Designing an Educational Game for Mobile Learning Environments

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Abstract

This thesis analyses the current situation in the world of designing educational games and applications. The specialization is done on the game design for mobile devices and mobile users.

The definition and the main aspects of the game design are represented, as well as general ideas of the game design process and existing theories. Game design principles and an overall game design procedure are considered in detail in order to give a comprehensive understanding of the process. The main accent in the thesis is done on the specialization of the game design process for educational purposes in a mobile environment. The significant part of the work is devoted to the investigation of the educational approach of the game design, as well as to the consideration of mobile gaming and mobile education mixed in one integrated essence. On the basis of the presented survey two main results are obtained:

(1) The main elements of an educational game for a mobile environment are identified; considered design rules are revised in order to make them applicable for educational purposes and in mobile environment; and the concrete scheme for educational mobile game is chosen.

(2) An educational game for mobile environment was designed according to the chosen game design scheme; and an example of simple J2ME mobile application which provides mostly presentation concept of the game design was implemented.

Keywords: game design, educational game, edutainment, Game-Based Learning, mobile game, J2ME, learner-centred design.

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1 Introduction

The amount of efforts to apply mobile technology to learning increases day by day. Moreover, the educational process is increasingly being frequency supplemented by games in order to make learning more attractive for learners and to make games more useful for players. In this way mobile technologies and profound game design offer an exclusive opportunity to embed entertaining learning in a natural environment. The mixture of these three concepts – game, education and mobility – opens great possibilities that can be addressed in numerous ways.

The main research objective of this work is to investigate of the application of game design principles with the context of mobile learning environments. The game design itself is considered as the main objective of this work. The theoretical and practical aspects of making games, the concepts behind the creation of meaningful play, the means of using these concepts in game design are the issues to which the main attention is given. Game design has its own essential principles and a system of ideas that define what games are and how they work (Salen et al. 2003). The game design fundamentals include understanding design, systems and interactivity, as well as player choice, action and outcome. They include a study of rule-making and rule-breaking, game representation, game experience, and social game interaction. Moreover, they comprise connection between game rules and the play that the rules entail, the pleasure games evoke, the constructed meanings, the embodied ideologies and the stories that games tell.

The work presented in this research can address not only game designers. It has direct application to fields outside game design: education, social sciences, product design, creation of interactive systems, etc. The specification of the game design process for educational purposes and for mobile environment narrows the consideration but by no means confines the field of research. Quite the contrary, it represents new opportunities that education and mobility aspects import to the game design process, and this is exactly the core idea that this thesis intends to present. In short, the work aims to consider the game as an educational tool within the context of mobile environments.

1.1 Questions to answer

The main challenge of this work is to define educational game design in the context of mobile learning environments. It implies providing solutions to the following questions:

- How learning and gaming are connected?
- What is the specific of designing educational games in mobile environment?

The process of answering to these basic questions can entail more specific ones that obviously will be considered in the research progress.

1.2 Methodology

Using some methodology means gaining new scientific knowledge through the utilization of defined processes for scientific investigation (Wikipedia 2005). During any scientific investigation conflicting assertions appeared. Methodology provides us with diverse tools to choose between incompatible assertions.

Most important processes or methods for scientific research:

- characterization
- hypothesis development (includes explanation of the subject)
- prediction (based on hypothesis with deductive reasoning)
- experiment (for testing of prediction)

Several aspects of the scientific method were applied while developing and writing this Master Thesis, especially in relation to the investigation about the educational value of game design for mobile learning.

The main question was set first to show the problem being investigated in this work. Next step was to collect information about the topic discussed and trying to find an answer to the main question through observations. This involved compiling a literature review through library books and journals, literature obtained from on-line sources discussion of problems with colleagues. There was a continuous process of throughout the investigation.

When all necessary information was collected and a wide understanding of the problem was achieved a solution for the question (problem) was proposed in the form of a hypothesis. During this stage of work different approaches are used in order to arrive at possible interpretations of the problem under consideration: suggestions from other domains, own ideas etc. (Schafersman 1994)

During this thesis writing process creative thinking was stimulated through brainstorming, discussions, and debates. The Brainstorming encourages participants to give a lot of ideas and stimulates productivity while working in a group. Discussions of the ideas help to choose the best ones for further work. Debates

provide us with ability to have different points of view to be presented; they develop logic, understanding of an issue, listening and speaking skills. All these methods were really helpful at all stages of thesis creation.

In the issue, the methodology used in this work included the following methods:

- problem definition (identification of the main problem and several related questions that are needed in order to comprehend and present the topic in the most intelligible way)
- gathering necessary information (making an observation with the help of different literature, Internet, discussions)
- proposing and discussing the ideas for solving the problem (proposing a solution that is discussed, changed, discarded, …)
- elaborating the solution (detailed solution is proposed)
- testing the solution (e.g. by means of practical application proposition)

1.3 Thesis structure

This thesis consists of six chapters. The introduction identifies the research problems, the objectives and the adopted methodology. The second chapter “Characteristics of the game design process” discusses the main notions and definitions related to game design, giving the general ideas about the game design process, considers game design theories as well as outlines the procedure of computer game design and implementation. The third chapter “Game design: educational approach” applies the game design process for educational purposes. Here the nature of edutainment and the essence of learning by playing are investigated; as well as importance of including entertaining moments in learning process is considered. The fourth chapter “Game design for mobile learning environment” discusses how educational game design is considered in terms of its utilization for mobile devices and in mobile learning environments. The key aspects of M-learning and mobile gaming are provided. J2ME devices’ features are outlined. The benefits and disadvantages of mobile devices for education are elaborated. The fifth chapter “Building an example of educational application” presents a concrete example of educational game design for mobile device. The final chapter summarizes all results and describes future development of the ideas considered in this project.

2 Characteristics of the game design process

This chapter is devoted to the description and analysis of game design concept. It gives the definition of the game, describes its fundamental elements, and presents the game design key aspects and theories that exist nowadays. The characteristic features of computer game design are provided in terms of their strengths and weaknesses. Finally, the main principles and the whole procedure of computer game design are provided.

2.1 What is a game?

The most proper and pertinent definition for a “game” is given by the Wikipedia. “A game is a recreational activity involving one or more players, defined by a) a goal that the players try to reach, and b) some set of rules that determine what the players can do” (Wikipedia 2005). The initial goal of the game is entertainment or recreation, but it is also extensively utilized for educational goals and simulation processes.

David Kelley defined the concept of “game” in the book “The Art of Reasoning” like “a form of recreation constituted by a set of rules that specify an object to be attained and the permissible means of attaining it” (Juul 2003). It is obviously possible to imagine a game that does not fit this definition well, and there is a number of definitions given by other researchers (Johan Huizinga, 1950; Roger Caillois, 1961; Bernard Suits, 1978; Avedon & Sutton Smith, 1981; Chris Crawford, 1981; Katie Salen & Eric Zimmerman 2003), but for the purposes of this work this is the best way to describe the concept that is going to be designed. Besides, it is necessary to add that the game implies punishment in case of rules violation (or incorrect behavior, insufficient number of points, etc.) and reward in case of excellent playing (fast win, a large number of points, wise choice, etc.).

Game designer Chris Crawford raises an enthralling discussion about understanding the nature of game and game design in his book “The Art of Computer Game Design” (Crawford 1997). In spite of the fact that the book was written so long time ago, it is still of current importance and enjoys a wide popularity among different game designer’s activities. It is one of the main bibliographical books at the 2000 Game Developers Conference (http://www.scottkim.com/thinkinggames/GDC00/); it is used as a basis for lecture notes in different educational institutions (for example in Colby College (http://www.colby.edu/), England). The course “Design and Implementation of Computer Games” was given in Colby College in Fall 2003 that signifies present topicality of the book. “The Art of Computer Game Design” is in great popularity at the

most famous book shops; and recent works on game design refer to this book (for example, the article “Exploration in computer games – a new starting point” by Simon Egenfeldt (Egenfeldt 2003) was presented in the year of 2003). Chris Crawford was named the “dean of American game design”, and, hence, his thoughts and ideas in this area seem to be trustworthy even if they were originally presented not in recent time. Crawford’s book was chosen as a main starting point of this thesis, his ideas are included in different chapters, but he is not the only one whose conceptions were investigated on order to obtain a complete view to the question of game design.

2.2 Game characteristics

In addition to the game definition, game characteristics, or game elements, are considered by number of game designers. Every of them propose his own elements or groups of elements; some designers even define the "game" through its characteristics. Most of works are devoted to the design of computer games, and as our application is designed for computer-supported environment as well, we turn to those game characteristics that are typical and distinctive for computer games.

The main requisites of any successful computer game are representation, interaction, conflict, and safety (Mukherjee 2004). *Representation* refers to a subjective and deliberately simplified view of emotional reality that game creates for the player. Player's fantasy, supported by a certain part of objective accuracy, makes the game psychologically real. *Interaction* is the property of reality representation which implies any kind of changing aspect. The most attractive thing is not itself the ability to change, but the way of changing. Interaction adds an interpersonal element into the game events, and transforms the nature of challenge from a passive form to an active one. Interactiveness allows players to invest themselves much into the play and to react in a rich way to their opponents. *Conflict* appears in any game and originates from interactiveness. During the game player meets obstacles that prevent him to achieve his goal. Conflict arises from the situations in which dynamic and purposeful impediments do not allow player to win. *Safety* means providing a psychological experience of conflict and danger without their physical realizations. Game is a safety way to experience reality.

Another way of game characterization includes nine elements each of which belongs to one of three classes (Järvinen 2005):

Systemic game elements: components, procedures, environment, and interface.

Behavioural game elements: players and contexts.

Compound game elements: goals, rules, theme, and game mechanics.

The view to the games is promoted as to the systems, or to the dynamic wholes with interacting parts. These parts are defined through various game elements which have been just presented.

The game elements can be also described in deeper and more complicated way. For example, there can be two senses of game *goal* (Bradford 2003): the first is the state of affairs that the game aims to achieve, and the second is winning. Reaching the goal in a first sense doesn't obligatory mean winning. The true goal of the game must be qualified by describing it in terms of the context of the game. The next two elements are *means* and *rules*: certain means are permitted by rules. The final element is player's attitude: it unifies all the game elements into one single whole which identifies any player's activity as an instance of the game playing. In other words, the player must follow the rules of the game in order to be able to perform the activity that the game suggests after he follows the rules.

One more way to divide game by elements is to present it by means of *graphics* (anything that player can see during the game: images, 3D objects, video, etc.), *sound* (anything that player can hear during the game), *interface* (anything that the player has to use or have direct contact with in order to play the game), *GamePlay* (encompasses how fun the game is), *story* (includes game background, all information the player gains during the game and any information player learns about characters in the game), *AI* (simulate an intelligent behavior of the game objects) and *Immersiveness* (the ability of a game to capture the player's attention) (Howland 2005).

As we can see, the game can be represented in different ways: not only through the formal definition, but also by means of its characteristics, features and elements. Table 1 presents a set of rearranged game elements that are the most important for the purposes of the designed application that have mostly educational orientation and is supposed to be utilized in mobile environment.

Table 1 Game elements

Element	Description
Environment	Game's environment is an element of the game what creates much of the emotions felt by the player and it is a crucial element of the game, especially if it non-action game. An engrossing, stylish and imaginative game environment is a one half of the game success. Defined in such terms, environment can comprise such game

	elements like topic (or theme), background story, as well as such technical elements like graphics, sound and interface. All game elements are closely associated with each other and even their hierarchy can change depending on the purpose of the game. For example, Story can be a part of the environment, but also can serve as a separate element; and in some games a powerful environment is useless unless there is a powerful story and engaging GamePlay are designed to support it.
Components	Components include objects that are in the game an which the player manipulate with, as well as the place where these objects are manipulated. So, the components can be divided into two categories: tokens and environment (we separated environment as a single element due to its different interpretation beyond the scopes of the belonging to components). Tokens are primarily dynamic components; environment, on the other hand, is that static thing which defines the place where the game is played.
Compound	This element defines the structure of the game: goals (in all senses), rules, theme (this element can be related to both environment and compound elements), game mechanics.
Interaction	Interactiveness reflects any kind of changing aspect in reality representation. It adds an interpersonal element into the game events, transforms the nature of challenge from a passive form to an active one, and allows players to invest themselves into the play and to react in a rich way to their opponents.
Conflict	Conflict is a direct consequence of the interaction. Conflict arises from the situations in which dynamic and purposeful obstacles, met by player, prevent him from winning.
Safety	Safety means providing a psychological experience of conflict and danger without their physical realizations.
Mobility	Mobility identifies the content of mobility in the game by several characteristics, like for example the area of mobility (within building or within city), mobile technologies utilization and area type.
Educativity	Educativity integrates an educational content, its level and field of knowledge in one property.

Since the work under question is devoted to the investigation of the games that are designed for mobile environment and in educational purposes, it seems evident to include appropriate elements, or characteristics, of the game that would indicate the

level (kind, meaning, etc.) of mobility and education. The last two elements (Mobility and Educativity) were added for these purposes.

