# A Pervasive Game to Know Your City Better

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*Abstract*— **This paper presents a pervasive game on Android platform where players can play a knowledge competition tour in groups in the city of Trondheim, and gain better understanding of the city through solving different tasks. From the evaluation, the result shows that the concept of using pervasive game in a learning context is an interesting concept that should be explored.**

## I. INTRODUCTION

During recent years, there is a growing trend that can be referred to as pervasive and social games, which brings more physical movement and social interactions into game world [1]. Concretely, smart phones with Internet, GPS and other capabilities have become increasingly common, making mobile phone-based pervasive games easy to play and more interesting. Inspired by the game-based learning [2], one possible research area is to provide learning platform through pervasive games. In this context, we have a tentative case study to explain how learning is perceived and integrated in pervasive game.

There are two main inspirations for this case study: one is about the game plot, and another is about the new and interesting applications of mobile technology. The first is the American television series "The Amazing Race" (http://en.wikipedia.org/wiki/The_Amazing_Race), a reality show where contestants compete to be the first to reach different checkpoints all over the world. Similarity, the other two are: 1) a treasure hunt called "The Game" (http://en.wikipedia.org/wiki/The_Game_(treasure_hunt)), *Shelby Logan's Run* is the 2002 edition of "The Game", a Seattle-based yearly puzzle hunt. 2) A pervasive learning space called *Heroes of Koskenniska* [3], it combined mobile and sensor technologies with environmental education. Another motivation is popularity of Android platform and its applications. Its features can meet our requirements in different technology demanding scenarios in our case study. By getting contestants to travel to several different locations, we can thoroughly put the GPS-unit, Wi-Fi or 3G into work. In addition, recent interesting applications based on the camera, microphone and headphone from Android Market provide a multitude of other technologies that can be integrated in a pervasive game. For instance, 1) QR code and barcode can be scanned through phone's camera, and we can use barcode generator to output clues for game tasks. 2) Google Goggles (http://www.google.com/mobile/goggles) is a free image recognition application. It enables the player to use pictures taken from the mobile phone to search on web resource; these pictures could come from text, landmarks, books, contact information, artwork, wine, or logo. 3) Layar (http://www.layar.com/) is a mobile platform for discovering information about the world around us by using augmented reality technology, 4) Shazam (http://www.shazam.com/) is an application for recognizing songs that are playing, the application listens to music snippets through the microphone, and search the songs information. 5) ShopSavvy (http://shopsavvy.mobi/) is an extensive application from barcode category to scan the information of products using the camera of the mobile phone. After reading the barcode, the application will identify the product information and provide a list of online and local prices for it. In this context we introduced Trondheim city through a knowledge race called "The Amazing City Game" (ACG). The game is an adventure game where the contestants have to solve tasks at different locations by using relevant technologies from the Android phone. The group that reaches the final destination in the least amount of time is the winner.

## II. DESIGN AND IMPLEMENTATION

The game has three main goals: 1) to integrate ubiquitous technologies from the Android platform in games, 2) to give the contestant knowledge about the city of Trondheim, and 3) to let the contestants have fun while playing the game.

Based on the above goals, we have constructed the following types of tasks for ACG. Each task may have 1-3 hints. If player uses a hint, a responding penalty time will be counted in the final score.

### *A. Tasks Design*

*Location Task*: The player has to find a specific location and confirm it with the use of the GPS.

*Scan Task*: The player has to scan a barcode, text, figures or audio in order to get assigned a route or answer.

*Open Task*: The player is given a question and has to type answer into the answer text box.

*Multiple Choice Tasks*: The player is given a question and has to select the right answer out of the possible solutions.

*Checkbox Task*: The player is given a question and has to select the right answer out of the possible choices, where multiple answers might be correct.

Further, some tasks are combinations of above two or three types of tasks. E.g. Shazam Challenge: The player is given a question and has to type answer into the answer text box. The difference between this task and the Open Task is that the player is given an audio clue in the task description, and can be recognized by Shazam. Shopsavvy Challenge: The player is given a series of multiple-choice questions. The difference from other tasks is that the alternatives for each question are printed as barcode on a sheet of paper at the location, where each corresponding answer is next to a commercial product

picture that can be found by scanning the barcode. By taking the first letter of the each product name and grouped letters in correct order to be a word, and then they will give this word that is typed into a text box and get relevant information about the city.

For the final game play, one task is to know the city flag and city flower. Players will find the left picture from Figure 1, and they can open the Goggles application from the phone to scan this figure and search and find the web resource link. The correct link information shows that the figure is the city flag. If they read the information carefully, they will know the flower in the flag is *rosa canina*. Another task example related to the right side of Figure 1 is that audio will be broadcast and searched by Shazam and get the songs information and find famous musical writer from the city. To all tasks, another possible solution is that they can ask local passengers for help or search information from city library.


Figure 1: Trondheim flag (left) and Shazam (right)

### B. User Interface

The user interface is clean and simple. Figure 2 shows examples of the interface: left top is the "Wrong Answer" pop up on a single choice task; right top is the Confirmation Box after choosing the answer. Left bottom is the GPS task interface and right bottom is the Shazam task.

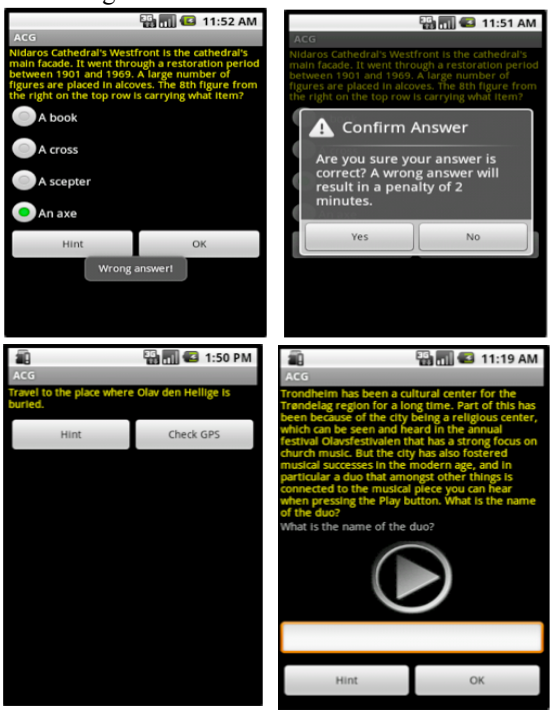


Figure 2: ACG user interface

## III. Results

### A. Participants and Execution

The contestants were students with computer science background. There were four groups with two students in each group, totally eight students. Four of them were Norwegian, two were Spanish, one was Chinese and the one was Lithuanian. Each group had one Android phone with ACG installed. The game play was set from 1:15pm to 4:15pm on 3rd of May, and took place in Trondheim city of Norway. All groups started at meeting point. When all groups were ready, a brief introduction was given, and the first location disclosed. Immediately after this, everyone raced off to this location.

Upon arriving at the location, each group received different routes according to their arrival time. The groups started solving the tasks, and observed and recorded closely by the tutors. When the task at first location was finished, the groups continued with unique routes. From this point, each group was alone with their tutor for the rest of the game play (Tutor followed the group and recorded the video about the group's activity for the later observation). To the left in Figure 3 is a group is using the camera of an Android phone to scan a barcode. To the right a group is asking for help from a person working in a Tourist Information Center.

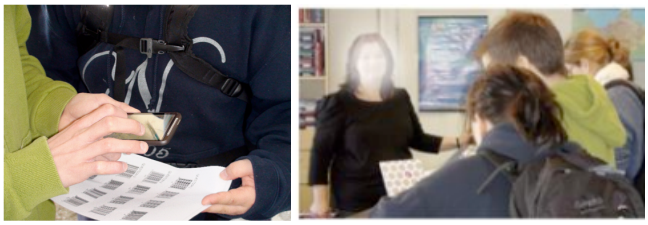

Figure 3: ACG play process

### B. Results

Most of the groups spent 2-3 hours in the city tour game. From several observations, the GPS accuracy did not reach participants' expectation. Also the participants' background was not at the same level for the competition: E.g. some tasks were difficult for the foreigners since they did not have relevant culture background, while other participants were unfamiliar with the android applications. Overall, participants thought the tasks were a bit challenge but interesting. They claimed to have gained a better understanding of the city and more interested in android technology.

## IV. Survey and Evaluation

A survey was conducted to evaluate our game system. The survey includes two parts: 1) System usability, and 2) Enjoyment of an educational game.

The System Usability Scale (SUS) [4] has previously been used to evaluate the usability of games, e.g. [5-7]. SUS is a generic questionnaire with 10 questions for a simple indication of the system usability as a number on a scale from 0 to 100 points. Each question has a scale position from 1 to 5. For items 1,3,5,7 and 9, the score contribution is given by subtracting 1 from the scale position. For item 2,4,6,8 and 10,

the contribution is 5 minus the scale position. This implies that each question has a SUS contribution of 0-4 points. Finally, the sum of the scores are multiplied by 2,5 and divided by the number of replies to obtain the SUS score.

We used the EGameFlow scale to measure the enjoyment of our educational game [8]. It is a scale that measures the enjoyment offered by E-learning games, and helps the game designer to understand the strengths and weaknesses of the game efficiently from the learner's point of view. EGameFlow consists of a number of questions in eight areas. The eight areas of EGameFlow are:

- *Concentration*: Games must provide activities that encourage the player's concentration while minimizing stress.
- *Goal Clarity*: Tasks should be clearly explained from the beginning.
- *Feedback*: Feedback allows a player to determine the gap between the current stage of knowledge and the knowledge required for completion of the task.
- *Challenge*: The game should offer challenges that fit the player's skill level, the difficulty of these challenges should change in accordance with the increase in the player's skill level.
- *Autonomy*: The learner should enjoy taking the initiative in game-playing and asserting total control over his or her choices in the game.
- *Immersion*: The game should lead the player into a state of immersion.
- *Social Interaction*: Tasks in the game should become a mean for players to interact socially.
- *Knowledge Improvement*: The game should increase the player's level of knowledge and skills while meeting the goals of the curriculum.

To answer the questions or statements in each area, the respondents have to express their degree of agreement or disagreement. Each item in the questionnaire is responded to by assigning a scale value from 1 to 7, where 1 indicates strong disagreement and 7 indicates strong agreement.

### A. The results from the SUS survey

The number of survey respondents was eight. This gives us a small sample size, and thus the results are seen as useful indications rather than definite results.

TABLE 1 SUS SCORE FOR AMAZING CITY GAME

| ID | Question | Avr | Score |
|---|---|---|---|
| 1 | I think that I would like to use this system frequently | 2.63 | 1.63 |
| 2 | I found the system unnecessarily complex | 2.13 | 2.88 |
| 3 | I thought the system was easy to use | 3.88 | 2.88 |
| 4 | I think that I would need support of a technical person to be able to use this system | 2.13 | 2.88 |
| 5 | I found the various functions in this system were well integrated | 3.38 | 2.38 |
| 6 | I thought there was too much inconsistency in this system | 2.13 | 2.88 |
| 7 | I would imagine that most people would learn to use this system very quickly | 3.88 | 2.88 |
| 8 | I found the system very cumbersome to use | 2.00 | 3.00 |
| 9 | I felt very confident using the system | 3.75 | 2.75 |
| 10 | I needed to learn a lot of things before I could get going with this system | 1.75 | 3.25 |
| -- | **SUS score** | | **68.44** |

Six of the respondents were students from computer science. All of the respondents therefore have a high technical competence. The SUS score for our game was 68.44, which is a bit below the mean score of 70.14 taken from 2324 surveys of other systems [9]. For a game, this score is a bit low meaning that the user-interface of the game was a bit difficult to use. In the debrief of the participants several challenging areas of the usability were identified. First of all, the participants were not sure about the overall goal of the game through the introduction and how the game should be used. Further, the users had to switch between several applications in order to solve the challenges (QR bar code scanner, Googles, Layer, Shazam, and ShopSavvy). The ACG application was open-ended and it was left very much in the hand of the user how it should be used. This made it a bit difficult for the players what to do next. An identified improvement would have been to integrate all the needed extra applications into ACG to avoid switching between applications. We also noticed that users with prior Android experience had far less usability problems compared to those unknown to Android. Our SUS score suffers also from users that both had to learn the application as well as Android.

### B. EGameflow survey

Table 2 shows a comparison of the ACG EGameFlow results compared to four other games found in [8].

TABLE 2 EGAMEFLOW GAMES VS. AMAZING CITY GAME

| Category | Game1 | Game2 | Game3 | Game4 | ACG |
|---|---|---|---|---|---|
| Concentration | 5.118 | 5.225 | 5.214 | 5.153 | 5.22 |
| Goal Clarity | 4.180 | 5.360 | 5.048 | 5.306 | 5.03 |
| Feedback | 4.890 | 4.950 | 5.230 | 5.149 | 6.22 |
| Challenge | 4.654 | 4.880 | 5.019 | 4.764 | 4.22 |
| Autonomy | 4.686 | 4.880 | 5.019 | 4.764 | 4.38 |
| Immersion | 4.686 | 4.378 | 4.651 | 4.265 | 5.44 |
| Social Interaction | 3.163 | 3.250 | 3.365 | 2.826 | 5.38 |
| Knowledge Improvement | 4.985 | 5.420 | 5.171 | 5.055 | 5.21 |

Table 3 shows detailed feedback for each area:

TABLE 3 EGAMEFLOW SCALE FOR AMAZING CITY GAME

| Concentration | Mean |
|---|---|
| Most of the gaming activities are related to the learning task | 5.13 |
| Generally speaking, I can remain concentrated in the game | 5 |
| I am not distracted from tasks that the player should concentrate on | 5.13 |
| Workload in the game is adequate | 5.63 |
| **Average** | **5.22** |
| **Goal Clarity** | **Mean** |
| Overall game goals were presented in the beginning of the game | 4.13 |
| Overall game goals were presented clearly | 4.63 |
| Intermediate goals were presented in the beginning of each scene | 5.75 |

| | |
|---|---|
| Intermediate goals were presented clearly | 5.63 |
| **Average** | **5.03** |
| **Feedback** | **Mean** |
| I receive feedback on my progress in the game | 5.75 |
| I receive immediate feedback on my actions | 6 |
| I am notified of new tasks immediately | 6.63 |
| I receive information on my success (or failure) of intermediate goals immediately | 6.5 |
| **Average** | **6.22** |
| **Challenge:** | **Mean** |
| The game provides ”hints” in text that help me overcome the challenges | 5.38 |
| The game provides video or audio auxiliaries that help me overcome the challenges | 4.13 |
| The game provides new challenge with an appropriate pacing | 5 |
| The game provides different levels of challenges that is tailored to different players | 2.38 |
| **Average** | **4.22** |
| **Autonomy:** | **Mean** |
| I feel a sense of control and impact over the game | 4.25 |
| I know the next step in the game | 4.5 |
| **Average** | 4.38 |
| **Immersion** | **Mean** |
| I forget about time passing while playing the game | 5.88 |
| I become unaware of my surroundings while playing the game | 4.63 |
| I temporarily forget worries about everyday life while playing the game | 5.13 |
| I experience an altered sense of time | 5.25 |
| I can become involved in the game | 5.88 |
| I feel emotionally involved in the game | 5.88 |
| **Average** | **5.44** |
| **Social Interaction** | **Mean** |
| I feel cooperative toward other classmates | 5.38 |
| I strongly collaborate with other classmates | 5.13 |
| The cooperation in the game is helpful to the learning | 5.63 |
| **Average** | **5.38** |
| **Knowledge Improvement** | **Mean** |
| The game increases my knowledge | 5.5 |
| I catch the basic ideas of the knowledge taught | 5.38 |
| I want to know more about the knowledge taught | 4.75 |
| **Average** | **5.21** |

Basically, from the survey, we found this pervasive educational game have high quality in feedback, immersion, social interaction since their average score is much higher than the other games' score shown in Table 2. It indicates that advantage to implant pervasive elements into an educational game. Although we can not make it as a general conclusion due to the limitation of total amount of participants, our results shows that the idea of using pervasive game in a learning context is an interesting concept that should be explored.

For the *concentration* and *knowledge improvement*, the score is similar to the other games' score shown in Table 2. But if we look further in Table 3 for knowledge improvement area, we get high marks on first two items: *game increases participant knowledge* and let them *catch the basic knowledge*. For the third item, it seems that this *game's motivation* is not as strong as we thought.

The rest of Goal clarity, *challenge* and *autonomy* are a bit lower score that the other games' score shown in Table 2. For the Goal clarity, we found intermediate goals are clear in Table 3, but *overall goal* is not clearly present. We thought that lack of detailed instruction in the beginning of game maybe the reason. For the Challenge area, two groups meet troubles in the *video and auxiliaries* maybe cause a low score in second item. For fourth item, it reminds us that more *resources and plots* should be input to create challenges to match different levels. For Autonomy area, it indicates that autonomy of the game could be improved to let participant to feel freer to control the game. For the second item, the participants are not supposed to know the next step of the game until they have arrived at it. Although, this item has a low score, it is exactly a positive feedback from our aspect.

## V. CONCLUSION

From our experiences we acknowledge that pervasive games for learning purposes need more exploration. Our study shows that pervasive educational games could be an informal learning environment and could be an interesting supplement to the formal and traditional education.

## ACKNOWLEDGMENT

We thank Runar Os Mathisen, Lawrence Alexander Valtola, Sondre Wigmostad Bjerkhaug and Trygve Bragstad for providing content and implementing the prototype of the amazing city game.

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