of, but within, their range of competence. That is, these challenges feel hard, but 'doable'.
	Cycles of expertise	Good pacing in learning is constituted through cycles of extended practice, tests of mastery of that practice, then a new challenge, and the new extended practice.
	Information on demand and just-in-time	Learners use information best when it is given 'just-in-time' (when they can put it to use) and 'on demand' (when they feel they need it).
	Fish tanks	When confronted with complex problems, letting the learner see some of the basic variables and how they interact can be a good way into confronting more complex versions of the system later on.
	Sandboxes	If learners are put into a situation that feels like the real thing, but with risks and dangers greatly mitigated, they can learn well and still feel a sense of authenticity and accomplishment.
	Skills as strategies	Learners learn and practice skills best when they see a set of related skills as a strategy to accomplish goals they want to accomplish.
Understanding	System thinking	Any learning experience is enhanced when we understand how it fits into a larger meaningful whole.
	Meaning as action image	Most learners do learn through experiences they have had and imaginative reconstructions of experience.

2. Objectives

The objectives of this paper are to generate insights into the practicalities and the effects of mobile game-based learning in secondary education on the development of pupils' engagement in learning (more specifically their motivation for the subject of history), historical knowledge and collaborative skills. Two pilots on testing the mobile city game of Amsterdam, Frequency 1550, have been set up. In the first pilot in 2005, the usability of the game has been the focus of the evaluation. In the second pilot in 2007, we evaluated the learning effects of the game using a quasi-experimental research design. Before presenting both pilots, we will describe the city game, Frequency 1550.

3. Case Description: Frequency 1550

3.1 Back story

Before the pupils actually start playing the game, it is placed in the context of a larger story (back-story). The storyline "constitutes a narrative framework for the structuring of learning contents, networked episodes, tasks and activities. It follows a narrative outline (setting the scene in time and place, introducing characters, creating ways of living) and a pedagogical outline with reference to key questions, learning tasks, activities, resources, media and cooperative interactions" (Hug 2005).

Frequency 1550 magically interacts with the year 1550 of the late medieval era. Via the UMTS-network, the medieval city's bailiff is getting in contact with the present, that is 21st century Amsterdam. Through all kinds of misunderstandings the bailiff mistakes the pupils for pilgrims visiting Amsterdam in 1550 in order to visit the Holy Host, a special relic associated with The Miracle of Amsterdam. The relic has mysteriously disappeared and the bailiff suggests a deal: he will give them easy access to citizenship provided they help him retrieve the holy relic. Teams of four pupils each - two of them located at Headquarters (HQ) at De Waag in Amsterdam, the other two walking the streets of Amsterdam - take up their roles as competing pilgrims and, thus, step into the game's world. With the help of the Internet, smart phones and GPS technology, Amsterdam changes into a medieval play-ground. For a more extensive case description, see Raessens (in press).

3.2 Technical infrastructure

The two members of the team who wander through Amsterdam are equipped with a gamephone linked to a Global Positioning System (GPS) receiver, and a UMTS videophone. Their two peers at HQ have a videophone too and a laptop with an Internet connection. All smart phones have Internet connection, the gamephone is permanently connected to the Game server at the Waag Society's lab.
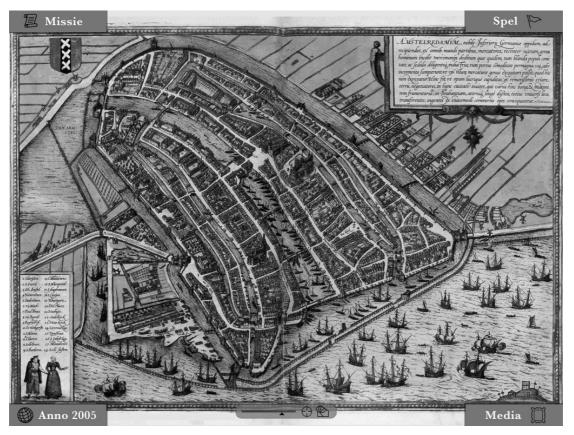

Figure 1: Map of medieval Amsterdam © Waag Society

With the help of a GPS receiver, a gamephone displays the position of its team on a medieval map of Amsterdam (see Figure 1). Using their videophone and gamephone a team can make (video)calls to their HQ, receive and watch pre-recorded video messages figuring medieval characters, and complete and send assignments (video clips and pictures) to HQ located at De Waag. Using their laptops, team members at HQ have a game application with Internet access in order to look up information, check out historical references and send relevant information to the players in the city, thereby helping them to complete their assignments. Because they are able to see each player walk through the city in real time as colored dots - on the medieval map as well as on the current map of Amsterdam - they can work out the team's strategy and use their phones to guide their team toward the locations where the assignments are hidden. At the end, HQ is responsible for the collection of all the data in an online presentation.

3.3 Assignments

A team of pupils can earn citizenship of Amsterdam by collecting as many of the required 366 so-called "Days of Burghership" as possible. These 366 points refer to the medieval year-and-a-day rule, which is the period you had to be living inside the city walls to earn citizenship rights. The team which manages to acquire burghership first has the right to keep the Holy Host in its monastery and wins the game.

The centre of Amsterdam is divided in six sectors on the Medieval map of Amsterdam. Each team of pilgrims gets assigned a starting sector of the city it needs to explore, map and master in a multimedial way. As the team moves around in the streets of (medieval) Amsterdam, it receives pre-recorded video clips with characters from the Middle Ages who provide information on historical locations and on the strange disappearance of the holy relic. Along the way, these medieval characters reveal bit by bit what happened to the relic, allowing players to piece this story together.

At the same time the teams are competing with each other. Each team of pilgrims has to decide to stay away from other teams or call on a confrontation – their order determines who wins. The winning team takes away hard-earned medieval Days of Burghership from the team who loses. Team members can also earn a monk's habit which makes them invisible to the other teams, and they can drop virtual bombs to kill each other's communication facilities with HQ.

As soon as a team of pilgrims has reached a certain location, video assignments are automatically sent from the server of De Waag to the UMTS videophone with the help of GPS. In order to obtain Days of Burghership a team needs to demonstrate its knowledge of medieval Amsterdam by doing small location-based media assignments and by answering specific questions on the city's history. Each team can make all of the eighteen assignments (three per sector) that are related to specific locations. Pupils are encouraged to fulfill at least two assignments per sector, in order to open up a new sector with new story and assignment locations. They can win points for these assignments helping them to win the game. To be able to do so, they have to study the historical buildings and sources. At the same time, they are experiencing the story, and reaching the game's pedagogical goals. Each assignment starts with an introductory video clip, and then the pupils are asked to do research and enact some kind of historical situation that they have to register and send to HQ with their smart phone.

4. Pilot 1

4.1 Methods

In 2005, Frequency 1550 was played for the first time with one class from a secondary school in Amsterdam. In this pilot, pupils played in six teams of four or five pupils for two days, in periods of three hours. In addition, they received instructions on Frequency 1550 at HQ during one hour before each period of playing. On the third day, after two days of playing, all teams gathered at HQ to collectively reflect on the media produced, their answers to the questions and the strategic decisions taken during the game. In addition, a test on historical knowledge of Amsterdam has been administered with questions, partly related to the game's back-story and partly to the factual historical knowledge.

Each team of pilgrims had a guide who also observed the team activities in the city and evaluated these afterwards. This means that the evaluation data includes the pupils' answers on the test, their reflections during the plenary meeting at the end, and their products of playing the game. Moreover, we collected the observation data of the guides and their evaluations. The observations, reflections and evaluations were verbalized into protocols, per team and per guide. The answers on the open questions in the test were recorded and summarized per pupil.

Four observers analysed the data from scratch and tried to find a story in the data. This narrative method of inquiry resulted in summaries and reflections on the data by the observers negotiating disagreements until the outcomes were agreed upon or disagreements were understood and reflected as such. (Marble 1997)

4.2 Results

On the first day, technical errors and problems with logistics diminished the motivation of pupils to continue with the game. Two pupils thought the technology was difficult to handle: "It took a while before we got used to it. But on Tuesday [the second day] we already did much better." Both pupils agreed that, in the end, playing the game had enhanced their technological skills and was much more fun than regular classes in history. And according to the evaluators, the technology was transparent enough not to disturb the game play.

The pupils described their motivation for the game as follows: "You take much of it in. But especially the struggle with the other teams makes it really nice. Much nicer than a normal history lesson. We are very glad that our teacher was able to arrange this." In response to the question whether they had learned more from playing the game than from a book, they answered: "Hm, yes I think so." The pupils had no difficulties with the non-linear structure of the game, they enjoyed the freedom that it provided. The narrative scenario also turned out to be an effective way to make them enthusiastic about this historical game.

But some aspects of the story and the game were problematic. Some of the pupils identified themselves so strongly with the story that they had difficulties differentiating between the fictional story elements (such as the role of the medieval city's bailiff in the game's back-story) and the real source material (such as the story of The Miracle of Amsterdam). And though it seems to be a good idea to use a narrative framework in order to relate the micro-elements of the game, some pupils thought that the storyline was not sufficiently sustained by the game elements and vice versa. Some also thought that the scenario was too complex, which made it difficult for them to fully understand the goal and the mission of the game and limited the flow of the game.