What does mobility means for the game? This question will be closely discussed in chapter 4, but here we have only a purpose to bring the mobility into the game as a property and define it like one of its elements. *Mobility* can be defined as a combination of several estimations:

- Mobility level (within the limits of one room, one building, one town, country, world)
- Mobile technologies utilization (only mobile phones and PDA, or some kind of complex system designed specially for the game purposes)
- Place type (indoor/outdoor, city/countryside, dry land/sea, etc.)

Taking into consideration these components, a special way of mobility calculation could be defined and used to indicate how the particular game is mobile.

Educativity could include the next constituents:

- Educational level (how much education itself the game comprises)
- Field of education (history, music, astronomy, etc.)
- Difficulty (can be divided for example by players' age)

It is obvious that these components can change both by number and by substance for different applications and specific domains. Some constituents can be estimated only roughly, but the idea still remains the same and rough estimation does not diminish the importance of the property.

2.3 What is game design?

Game design is the process of designing the content, background and rules of a game. Any kind of document that describes game design process and is used for game development can be also called "game design" (Wikipedia 2005). Another definition says that *game design* is the set of type definitions and rules of a game, usually composed from several game modules (Glossary 2005). In terms of our approach to the game design it could be defined as the art, the discipline and the sequence of designing the content, background and environment of the game, deciding what the rules should be.

There are three main concepts in game design: theme, gameplay and presentation (Answers 2005). The *theme* describes what the game is about: historical adventures,

abandoned submarine or making money on the broker's board – any topic can become the basis and starting point for the game design. *Gameplay* is the set of actions that player perform during the game. It is the central issue of the design process, which tested a lot and continuously improved and to which the main attention is given. The aim of the gameplay is to make the game pleasant and exciting to the player. It imparts interactivity and challenges the player. *Presentation* is about the game's theme realization: how game looks and how it is felt by the player.

Game design starts from the concept idea of the game, and then includes following steps: creation of the initial game design (or proposal) based on the concept idea of the game; dissemination of the concept idea among the production team; generating of concept sketches and game prototypes' development, testing various game concepts. Game design is intensively changed during the process of development; it grows and obtains new forms and new features. One of the traits that game designer should obligatory have and advance is creativity.He must be an intelligent individual with a wide background on order to be able to generate new ideas for the game and create an amusing content. The great creativity and patience during the game formation are the key demands for the creation of successful, funny and interesting game.

2.4 Game design theories

There are several theories that are related to the game design process. The first one is *The Threefold Model* that was developed by the debaters on the RGFA forum and the principles of which were outlined by Mary Kuhner in July 1997 (The Threefold Model 2005). Subsequently the model was written down in FAQs form by John H. Kim (Kim 2003). The *Three Way Theory* is quite similar to the Threefold one, but is revised for the live action role-playing games and documented also by John H. Kim.

According to M.J. Young (Young 2002), two related theories appeared out of the Threefold Model: the *GNS theory* by Ron Edwards (GNS is an abbreviation from Game, Narrative and Simulation), and the *GENder theory* (that is the revision of the GNS) by Scarlet Jester.

2.4.1 The Threefold Model

This model has appeared as a result of debates over the proper style of role-playing. The conceptual models of RPGs (Role-Playing Games) that were presented earlier separated game styles into different axes (storytelling, role-playing, war gaming), but

the Threefold Model expresses the way of grouping different aspects into logical categories (The Threefold Model FAQs 2005). Every facet of the game is described including mechanical rules, scenarios' construction, the behavior expected from the PC, the way of handling the actions that are not covered by the rules, and others. The Threefold Model suggests three functional paradigms, or categories, of play known as Drama (or Story), Simulation (or World), and Game (or Challenge).

An important point of the model is that it admits the validness of different goals for gaming. Different game styles are considered like just other ways of playing. This model does not classify RPGs into good and bad. The same game can be attractive for one player, but humdrum for another. The aim is not to dispute about the taste, but to find out the style patterns that different players enjoy. The Threefold Model gives the way of classification that determines the style depending on the extent of its Drama-, Game- and/or Simulation-orientation.

Drama is a style which estimates how well the storyline is created by the game action. *Game* is the style that evaluates setting up a challenge for the player who must solve the problem he faces by means of intelligent acting. *Simulation* is the third style which values the resolving of in-game events based only on game-world considerations. In other words, the actual in-game events should be based exclusively on what would "really" happen.

Due to the names of these styles the Threefold Model has obtained one more name: *GDS* (Game, Drama, Simulation).

Irina Rempt illustrated the Threefold Model as a triangle with "World", "Story", and "Challenge" as its vertices (Fig. 1), and placed a person's usual gaming style as a dot inside that triangle (Rempt 1997).

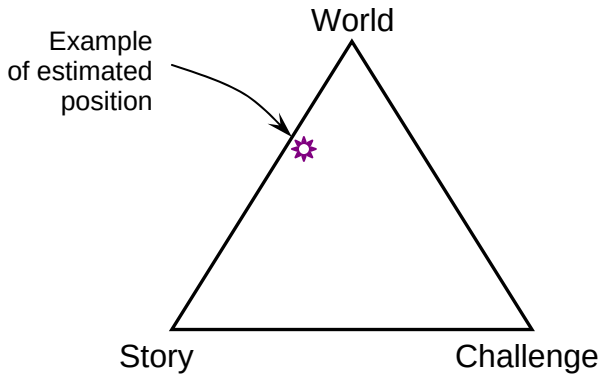

Fig. 1 The illustration of the Threefold Model

The shown position reflects Irina's gaming style. The World is the most important thing in her games, Story is an additional aspect that is needed only in some cases; and the Challenge is almost excluded, because it is not at all important for her.

The Threefold model is applied to different aspects of game design. It is often used by game designer while making the decisions during a session about what should happen in the game-world, and also during adventure design. The model can be applicable in some cases to player behavior, system design, campaign design, out-of-game methods and other aspects.

There was a suggestion to add Social concerns (player as a social entity, opposite to PC) to a Threefold model and to construct so-called *Fourfold Model* (Early Threefold Model FAQs, 1997). But there is still undefined whether "Social" actually forms another vertex in the model, or it is a separate concern.

2.4.2 Three Way Theory

The Three Way Theory is a revision of the Threefold model for Scandinavian LARP. LARP (Live Action Role-Playing game) is a form of RPG where participants perform the physical actions of the characters they are play the role of. LARP can be considered as a form of storytelling-based improvisational theatre (Wikipedia 2005). The difference between LARP and RPG is that the players in a LARP are usually in a moving similar to actors in a play, while standard RPGs are held with the action that is narrated by the game master.

This model is short and concise; it uses layman's terms and has restrictions in a scale. That was the reason to convert it for LARP use, where most of actions are done by person, not through the simulation like in RPG (Bockman 2002). The "Simulation" category was not included into the model, but instead the "Immersion" was added.

The Three Way Model combines the aspects of playing live role-play into logical categories. The model defines how the game is played, its style, how game style influences players' style, settings construction, and so on. The categories that Three Way model suggests are Drama, Game and Immersion.

The definitions of Drama and Game were given for the Threefold Model, and they are exactly the same for the current model, but the Immersion differs from the Simulation and needs to be defined separately:

Immersion is a style which evaluates living of the roles' life. It gives the understanding of what the role would feel and how in-game events are resolved based only on

game-world considerations. An important point is that a true immersionist player will never falsify the rules to save his role character and will never change the background story in setting in order to suit the play. A genuine game designer always tries to make such that the plots and the setting would be believable for the players.

2.4.3 GNS theory

The Threefold model has served as an inspiration for the related model known as a GNS. Originally the GNS theory was developed to describe everything that concern gamers, but it was extrapolated to direct and support the game design (Wikipedia 2005). The usefulness of this theory for game designers is in that fact that it explains the reason of person's participation in the game.

Edwards states that all the participants in RPGs have only one of three aims, or perspectives (Edwards 2004). The three GNS perspectives are:

- Gamists who play for competition and challenge;
- Narrativists who play for story and characterization;
- Simulationists who play to explore and experience.

The enjoyable RPG to his opinion focuses only on one of these perspectives, and it is a mistake when designers try to satisfy all three outlooks at once. The result in this case will be, unfortunately, such that almost any player will be exasperated by some aspect of the game during play.

Collectively, the three perspectives are called GNS. The statement "GNS", "GNS perspectives", or anything similar, refers to the diversity of approaches to play (Edwards 2001). One might refer to "GNS goals", and in this case the meaning would be "one can apply any of them for this act of role-playing".

The GNS theory involves three forms of task resolution that determine the outcome of an event (these task resolution forms were suggested by game designer Jonathan Tweet) (Wikipedia 2005). The task resolution system (or a combination of systems) is needed in order to determine the most appropriate GNS perspective for the game. The task resolution forms are *Drama* (where game master decides the result), *Fortune* (where chance decides the result, e.g. by using dice) and *Karma* (where a fixed value decides the result, e.g. by comparing states). There is an opinion that the main reason of changing Threefold Model's Drama type to Narrative for GSN was to avoid confusion with Drama as a task resolution system.

There are five elements of role-playing that the GNS Theory identifies:

- Character (a fictional person)
- Color (details that provide an atmosphere)
- Setting (location in space and time)
- Situation (or dilemma)
- System (determines how in-game events proceed)

The theory also explains four Stances that player can have in making decisions for his character: *Actor* (decides based on that his character would know), *Author* (decides based on what he want for his character and then explains why the character made such decision), Director (make decisions that affect mostly environment, but not the character itself) and Pawn (decides based on what he is as a player want for his character without explaining the reason for making such decision).

The terms of GNS theory apply to real people engaged in the act of role-playing (Edwards 2001). The distinguishing between game master (GM) and game player is inappropriate for this purpose. Nevertheless, the reverse case has a meaning, i.e. the GNS focus of play defines specific shapes for GM and player.

2.4.4 GENder theory

The name for the GENder theory was created by Scarlet Jester, who altered Ron Edwards's GNS concept (Young 2002). In both cases "G" means Gamist, which defined as playing for the fun of challenge and competition. "S" in Ron's interpretation stands for Simulationist, which implies creation of such a play that immerses the player to some kind of realistic world (the word "realistic" should be interpreted like "having a feeling of being real", but not "similar to reality as we know it"). The main Jester's contribution was to replace the term Simulationist with Exploravist. He recognized that the simulationist player was not creating the world but discovering it. Edwards has continued his work under the GNS after Jester's finding. He placed Exploration on different axis and retained Simulationist as a way of playing where the reality is created in exploring the world, or the nature of the character, or in some other aspect. In later GNS theory Simulationist still remained a concept opposed to the both Narrativist perspective of creating a meaningful story and to the Gamist one of winning the game.

Jester appeals to game designers with an advice to pay important attention to making sure that the game content of RPG really supports at least one of the 3 role-playing

goals: Gaming, Role-playing or Storytelling (Jester 2001). This makes the game “playable”. Some designers make a mistake coming up with amazing settings, which are actually useless, because they do not support any of the activities that in fact are used during playing.

The overview of the game design theories was done in order to obtain an understanding of the game to be designed in terms of officially known theoretical views. Analyzing all four theories, it is possible to conclude, that an educational game for mobile environment can be possibly related to the Three Way Theory. Most of actions are supposed to be done by person in real environment. The category to which the designed application would belong to is Immersion, because it allows a player to experience real life situations.

2.5 Computer game design: main principles

Contemporary game design is usually a task that is performed with the help of computers and for computers. In other words, the design of computer games is the main sphere where game design principles are applicable and where design itself is performed by means of computers.

The most remarkable feature of the computer in a game context is its *responsiveness* that is crucial for interactivity important to any game (Crawford 1997). There is a variety of ways that computer can use to respond a human player. Computer can change the length of the game, the level of difficulty, as well as the rules of the game. It allows react to the player's actions quickly and appropriately (Howland 1999). Computer is able to act as a *game referee* that means that it handles all the administrative responsibilities in the game freeing the player and allowing him to concentrate on playing. It gives one more advantage: due to computer-based game administration, the rules can be arithmetically and logically complex that makes the game more interesting. Computer supports a *real-time play* as long as the computational power of the modern computers allows handling administrative matters much faster than the humans can play the game. Computer allows providing an *intelligent opponent*; it has an *ability to limit the information given to the player in a purposeful way* that encourages the player to use guesswork and imagination; it can use *telecommunications* for game play that allows creating game structures impossible for other technologies (computer networks allow creating a game with large number of players).

Like any technology, computers have weaknesses as well as strengths. The most distressing is the *limited I/O capability*. Computer communicates with human through

the I/O: most output is through graphics and sound; most input is through keyboard, joystick and mouse. Input through the keyboard and controllers makes some problems for the game designer. One cannot say much with joystick and keyboard. A joystick can say only five fundamental words: “up”, “down”, “right”, “left”, and “button”. Keyboard has more abilities for communication, but one can say something only after some time spent with trials to find the right keys. The indirectness of keyboards and joysticks makes the input even more difficult. There is almost nothing about such devices that correspond to real-world activities. Actions that are simple to perform with other technologies become vague with the computer. One more difficulty of the computer is its single-user orientation. It was designed like personal machine. This is the reason why so many computer games are solitary; moreover, this fact has led to an opinion that computer games are anti-social. A computer game encourages one player, accepts two, but discourages more.

Considered strengths and weaknesses of the computer give a possibility to construct a set of advices, or guidelines, for computer game designers.

a. Don't set unrealistic goals and try to force computer to perform tasks that are not suitable for it. Computer is human's servant. Make it work in the best way and extract maximum from its abilities.

b. Don't try to implement on the computer a game that works perfectly on another medium. The computer version can be less successful that the original. Every "transplanted" game loses something during the translation. If some game succeeds in one technology, it does so because it is optimized to it. The trial to apply the same design to different medium with its own strengths and weaknesses will most probably fail.

c. Design around the I/O in such a way that information given to the player is represented naturally, and the use of input facilities is clear and free. The limitations that concern I/O aspects of the game direct the game design and implementation. The shape of the game is decided around the questions what can and cannot be displayed, or can and cannot be inputted.

d. Keep the structure of the game design "clean" while developing the details. The game design must closely follow the theme and avoid distracting details. In this case it will have an emotional impact on its audience.

e. Keep an optimal balance between stored data and processed information. A game that stores huge quantities of static data do not uses the strengths of the

machine at its full potential (such game in not dynamic, not responsive, an hence, not interactive). A game that emphasizes information processing and handles it dynamically is more in tune with the machine (it is interactive).

f. Maintain the unity of the design process by integrating the design people and programmers in one team in such a way that they would realize the possibilities of each other's work. There should be an individual with design and programming skills involved into the design team. All other designers and programmers can be subordinated underneath him in order to support him and multiply his creative power. The point is that creative process should be unified in a single mind.

2.6 Game design procedure

Game design is primarily an artistic process, but not without a technical support. The process of designing a game turns to two completely different worlds: artistic world and technical world. Managing an integration of such dissimilar worlds around the game design is a task that requires careful consideration of both sides and accurate planning of every step. There is no such thing as a "standard" game design rules (Laramee 1999). It would be absurd to apply the same technique to both interactive adventure game and Tetris-like puzzle. Nevertheless, all games have a particular number of common characteristics, and it is possible to suggest a methodology which provides a general structure for the game design activities.

The steps of the game design process that are given in this subchapter were compiled and constructed after investigating methodologies and game design ideas suggested by Francous Dominic Laramee, Chris Crawford, Wolfgang Kramer and by the Game Design Patterns Project researchers.

2.6.1 Goal and Topic

The goal of the designed game should be clearly defined and should be expressed in terms of the effect it would have on a player (Crawford 1997). The goal must set up the fantasies supported by game and the types of emotions provoked by the game from its audience. In addition, the goal should also contain the educational aspect: what the player will learn. An importance of clear goal becomes obvious in the game design cycle. It serves like the main criteria when facing the problems that require making trade-offs like, for instance, including or rejecting some features. If the goals are clear, the decision will be obvious.

When the goal is chosen, it’s time to select a topic, which is a means of expressing

the goal. It constitutes a collection of conditions and events which are used to deliver an abstract goal. It is important to keep an order at this phase: first the goal should be set up, and then the topic should be chosen.

2.6.2 Design treatment

Design treatment is a brief discussion of the game unique features and target audience (Laramee 1999). At this stage the main purpose is establishing a framework for future design work that serves as a marketing tool to generate interest in the product in company executives and/or publishers. Designer should define the next attributes: he game's genre and key features; description of the experience that is given to the player; game structure (levels, missions, episodes, their number and duration); resources (the number of people with different knowledge, time, tools, facilities and platform(s)); major characters (units, game pieces); target audience; preliminary budget estimation and production schedule. The game design treatment is project's business card. It should be short, factual and representative.

This stage in game design has some points in common with the "research and preparation" step in Crawford's approach. The major difference is that financial affairs are not included (they are probably considered like not game designer's duty), but the general direction is to immerse to the topic investigation: understand the mechanics of the environment; gather the information about previous efforts in game design related to the chosen goal and topic; processing the information and generating the ideas for the game (Crawford 1997). As we can see, these activities are implicitly included to those that are proposed by Laramee.

At this step it is useful to know and to remember that there exists such thing like Game Design Patterns (Game Design Patterns 2003). Originally design patterns were used in any kind of design process in order to perform the work in a structured fashion. A collection of Game Design Patterns can be used in the same way. A collection of patterns introduces a listing of concepts that other game designers have found useful for designing games. While designing a game, these patterns are analyzed in the specific context and potential subpatterns are identified. Then subpatterns are analyzed, and their subpatterns are identified. This activity goes on recursively until an initial design has been completed.

The number of Game Design Patterns is continuously grows, new patterns are identified; their relationships to each other are described. This is done by Game Design Patterns researches by means of thorough investigation of different kinds and genres of games and also by viewing the theories and models presented by other

researchers and by examining the working practices of professional game designers. The collection of Game Design Patterns could be successfully used as a basis for a structured methodology of designing computer-augmented games (i.e. for the games supported by smart phones or PDAs).

2.6.3 Preliminary design

The next step is preliminary design which discusses the game's rules, content and behavior. It can be thought of as an organized list of features (Laramee 1999). It describes what the game offers in terms of gameplay, technology and look, without considering the way of implementation. The content of work at this phase strongly depends on the type of the designed game, and so, it is difficult to define a standard set of activities. Some of them could be: Technical specifications (frame rate, texture resolution and color depth, number of characters, single and multi-player modes); back-story; character types and their unique talents; list of the game's environments and the missions taking place in each; lives, health, list of moves, etc.

It is important to emphasize that game rules are formed at this stage, and the crucial moment is to make the rules to be consistent (Kramer 2000). For example, a strategy game cannot be influenced in any way by luck. Games of chance must have simple rules and offer few alternative possible moves. Games of strategy, on the contrary, should offer abundant alternatives each move. This will let players realize their potential.

2.6.4 Design phase

The primary goal at this stage is to create a description of three independent structures: the I/O structure, the game structure, and the program structure (Crawford 1997). The *I/O structure* is the system that makes possible communication between computer and player. The *game structure* is the internal architecture that defines the situations the player paces and the difficulties he needs to overcome during the game. The *program structure* defines the organization of the mainline code, subroutines, interrupts and data that make up the entire program. All three structures must be designed at the same time because they are highly interrelated.

I/O structure

I/O consists of input and output, which are asymmetric. Currently the computer has two general means of output: graphics and sound. Graphics is more important of these two probably because humans are more oriented towards vision than hearing. This is the reason for many game designers paying too much attention for designing

high-quality graphics. However, the attempts to create attractive graphics should not become the primary goal in game design, it is important not to lose the goal of the game. Graphics serves mainly as a means of communication, like deliverer of the critical game information while supporting game fantasy. The same rules are valid for the use of sound.

A special care should be devoted to the input structure of the game, which represents the player's tangible contact with the game. Designer must remember that people attach deep significance to touch. The input structure of the game must be such that not to frustrate and anger the player with its inability to realize human's desire.

The I/O structure is the most important of the three structures of the game, because it is a face of the game and the means of interaction. It is also the most difficult of the three structures to design, demanding the most human's attention.

Game structure

The main problem in creating the game structure is to figure out how to deliver the game's goal and represent the topic in form of fantasy. The game designer should single out some key element in the topic environment and build the game around it. This element must be central in the topic, representative, easily controllable, and understandable. For example such key element can be movement. It is an aspect through which many other aspects of the game are expressible. One should concentrate also on providing enough color to guarantee an actual feel of reality, but at the same time the sense of proportion should present while adding details to the game structure.

Designing the game structure is very different from designing the I/O structure. The main problem in designing the I/O structure is overcoming the constraints; and the main problem in creating the game structure is realizing possibilities. While designing the I/O structure, the designer must thread a path between an expressive power and complete clarity in conditions of strict hardware limitations that toss the design in different ways. While designing the game structure, the designer has inappreciable amount of limitations, but the challenge now is how to do it.

Program structure

The program structure is the third aspect of the game design. This is the means of transforming the I/O structure and game structure into a real product. One of the most important elements of this structure is memory map which describes memory chunks allocation for specific tasks. Wisely planned memory map helps to avoid

excessive use of memory for minor functions, and having insufficient amount of memory for important tasks. Here definitions of critical variables and subroutines are necessary as well. Finally, the documentation on program flow is important.

Evaluation of the design

At this stage designer has three structures in hand: the I/O structure, the game structure, and the program structure. The next step is to evaluate the overall design for the most common design flows that compose the game. The first and the most important question that designer should ask himself is: does the design satisfy the goals that were settled for the game? If the answer is positive several evaluation procedures should be performed. The first one is testing the stability of the game structure (searching and examination of the situations when the game could get out of the control); the second is testing the design for unforeseen shortcuts to victory (such shortcuts should be blocked so that player would experience all processes that designer suppose for him to practice); and the third is to make a decision about proceeding or aborting the game. The last evaluation procedure is crucial point in the game design, because it is the nearest one to the programming phase. There can be a lot of reasons for aborting the game and some of them are lack of excitement about the game, lack of assurance that the game will be successful or can be successfully implemented.

2.6.5 Documentation phase

Now it is the time to prepare the complete game documentation. Several documents are consecutively created at this stage: final game design document, product specification and the graphic bible (Laramee 1999). The first task is to commit all game design results from the previous phases to a *final design document*. The I/O structure and internal game structure should be defined in as much detail as possible. The documentation is written from the player's viewpoint: it should emphasize the player's experience rather than technical aspects. When the design itself is over, it is time to create a *product specification* which should contain a list of the sound effects; a list of the animations, 3D models, textures and other graphics which need to be produced; a list of the algorithms which must be developed to implement the game engine; a list of all other materials which must be produced by the team: press materials, demos, screen shots, box art, manual, etc.; a detailed project plan and schedule, a list of reasonable milestones, and contingency plans; a detailed production budget. The third document is a *graphic bible* which defines the look of your product. It contains style sheets and color schemes for the characters,

major objects, maps of the environments, background drawings, the intro, etc.

2.6.6 Programming phase

Programming itself is a straightforward and monotonous work that requires attention to the details. It is a rare case when game fails because of programmer's poor skills. The game might not maintain the entire potential that designer intended to involve, because programmer did not make enough efforts, or have been in impermissible hurry to finish his work, or did not care about the language, but the lack of talent or programming skills can be hardly considered as a crucial factor for game's fail or success.

One of the most important points of programming phase is that implementation may influence the design itself and often do so.

2.6.7 Playtesting phase

Playtesting is a process that has an aim to polish the game design. Practically it often discloses fundamental design and programming problems that need to be corrected at the cost of much efforts and time. It can happen that playtesting reveals very serious flaws in the game. If mistakes are nonfatal (e.g. not enough color, not enough action, or too many items) the game can be saved at this stage. The case of fatal flaw appears when a fundamental conflict arises between two important elements of the game whose contradiction was difficult to forecast at earlier stages. The designer should have the courage to abandon such game, because patching after programming phase can lead only to some limited improvements. If playtesting discloses serious but not fatal problems, designer should examine these problem cases thoroughly. When the nature of the problem is identified, the set of solutions must be generated in order to choose the best one. The criterion for solution selection must be its correspondence to the goals of the game. If the initial design was developed in a right way, then the problems that designer can meet are the problems of polish. These are little things that should be "tuned" in order to make the game go in its best way.

The evaluation of the playtesters' critics is one more difficult problem that game designer faces after collecting the feedback. Most criticism must be rejected, and there are a lot of reasons for that: incompatibility with game's goals, insufficiency of remaining memory space, effort consuming redesign with little gains, and others. If from all the collected feedback designer has 10% of right, worth implementing suggestions, it is a very good result.

2.6.8 Preparing a game manual

One of the last tasks is to prepare a game manual. It is a vital element of the overall game package. Some computer limitations can be overcome with a good manual, much of the static information about the game can be represented here. Manual is also an excellent place for adding fantasy support for the game in form of pictures and background stories. Designer must write his own manual for the game, even if it will be written further by professional writer. There is no matter how poor author one can be, it is necessary for designer to write and to improve his writer skills. One more reason to create an own manual is a possibility to get a feedback about the cleanliness of the game design: ungainly design is hard to describe, while clean design can be described without any trouble. Finally, the designer's manual is a valuable source for the professional writer.

2.7 Conclusion

The purpose of this chapter was to give a comprehensive understanding of the "game" and "game design" concepts. The special emphasis was done on the design of computer games, and the procedure of computer game design was considered in detail. The set of steps in this procedure has no intention to be perfect and the only one that should be followed. It seems not impossible to follow it in step-by-step fashion. Game design is too complex activity to be reduced to a formal procedure. Designer should use his own working habits and do not formally rely on procedures, which are not a normative formula for designing, but just a consequent set of suggested habits that game designer might use.

3 Game design: educational approach

This chapter has an aim to make more detailed description of the game design process specialized for the educational purposes. It gives the specifics of educational game, discloses the nature of edutainment as well as its powerful advantages and design specifics. The essence of learning by playing, learning-playing process and importance of including entertaining moments during knowledge obtaining are considered. The definition and main aspects of Game-Based Learning (GBL) concept and the learner-centered design principles finalize the chapter.

3.1 Educational game

An *educational game* is a game designed to teach people, typically children, about a certain subject or help them learn a skill as they play (Wikipedia 2005). The final goal of the game designer is to educate, entertain or edify the game-player; therefore the human as a player is a primary concern for the game designer.

Games are the most ancient means of education. They are the primary and natural educational technology, and have a vital educational function for any creature capable of learning. It is natural to associate playing the games with children. In fact, “playing” is an activity that in vast majority of cases connected with kids. The reason (may be not evident and unconscious) of children’s playing can be seen in the fact that game is a fundamental educational tool. Growing up, people devote less time to the playing because of cultural pressures changes and necessity to give themselves to more serious activities.

Learning is the fundamental and the original motivation for all game-playing (Crawford 1997). Firstly, the educational motivation may not be conscious, and can simply have a form of vague passion for playing games. This fact does not lessen the significance of the assertion that learning is a truly original motivation for playing. Secondly, there are plenty of other motivations to play games that are hardly related to learning, and in some cases they have even greater local importance than motivation to learn. These motivations are possibility to explore a fantasy world, to overcome social restrictions, to demonstrate oneself his heroism, to exercise one's physical skills, cognitive attainments or intuition, or to obtain an acknowledgement by other people. It is crucial for the game designer to be aware about the reasons of human’s playing the games. Considered motivations give a comprehension of what is needed from the game designer in order to create an exciting, useful and enjoyable game which not only entertains but also educate and edifies.

3.2 Edutainment

The processes of learning and playing being usually used together and affecting each other finally has merged and formed a new term called *edutainment.* Edutainment is a recently coined term, a portmanteau (a word that is formed by combining two words) that expresses the union between education and entertainment in a television program, game or website. A bit different definition is given by IGDA: Edutainment is combining educational information in a gaming environment to make the presentation more entertaining (IGDA 2005).

Edutainment refers to an innovative term which implies that a piece of software is entertaining enough to keep a child's interest while also being educational (Kidsware 2005). This notion was created in order to distinguish computer games from more educational software. This is not just a marketing term but a concept that really exists. Edutainment is the art of educating through entertainment.

The term “edutainment” has appeared in the lexicon of the location-based leisure (LBL) industry in 1995 with appearance of the first children’s edutainment centers (White 2001). Initially this term was used in the computer industry to describe CD-ROM programs designed to teach children in an entertaining way. Nowadays the meaning and application of edutainment has shifted its primary focus from education to entertainment with learning as a secondary product.

For children edutainment is a developmental game through which they learn about themselves, surrounding world and how to become a part of society. Edutainment provides an environment for children to construct their own knowledge. There are several characteristics that are peculiar to children’s edutainment:

- Pleasurable;
- Hands-on/participatory;
- Self-directed;
- Imaginative;
- Non-goal directed;
- Spontaneous;
- Open-ended;
- Free of imposed tasks or adult-imposed rules.

Children have different skills and interests, therefore edutainment products must appeal to diverse interests, developmental skills and multiple intelligences (such as musical, linguistic, spatial, interpersonal, etc.). Children's interests change with time. They grow, master new skills and look for new challenges. Taking into account these movings and multiple targets, the design of children edutainment can be considered along two dimensions: (1) although the evolution of every child is a specific process that can have different rates, there is a scale that identifies generalized “developmental stages” or “ages of play”; (2) within each age of play, it is necessary to provide different challenges that appeal to as many of the multiple intelligences and offer as much variety as possible.

3.2.1 A shift in values

It used to be that people thought about leisure like a reward for hard work: work was associated with self-improvement and leisure with relaxation that had no practical use. Today the situation is different. People see their scarce free time as an opportunity to improve themselves and do useful things rather than purposeless relaxation.

The transformation in values has happened in Western societies in the past several decades. We have moved from a manufacturing-based to a technological society. A lot of people are involved in a work where they use their brains but not bodies. They are belong to a Knowledge Society which places a high value on education and enrichment, therefore lifelong learning become an important priority for many adults.

Many parents devote their limited free time to the entertaining activities that are developmentally and educationally enriching for their children. There is a particular research which shows that children in the age of about eight years old learn best by self-directed play. Parents in contemporary society prefer to provide their children with such opportunities even though others conservatives consider unsupervised play as a non-safety way of education.

3.2.2 Powerful advantages of children’s edutainment

Children’s edutainment meets the needs of children, thus, it naturally appeals to them in such a way that no other form of education or entertainment could do. It based on issues which children are biologically motivated to want. Edutainment offers a wide variety of exciting events and challenges so that children never get tired of it and do it every day. One more advantage of the edutainment is that it also appeals to young children (six years old and younger) that is not an easy but still very important thing,

because it is a wide demographic group. Over 50% of all families with children have at least one child 6 years or younger, and 25% of all families with children only have children 6 years or younger (White 2001).

3.2.3 Edutainment design: special considerations

Edutainment design differs quite a lot from the designing of other types of entertainment and educational activities. It requires to perform a comprehensive and coordinated research and to make an approach to the design of the activities and their environment. The environment is an essential issue in designing, because it shapes children's behavior.

Anthropometrical aspects are very important. Everything must match the size, physical range and abilities of young children, and all these can greatly change as children grow. This requires activities and events to be designed for a wide range of ages and anthropometrical properties. Research shows that scaling the environment to match different children's ages not only improves the quality of the play, but also extends the length of the play.

There are some other important aspects in the edutainment design:

- Cleanliness: with materials that can be easily cleaned and sanitized;
- Ambiguity: with events and areas that are not too defined, structured and themed. Instead, they need to be as open-ended as possible to allow children to use their imaginations;
- Visibility: so that children can be monitored by parents and staff;
- Wayfinding: so that children understand the environment without reading words.
- Accessibility: the environment should meet ADA regulations (The Americans with Disabilities Act – a wide-ranging civil rights law that prohibits discrimination based on disability (Wikipedia 2005)), and universal design so that children with disabilities feel like they fit in;
- Safety, which means offering developmentally appropriate challenges and safe risks.

One more important requirement of edutainment is a trained stuff capable to facilitate play and interact with young children. Vicki Stoecklin, WHLLG's Child Development and Education Specialist, says: "Owners often assume that any staff member with

baby-sitting experience and a positive attitude is skilled at working with children. This is a risky attitude, as it actually takes special skills and training. Treating them like small adults simply won't work.” (White 2001).

According to Stoecklin, stuff members who facilitate edutainment activities must have a comprehensive understanding of four key areas:

- children's growth and development,
- adapting to a child's individual needs,
- how the surrounding environment affects the behavior of children, and
- how to interact with children and positively facilitate their play and transactions.

It is not a simple work to design an edutainment activities and events, but with thought and experience it can open a whole new target market for existing LBLs (location-based leisure) and at the same time provide children with new educational and playful experiences.

3.3 Learning by Playing

Learning by Playing is a concept describing the educational value of play as a part of informal learning (Niemeyer 2005). It is another approach to the combination of education and entertainment but with the accent done on the learning process while playing a game rather that on the entertainment itself. Usually people learn by doing or by studying, but already Johann Heinrich Pestalozzi (1746-1827) realized that “there is much seriousness in child's play”. Instead of dealing with words, he argued, children should learn through activity and through things. They should be free to pursue their own interests and draw their own conclusions (Smith 2005). Pestalozzi mostly meant that playing is an essential part of growing up, but now we can observe that during the play children obtain a vast amount of essential knowledge. In playing they absorb behavioral patterns (rules) and play according to them towards defined or undefined outcomes: winning, losing, getting distracted, inventing new rules. The importance of learning by playing is not in encountering a new content in playing, but in experiencing new rules through exploration. The lessons learned in games are carried over the real life easily. They strengthen person’s character, improve perceptive or cognitive performance, and can transform human’s fundamental comprehension about social, political and economic relational behavior.

3.4 Learning-playing process

This subchapter discloses the importance of playing and relaxing moments in learning processes and obtaining a new knowledge while speaking not about children, but about adult people who has their ordinary work day, office tasks, and different activities during the working day. How to support knowledge worker's activities by means of entertaining and relaxing aspects is the main question that is considered here.

Learning-playing process forces the way people get their new knowledge (Glotova 2005). It is not a traditional academic way of learning, but should be done as a laboratory for testing new things. Quite new trends in Educational Technology propose Problem-based learning (PBL) as a tool to encourage creativeness in learning process and motivate people to do their best during the work. Elements of game brought from impressive and inspiring pieces of art creation and relax in nature influence the learning process of individuals.

The process of forming a solution for a particular task or problem is rather long in its usual way: Idea – Problem – Reason – Information – Solution. But including relaxation moments and a switching from one kind of methods and environments to another help to increase the people's interest and get boredom away. If we would take, for example, only one step of the chain of human interactions – brainstorming – then we could offer several means of organizing it in a different manner in order to make it more entertaining. We could use 3D virtual conferences to support distant communication instead of teleconferencing. A real sensor screen could be added to a shared virtual white-board in order to improve and hasten the processes of information and knowledge exchange. Collaboration could be done while playing or resting, and of course using new technologies, like Voice-controlled or Voice-recognition systems. Special furniture that allows relaxing and easily communicating with each other can be used to make people feel more comfortable.

People learn from each other, from the Web, literature and knowledge distributed in human networks, using technologies that should be done "invisible" and easy to use, making the whole process of learning more fun and relaxed.

3.5 Game-Based Learning (GBL)

The Game-Based Learning (GBL 2005) was created by Rebecca Teed, SERC (http://serc.carleton.edu/serc/about.html), Carleton College. The features of the GBL are follows:

- GBL uses competitive exercises, either pitting the students against each other or getting them to challenge themselves in order to motivate them to learn better.
- Games often have a fantasy element that engages players in a learning activity through a storyline.
- In order to create a truly educational game, the instructor needs to make sure that learning the material is essential to scoring and winning.

Let's consider separately the elements that define, firstly, the game and, secondly, the learning process and compare them. There are several elements that define an activity as a game (GBL):

- *Competition*: It is represented through the score-keeping element and/or winning conditions which motivate the players and provide an estimation of their performance. Players are not necessarily competing against each other. Indeed, a lot of games demand players to work as a team to overcome some obstacle or opponent which is built into the game.
- *Engagement*: Once the person starts the game, he or she does not want to stop it before the game is over. This phenomenon is referred to as "intrinsic motivation" and is ascribed to four sources: challenge, curiosity, control, and fantasy (GBL 2005).
- *Immediate Rewards*: All players attain victory or get points, sometimes even descriptive feedback about their performance, as soon as goals are accomplished.

These features are typical for the learning process and are quite similar to the game:

- *Achievement*: Any kind of learning process (e.g. lecture or lab) is based on objectives for students (or any other person) to achieve: new understanding and skills to master. The activities and material challenge students.
- *Motivation*: The topics to study are supposed to be fundamentally interesting. Instructors' aim is to encourage students' motivation by stressing connections between the content of learning process and the students' own lives and concerns.
- *Assessment*: The reward for doing well while studying is increased understanding of the matter under investigation and new abilities. These are represented in form of grades and credits, sometimes more detailed feedback.

So, the challenge for the designer/instructor is to combine the two issues – game and learning – in such a way which enhances the strengths of each approach, makes learning fun and games more useful.

3.5.1 Why to use GBL?

By means of integration of learning and gaming GBL not only makes science more fun, but also:

- Stimulates students' motivation to learn;
- Immerses them in the material in such a way that they can learn more effectively;
- Encourages them to learn from their mistakes.

> *"PLAYING SHOULD BE FUN! In our great eagerness to teach our children we studiously look for "educational" toys, games with built-in lessons, books with a "message". Often these "tools" are less interesting and stimulating than the child's natural curiosity and playfulness. Play is by its very nature educational. And it should be pleasurable. When the fun goes out of play, most often so does the learning." Joanne E. Oppenheim* (GBL 2005).

One of the reasons to promote educational games is to encourage students to learn outside of class. It is also evident that games allow students to focus well enough to learn better. It was found that a lesson rewritten with a story context combined with a challenge for the student to overcome (in other words, transforming lesson into a game) significantly improves the learning performance.

3.5.2 How to teach with GBL?

In order to integrate effectively learning and game play one need to:

- Define how to give points to students for accomplishing certain goals in learning process;
- Decide what kind of rewards will be assigned for the victors;
- Create game pieces;
- Test your game before you run it.

“Traditional "edutainment" is based on limited pedagogical models, and does not take advantage of the games' potential to simulate phenomena, engage the player through story, express ideas creatively, or collaborate with other players.” (GBL 2005).

There exists a line of guidelines for integrating learning with playing in order to create a GBL approach:

a. Define objectives

Here the designer or instructor must ask himself: What students are supposed to learn from this game/lesson? It is very important to keep the objective in mind during the planning process and designing or choosing a learning game.

b. Choose the type of game and storyline

It is possible to use some game that is fun and interesting, or one can modify the rules or the environment in order to make it more suitable for learning purposes. The following questions are important:

- What kind of game to use: a race, a quiz bowl, a simulation, or some other?
- How the students should play: individually or in teams? If they have teams, it would be nice for them to come up with cool names.
- Will students compete against each other or just for a score? If players are not competing against each other, it is necessary to create some kind of storyline for the game.
- What kinds of roles do players have (e.g. prospectors, paleontologists, or explorers)?

c. Break objectives down into challenges

One more possibility that is often desirable is to have multiple levels of challenge. It might be individual questions, identifications, measurements and other tasks. When e a certain number of challenges have been accomplished, it's time to move on to harder tasks or a different kind of task.

d. Design Rewards

It would be very nice for player to get an appropriate prize for completing or winning a game. Prizes usually include:

- Certificates

- Snacks
- