Where is the answer? – The importance of curiosity in pervasive mobile games

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ABSTRACT

Today games are increasingly recognized not only for their entertainment value, but also for their positive impact on social interaction, educational potential, technical interests, publicity and economical power. A new game genre of pervasive games extends a virtual game world into the real world environment, allowing players to move seamlessly from one to the other. Our research is focused on identifying the elements that are important in a pervasive playful application that can trigger the interest of different individuals towards the reflection and understanding of the knowledge surrounding them. Our findings suggest that stimulating the curiosity of players is one of these key elements, and that it should be considered in the design of serious mobile games with pervasive characteristics, while looking to enrich the informal learning. In addition, mobile phones are well accepted as play tools. These results are based on the feedback given by 45 players of our game entitled SciMyst, which is a mobile adventure game with pervasive and multiplayer characteristics. The player has to solve different types of enigmas, which are based on the information from the real world. The player is required to become familiar with the surroundings in order to succeed, and at the same time s/he is learning from the environment in a playful manner. The game was in action and the data collection took place during SciFest 2007, a science festival in Joensuu, Finland, in March 2007.

Categories and Subject Descriptors

H.5.2 [Information Interfaces and Presentation]: User Interfaces.

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General Terms
Design, Experimentation, Human Factors.

Keywords
pervasive games, pervasive learning, environment and player, playful learning, mobile games, mobile learning.

1. INTRODUCTION

Games can be designed and used for a wide range of purposes: for individual entertainment [8], as a catalyst of social interaction [12], for teaching-learning [1], as an experimental platform for new technologies and design concepts [4], and as a publicity campaign, to name but a few. In addition, games present a wide range of genres, independently of their digital or non digital nature.

The actual taxonomies for games depend on the parties who define them, e.g. game designers or educational scientists. In the information society era the ongoing debate and tension between instructional designers and game designers makes the development of digital instructional games, or serious games, a difficult task [2].

One interesting intersection where the instructional designers and game designers might be able to join efforts easily is with the use of mobile and ubiquitous technologies. This is due to the fact that for both disciplines the use and experiences of this type of technologies is new. From these technological trends and from the expansive world of games, we can find a relatively "new" game experience: pervasive gaming. According to IPerG [9] pervasive games are “a radically new game form that extends gaming experiences out into the physical world". At the same time there is an open invitation by Helms [7] and de Souza e Silva [6] on how to work with knowledge and learning in pervasive environments, making use of the possibility “to look at familiar spaces from unfamiliar perspectives and at content learned in classroom from different point of view”.

Inspired by the concept of pervasive gaming, merged with the idea to engage players into scientific or cultural expositions, and with the main goal to trigger their interest and to make use of the informal learning, we ventured ourselves in the creation of a mobile game with pervasive characteristics: SciMyst. In SciMyst
the player explores the physical environment in order to solve different types of problems. Moreover, the reason for combining these ideas in the design of the game, is the need to seek an answer to the following question: how can one trigger the interest of different individuals of different ages towards the reflection and understanding of the knowledge surrounding them, and to encourage them to collaborate with each other in the process? In this paper we explain the concepts and development of SciMyst, a mobile game with pervasive and multiplayer characteristics. We start by presenting the fundamentals of this type of games and our motivation for it. Next comes an explanation of the SciMyst features followed by the game description. We continue by presenting the main technical concepts and the game definitions, followed by the research methodology description and research findings. Finally, we wrap up the study with discussion and conclusions.

2. RELATED WORK AND MOTIVATION

The terms we use affect our attitude towards all activities and things. Before developing any application or tool, we should grasp and understand the basic idea of what we want to develop and define the terms we use to describe it with. In case of creating an educational game, instructional game, or serious game, as it is nowadays referred to, we understand the creation process by using the terminology analysis made by Resnick [14]. In his work, he explains clearly the dichotomy of games and learning. According to his own words: “[i]n fact, you are likely to learn the most, and enjoy the most, if you are engaged as an active participant, not a passive recipient. The terms play and learning (things that you do) offer a different perspective from entertainment and education (things that others provide for you)”. Therefore, understanding how we refer to things impacts the way we develop and use them. Consequently, it is in our best interest to focus on the things we do: playing and learning.

We sought a solution to the challenge to involve the richness of the knowledge that our surroundings offer us for learning in a playful manner. As a result, we found Siobhán's [13, 19] definition of pervasive learning. He mentions that “[p]ervasive learning is a social process that connects learners to communities of devices, people, and situations so that learners can construct relevant and meaningful learning experiences, that they author themselves, in locations and at times that they find meaningful and relevant.” In order to create playful learning concepts involving the environment, we must explore pervasive learning as well, which in turn can be related with pervasive gaming experiences.

At the time when we were making this concept analysis, the SciFest 2007 science festival [17] coordinated by University of Joensuu was in its organisational phase. Therefore, we decided to explore this type of pervasive gaming concept within the festival arena. The main idea was to offer an application that would trigger the interest of the participants, at any time and for any individual, towards the exhibitions and workshops at SciFest. Based on this idea we created a multiplayer mobile game with pervasive characteristics, keeping in mind learning as part of it. This was done by compelling the immersion of the players in the different stands and their content in a playful learning manner. The game was entitled SciMyst [18].

Our theoretical foundations and inspirational elements were provided by diverse studies conducted on this topic. For example, we used the outlined principles that Brodbeck [3] suggests from experimental psychology: acquisition, asymptote, extinction and spontaneous recovery in order to maintain an adequate learning curve and flow in the game.

The development most similar to our application that we found is the German game REXplorer [20]. It is a pervasive mobile game for tourists to explore the culture and history of Regensburg, Germany. The main differences between REXplorer and SciMyst are the target group and the way to interact with the environment. For REXplorer the target group is young adults between 13 and 30, while SciMyst is targeted to virtually any ages. The audio guide that is triggered in the gameplay of REXplorer does not depend of the location of the player nor of his/her interaction with the environment. This in comparison within SciMyst, where within the gameplay, a dependency exists and, in specific moments, interaction with the environment is needed in order to continue playing. Furthermore, REXplorer has been strictly defined to be used as a game for tourists at certain locations only, while SciMyst can be used practically anywhere.

3. SCIMYST CONCEPT

The main goal of the game design was to bring together the technology, people, playing, learning and the environment (see Figure 1). These elements are described briefly in this section.

![Figure 1. Graphical representation of the main concepts of SciMyst](image)

- Technology (simple tools). In this case our focus is on mobile phones, which are devices that almost anyone can own, and everybody can use. By its nature a phone can be considered a social instrument, in that it is used mainly for communication. Additionally, many mobile phones nowadays present multimedia capabilities such as cameras that can be exploited for creative purposes.

- Playing. Our aim is that anyone can play the game and enjoy it, from youngsters to elders. The only requirement for playing is that the player is willing to use a mobile phone and to move around in the physical playing area looking for answers to presented problems. We seek to support an individual flow of game experience for different types of players by granting them control of the game progression. However, limitations can be set.
on the length of the game to assure that the same players will not be occupying the game for the entire day and that the players will not get frustrated by the sheer size of the game. Furthermore, the amount of content created for the game effectively limits the maximum length of the game.

- People. We wanted to enhance social interaction between the players by introducing a collaborative feature in the game. If a player is stuck with some game task, s/he can request help from another player. The decision to contact someone else or to help another player depends on the player her/himself. If the other player accepts the help request, both players are directed to a physical meeting point where the actual collaboration to resolve the enigma initiates. A player who successfully helps another player to solve an enigma (i.e. a question or task to be solved) is rewarded with special helping points which are added to the total score. In addition to this social interaction between players, the game encourages the player to talk with the expositors to get information either for resolving a question or because s/he got interested in the exposition content.

- Environment. The game uses the information of the real environment in a playful manner to trigger players' interest on the subject. Every part of the game is intrinsically embedded in the environment. In this way, the game creates a bridge between the virtual world and the real world.

3.1 In-game definitions
This section describes the enigma types, the game modes and the help. We consider these elements crucial for SciMyst.

Enigma Types
As mentioned previously, enigmas are questions or tasks to be solved during the game. The concept of the game presents three types of enigmas: multiple choice, take-a-picture and find-a-picture. These enigmas are briefly described in Table 1. Nevertheless, due to the nature of the SciFest event, we only tested Multiple choice and Take-a-picture enigma types. The reason for this is that the festival was set up just some hours before the opening of the event. This increased the challenge for the creation of the content. However, find-a-picture enigmas would be possible to use in locations such as museums or galleries where the content is in place for a longer period of time.

Game Modes
SciMyst presented two game modes: casual and battle mode.

- Casual mode. The objective of this mode is to explore and enjoy the environment in a free and relaxed manner. There is no time pressure for resolving the enigmas. Correct answers to enigmas yield an enigma-specific amount of points, and the penalty of a wrong answer is that the next time the player tries to resolve the same enigma again, there will be less points available. The help features of the game are available in this mode. Additionally, the player can relocate her/himself to any other area at any moment.

- Battle mode. The battle mode consists of a set of random enigmas and a timer; the more enigmas the player solves in a fixed amount of time the more points s/he earns. Wrong answers diminish the score. After the battle is over, the game ends and the final score is recorded in the Hall of Fame. The help feature is not available in this mode. The battle has the function similar to the final opponent (i.e. the big boss) or the final challenge in many video games.

<table>
<thead>
<tr>
<th>Table 1. Enigma descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Enigma Type</strong></td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>Multiple choice</td>
</tr>
<tr>
<td>Take a picture</td>
</tr>
<tr>
<td>Find a picture</td>
</tr>
</tbody>
</table>

Help
According to diverse experts [1,15] help and feedback are important elements that should always be present in playing and in learning. In the case of SciMyst, we paid special attention to these elements.

With the help feature we specifically looked to offer the players the tools to facilitate the game play. The help consists of the game instructions, controls of the game, map of the environment, and collaborative help. In pervasive games like SciMyst, collaborative help presents a social interaction channel. When a player contacts another one via collaborative help feature to request her/him to assist resolving a specific enigma, both players are guided to meet each other physically in an agreed meeting point. This specific location is shown to players before they start to play. When a
player accepts a collaborative help request, s/he is rewarded with a predetermined amount of points when the enigma in question is solved correctly. Once the players meet each other, they can decide whether to start playing together or continue playing separately.

3.2 Game setting description
The game was running constantly at the SciFest 2007 science festival organised by the University of Joensuu, Finland. The physical area consisted of 14,600 m² floor space and its floor plan is shown in Figure 2. For the game purposes the area was divided into four sub areas by colour code: red, violet, green and yellow.

There were eight Nokia N80 mobile phones available for the game play. These phones were loaned to anyone who wanted to play the game, if her/his phone did not meet the technical requirements of SciMyst. The phones were equipped with 3 megapixel camera, WLAN connection, Java support, screen size of 352x416 pixels and 18 MB RAM memory.

Once the player had a phone that supported the SciMyst application a short introduction to the game was given to her/him. This was done to ensure that the player understood the concept. After the introduction s/he was on her/his own to start to play the game.

The game began in casual mode and the game play consisted of two main activities: changing areas and solving enigmas at current area. There was no restriction for changing the area constantly, but after changing an area at least one enigma had to be answered, if there were unanswered enigmas in that area. When the player had solved at least two enigmas of each area s/he was given the permission to enter the battle mode. After finishing the battle mode, the game ended and told the player to return the device back to the stand where the game had started. After returning the device, the player was given a questionnaire to fill in.

3.3 Technical Features
SciMyst was designed so that it can be adapted easily to any setting (museum, building, expo, or outdoors). However, the main limitation of the game space is the connectivity of the mobile phones. At this moment the game has been designed to run inside a WLAN. This design decision was made in order to avoid the costs of mobile data when connections of mobile operators are used. The usage of WLAN might bring challenges of the connectivity, if the network is not well planned and implemented (i.e. is not accessible everywhere in the game area). Theoretically, the game works smoothly in any high bandwidth mobile network such as 3G.

As taking pictures is one activity in the game, we use the Semacode library [16] to provide two-dimensional bar codes (i.e. tags, see Figure 3). Each bar code represents a tag string and a picture taken from the bar code can be decoded in order to discover the corresponding tag string. Bar codes are used in the game to relocate a player or to tag potential answers for take-a-photo enigmas. The reason of using tags is because automatic decoding of tags is more feasible than identifying real objects from photographs.

A simple, attractive and intuitive user interface (UI) is fundamental for SciMyst design, and is intimately related to the game concept. As in any software or device meant to be used by a human, the design decisions in the UI greatly affect the usability of the system. In order to make the UI intuitive and attractive, we used short texts, icons, high contrast colour scheme and minimised the number of keys used for controlling the game.

As we recognised the importance of properly created and authored content for a successful game experience and learning, the game content was created in collaboration with the content matter experts. This made the content relevant and interesting both from the players' and the exhibitors' points of view.

![Figure 2. Floorplan of the SciFest 2007 arena](image)

![Figure 3. 2D bar codes: a player is relocating herself](image)

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had played a pervasive game before. The language used was mainly English. However, on the last day of SciFest the game content was also introduced in Finnish.

The research consisted of two parts: observation and questionnaire. In the observation part the subjects were approached one by one and they were offered to play the game. The researchers monitored the subjects' actions. The subjects were aware that they were being monitored. After the subjects finished playing, they were asked to fill in the questionnaire.

During the observation the researchers monitored the users' reactions to the game, paying special attention to (1) the total playing time per player; (2) if the players ever got "stuck" with the program; (3) players' movements along the exposition; (4) the players' general reactions to the game.

The questionnaire consisted of nine questions in four sections. In section I, the focus was to detect which element was the most important reason for the subjects to finish the game. The questions were based on the elements suggested by Malone's [10] research outcomes (challenge, fantasy and curiosity). We added the fourth element, personal control, to discover how important having a control over the game was for the player. Section II focused on what the players learnt indirectly from the festival through the game. Section III sought to measure the game experience and the players' age or gender and their behaviour were not perceived. We observed that towards the end of the game the subjects began to resolve the questions faster and with more confidence, moving smoothly around the game area, as they began to see to which concepts they should pay attention. We also noticed that adult players in particular stopped occasionally to observe a stand or to talk with another person, thus leaving the game waiting. After a while these players resumed the game.

It was interesting to notice that children often teamed up with their parents to solve enigmas. Both parents and children seemed to enjoy the game; the children were primarily in control but they asked help from their parents if they met a challenge. Another observation was that a group of friends often shared a phone to play together as a team. In addition, we could witness another kind of team play when two girls, both having their own mobile device to play with, started playing together despite the different sets of enigmas. These girls seemed to know each other before the game play. Even though the game offered a multiplayer feature as a form of help requesting, it was not used. This was probably due to the fact that the feature was placed in the help menu of the program, thus being hidden from normal game play.

5.2 Questionnaire

The purpose of section I in the questionnaire was to identify which element was the major reason for the players to finish the game. The results are shown in Table 2. For each question, the player should select one option between Strongly Agree (SA), Agree (A), Disagree (D), Strongly Disagree (SD). The option of no answer (NA) was not given to the player. However, for the visualization of the information it was added to the table.

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<td>35</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>I wanted to win</td>
<td>4</td>
<td>20</td>
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</tr>
<tr>
<td>I wanted to be in charge of what was happening</td>
<td>4</td>
<td>23</td>
<td>12</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>I like to pretend that I was and “agent”</td>
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<td>15</td>
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Graphical representation of the results to the section I is shown in Figure 4.

5.1 Observations

We noticed that the players' pace and concentration differed significantly. However, specific connections to players' age or gender and their behaviour were not perceived. We observed that the end of the game the subjects began to resolve the questions faster and with more confidence, moving smoothly around the game area, as they began to see to which concepts they should pay attention. We also noticed that adult players in particular stopped occasionally to observe a stand or to talk with

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Table 3. Results of the questionnaire section IV

<table>
<thead>
<tr>
<th>Question</th>
<th>SA</th>
<th>A</th>
<th>D</th>
<th>SD</th>
<th>NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>It was easy to use the phone as a tool for playing</td>
<td>15</td>
<td>18</td>
<td>8</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>The icons were easy to understand</td>
<td>15</td>
<td>25</td>
<td>1</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>It was fun to play with the phone</td>
<td>17</td>
<td>25</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

![Figure 5. Technology feedback](image)

The last question of the section IV was an open question: what were your major problems with the phone? From the gathered information, we distinguished patterns according to similarities and differences of the answers [5]. Based on the patterns, we categorised the problems, as shown in Table 4.

Table 4. Major problems with mobile phone

<table>
<thead>
<tr>
<th>Problem</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow response</td>
<td>7</td>
</tr>
<tr>
<td>Connectivity problems (network)</td>
<td>9</td>
</tr>
<tr>
<td>Problem taking the photos</td>
<td>15</td>
</tr>
<tr>
<td>Keyboard (the physical keyboard of the phone)</td>
<td>8</td>
</tr>
<tr>
<td>Hardware (mobile phone itself as a whole)</td>
<td>2</td>
</tr>
<tr>
<td>Language</td>
<td>1</td>
</tr>
<tr>
<td>Starting</td>
<td>1</td>
</tr>
<tr>
<td>Pop-up windows</td>
<td>1</td>
</tr>
<tr>
<td>No problems reported</td>
<td>14</td>
</tr>
</tbody>
</table>

Looking for a clearer understanding if the motives that players selected for finishing the game (curiosity, challenge, fantasy and control) are dependent of each other or not, an inferential statistical analysis was performed. According to a chi-square test for independence algorithm [11], we compared all the categories pairwise. The results of this analysis assure us that each criteria is independent of each other.

6. DISCUSSION

We noticed that even though the subjects did not have previous experience playing this type of game they were willing to try SciMyst. Although we do not know the reason for not invoking the collaborative help feature, the lack of its use suggests that it is important to build the user interface as intuitive as possible. Furthermore, the collaborative help should be integrated firmly to the normal game play rather than keep it hidden under the help menu.

During the observation we noticed two interesting aspects: (1) players often stopped playing in order to receive more information from exhibitors, and (2) players often teamed up with their friends and family to solve the enigmas together. This is a clear indicator that the main idea of SciMyst to have the visitors interact more with the exhibition was realized. In addition, it suggests that the use of the common environment as a playground seems to be a path for the social interaction of different types of players playing at the same time. According to Table 2, the main driving force for finishing the game was curiosity followed by challenge. After the statistical analysis, we know that these four criteria are independent of each other. This result might be due to the fact that SciMyst was played through different areas with unpredictable questions and tasks. Another possibility is that the game was new for them, or that new mobile devices naturally can catch people's interest. We suggest that a further study on the possible ways to motivate players to finalize this type of games can give more detailed answers.

In Table 3 the overall results for the UI are favourable. However, in further studies the intuitiveness of the user interface should be properly measured and improved according to the results. Regarding the adoption of the technology, the use of mobile phones as a play tool is considered fun and they are easy to use, receiving high acceptance among the participants. Nevertheless, according to Table 4, in order to enhance the game experience with this type of technology some improvements should be made. Firstly, the tag recognition system should be improved or a better alternative should be discovered. Secondly, the network stability should be increased. An alternative system for “tagging” could be RFID (Radio-Frequency Identification) or NFC (Near Field Communication) technologies which might be available in mobile devices on a larger scale within a few years. Better network stability can be achieved by using high quality access points and stable mobile devices. As a consequence of resolving the two previous points, the problem of slow response might be solved as well. The challenge regarding the physical keyboard affects the UI and the game experience, hence this device feature should be taken into account while considering the equipment.

None of the feedback we received or the observations we made suggest that there was any fear towards the familiar mobile phones used as play tools. Therefore we conclude that our initial assumption that mobile phones are nowadays so common and well accepted that using them for playing allows the players to concentrate more on the game without having to pay any special
attention to the play tool itself. For this reason a mobile phone as a play tool or controller in pervasive gaming has significant potential.

After the observation of the 45 participants, there is a clear need to reanalyze and improve the game design and user interface for successful multiplayer and collaboration experience.

From our experience with developing SciMyst, we can say that the design of a serious mobile game with pervasive characteristics nowadays needs to incorporate knowledge from very different areas such as technology, education, aesthetics, game studies and usability. It is difficult to implement a tool without emphasizing some of these areas at the cost of others. We reinforce the knowledge that it is difficult, but not impossible, and it can be an arena where game designers and instructional designers can join their efforts. Combining these aspects and paying attention to all of them at the same time complicates the design and implementation task immensely.

7. CONCLUSIONS
A definitive answer to the question how one can trigger the interest of different individuals of different ages towards the reflection and understanding of the knowledge surrounding them, and to encourage them to collaborate in the process, cannot be given at this moment. However, our experiences with SciMyst suggest that the rise of curiosity on this type of games is an important factor in order to keep different users playing. Taking advantage of the environment's information content is already one way to trigger the curiosity in the game. Furthermore, our experience also shows that proper content creation embedded in the environment in combination with the players' curiosity and desire to win, guides them to give attention to the content of the festival. In addition to curiosity, challenge offered by the game play was considered an important element for completing the game. Results of this experience suggest as well that the overall usability and operation of SciMyst was good. We received valuable feedback for improving the game further. Moreover, the use of the common environment as a playground seems to be a unifying factor between different types of players.

To investigate deeper for an answer of the research question of this paper, the results of our experiences raise other questions for further research such as: How are the curiosity and the challenge related? How can we enhance informal learning with pervasive mobile applications, including games? What is the role of technology in this informal learning process during an enjoyable game experience?

For the future we intend to continue developing and testing SciMyst in different environments. The remaining two sections of the questionnaire will be analysed in future publications as well. In order to discover the effects of cultural differences we intend to set up the game setting in other countries besides Finland. One further challenge is also to establish a real time pervasive game between two distant locations.

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9. REFERENCES