One of the aims of this pilot was to find out how long the game ideally ought to take. Many commented that the game should take no more than a few hours instead of two days. Last but not least, some of the pupils thought there was too much emphasis on the learning part, which spoiled the fun part of the game for them. However, it is still unknown whether playing Frequency 1550 affects pupils' learning activities and learning outcomes. According to one evaluator, "It is clear that they have learned a lot, and that they are also very enthusiastic. The results of the test were better than we had expected. Such a view on the daily life in the Middle Ages has apparently stayed in their memories quite strongly." Therefore, evaluation of learning effects is the main aim of the second pilot with Frequency 1550.

5. Developments

In addition to the investigation of learning effects, the evaluation of Frequency 1550 in the first pilot produced some insights in how to change aspects of the game. The technical infrastructure has not been changed. However, the back-story and the assignments have been adjusted. The goal of the game still includes that a team of pupils can earn citizenship of Amsterdam by collecting as many of the required 366 so-called Days of Burghership as possible. However, the narrative framework of the Miracle of Amsterdam, with the disappeared relic and the bailiff asking pilgrims to find this relic, has been deleted. In each of the six sectors of playing, there is introductory video clip presenting an important event in medieval Amsterdam which is related to the particular sector. The sectors are explicitly labelled as 'labour', 'trade', 'religion', 'rules and government', 'knowledge', and 'defence'.

The pupils in the city take the identity of beggars or merchants instead of pilgrims who compete to find the relic. These identities give the pupils different rights in the game, if teams meet in the city. The content and the level of assignments have been changed as well as the way teams can compete. The latter means that pupils can still earn point by competing with other teams, but less than in the first pilot. The newly developed Frequency 1550 can be played within one day.

6. Pilot 2

6.1 Methods

In 2007, the mobile game has been redesigned into a one-day activity, which has been tested, implemented and evaluated during three weeks in May and June 2007. Data which will be gathered are summarized in Table 2. The tests and administration data are quantitative data; the data from the evaluation meetings, essays, learning products, logbooks, observations and track and tracing from the game are qualitative data.

A quasi-experimental design is followed in which additional -mostly qualitative- information will be gathered on the process of gaming and learning. We use one experimental condition (10 classes play Frequency 1550) and one control condition (10 classes receive a series of two regular lessons on the medieval history of Amsterdam). These are the educational interventions. The content of the regular lessons is similar to the content of Frequency 1550. The participants are about 500 pupils in 3 schools for secondary education in Amsterdam.

The quantitative data will be analyzed performing multilevel multivariate regression analyses with the intervention as independent variable, motivation, knowledge, and attitude towards collaborative learning as dependent variables, and pupils' background and ability as covariates. In order to analyze the qualitative data, we will use the method of thick descriptions.

Table 2: Data Pilot 2 Frequency 1550

	Before intervention	During intervention	Immediately after intervention	After 1 week	After 2 months
Pupil background (sex, age, ethnicity)	administration				
Motivation for the subject History	test		evaluation meetings	test	test
Ability (credits in History)	administration				
Knowledge on medieval Amsterdam		learning products and track & tracing from the game	evaluation meetings	test and essay	test and essay
Attitude towards collaborative learning	test		evaluation meetings	test	test
Learning activities		logbooks, observations and track & tracing from the game	evaluation meetings		

6.2 Preliminary results

The pilot was finished in June 2007. Most data have not been analyzed yet. In this paper, we will report the preliminary results, which are based on the analysis of the evaluation meetings, our observations during the weeks the game was played and partly on logs from the computer and student essays.

In the evaluation meetings, all guides (of both the city teams and the teams at the Headquarters) were interviewed in order to get insights into their perception of the process of learning and gaming, possible learning effects, pupils' motivation, and their collaborative activities during performing Frequency 1550. Each of these 10 group interviews was held immediately after playing the game at the end of the day.

6.2.1 Practicalities

Technical problems occurred during the first three days of Frequency 1550 and diminished afterwards, though sometimes it got a little bit worse again. The main technical problems were related to the connection between the pupils walking in the city and the pupils at the HQ. Firstly, the GPS did not send the correct information (if at all) and, therefore, the pupils at HQ could not see where the city teams were located. This caused a lot of additional communication by phone in order to navigate the city teams to the correct position in the city. Secondly, the videophone of the city teams sometimes lost connection which meant that it had to be restarted, which took some 10 minutes. Thirdly, sending videoclips and pictures sometimes took a long time, which caused that pupils at the HQ as well as in the city had to wait for some time. They had to wait before they were able to continue, because the next assignment would not appear until the videoclip or picture had been received.

The level of assignments and the diversity of the pupil sample did not completely match. The pupils (all age 13 or 14 years) of secondary school for pre-university education were able to complete the assignments on their own, whereas pupils from vocational secondary education needed both technical and instructional support from their teacher or guide. The difference also be noticed in the amount of assignments pupils finish and their scores. The lowest scores (earned days of Burghership) of the pupils of the secondary school for pre-university education were not much lower than the highscores of pupils from vocational secondary education. Though points do not reveal everything about completing assignments, because they can also be earned by confrontations, for the most part the amount of points seems to be quite representative for the amount of finished assignments. The pupils of the secondary school for pre-university education finished on average more sectors than the pupils from vocational secondary education. Most pupils finished their assignments in one out of the six sectors or even none. Two completely finished sectors was the maximum pupils achieved. This doesn't mean they only made assignments in two sectors, but that they didn't finish the other sector(s). The fact that no pupil finished all six sectors meant that their knowledge about the other sectors was based on the presentations of their peers during the plenary session at the end of each day. For all pupils, reading the assignments on the videophone took a lot of time (small screen, much sunlight), as well as walking towards the place where the assignment would appear.

The use of medieval rats (virtual bombs that cut off connection) and magic mantles (which make a team invisible for other teams) in combination with the medieval status of the city teams has been evaluated as improvement compared to the first pilot. Pupils were more focused on completing the assignments and paid less attention to competing with their peer teams. An additional improvement could be made with the use of rats. Now, teams who received a rat could not do anything for 10 minutes. It would be better to reduce the total number of points instead of losing off the connection for 10 minutes.

6.2.2 Engagement in learning

In general, pupils were very enthusiastic about the game, both at the Headquarters and in the city. Although there were technical problems with the connections between the city teams and the pupils at the HQ, most pupils were engaged to complete the assignments, being on-task most of the day. At the HQ almost all classes were on-task most of the day, with the exception of one day when a few pupils started to watch YouTube-videos and the other pupils followed. The city teams had more problems staying on-task in case of technical problems. Whereas HQ was able to watch the other

teams or try to find some information on the internet, the city teams could usually only wait for the technical problem to be solved.

Pupils reported at the end of the day and in their essays (which they frequently used as an evaluation of the game) that they liked HQ (even) more than walking in the city. This was contrary to what we first expected, but during the pilot we saw that HQ pupils were more in control in different ways: they had a better overview of the game, they were guiding the city teams and they had more to do in case of technical difficulties.

As the data is not fully analysed yet, we do not know yet whether the student's motivation towards history has changed by playing the game.

6.2.3 History knowledge

Pupils got a knowledge test about Medieval Amsterdam. We have not analyzed these tests yet. What we do know is that some pupils wrote in their essay that they had learned a lot and others wrote that they didn't learn much. The essays strongly differ in both quantity and quality of what pupils write about Medieval Amsterdam.

The guides reported that they are not sure about how much history knowledge the pupils acquired, though often small successes could be pointed out (e.g., pupils realizing that not every tower is a church). Also the guides are more positive about the learning of the pupils of secondary schools for pre-university education than of the pupils coming from vocational secondary education.

6.2.4 Collaborative skills

Both teachers and guides report that pupils learn to navigate throughout the city and that they learn to collaborate at a distance with their peers. The collaborative activities include communication and interaction with their peers in a team as well as work collaboratively on the team assignments. The pupils needed to imagine oneself in the position of the other. For example pointing out that your standing in front of a big white building does not help the peers at HQ much in finding out where you are. And if pupils from HQ tell the city team to walk up (in cases that the assignment is above the place on the map where the city team is), this does not work either.

Overall we can say that compared to the regular classes, pupils playing Frequency 1550 were highly motivated and engaged. In the conference presentation, we present in more detail the effects on motivation, historical knowledge, and attitude towards collaborative learning.

7. Conclusion and Discussion

One of the conclusions is that pupils are motivated and actively engaged in playing and learning in Frequency 1550. For the game to yield more learning effects it needs some amendments. A few examples of what should be changed are:
- the technique should be improved (less technical difficulties);
- the screen of the gamephone should be better visible;
- assignments should better fit the pupils level, and
- the use of rats should be changed into something less demotivating than loss of connection.

During the research a lot of things went another way than planned. The game has only been tested with a paper version, because the technical part of the game was not finished yet. This also resulted in a lot of technical problems on the first day. The game had already been delayed because of technical and organizational problems, which diminished the motivation of the teachers in the pilot.
We weren't able to gather all the data we planned. In some classes one of the tests have not been administered. Partly because teachers couldn't fit it in anymore (because of the delay post-tests were administered close to summer vacation) and partly because the fact that post-test en pre-test were exactly the same and teachers decided not give the pupils the test twice. Apparently, it was not communicated clearly enough that it was essential for both tests to be done though they were the same.

In conclusion we think this mobile city game has good potential to support Gee's game-based learning as described in the introduction. Especially 'empowerment of learners' seems to have possibilities to be related to a game like Frequency 1550.

It is good to realize that learning together, working together and collaborative learning in education sometimes require a lot of effort and yields not much at first. Or as Chancellor of Germany Merkel said at the EU-summit in June 2007 (after an African saying): "Who wants to go fast, goes by himself; who wants to go far, goes together".

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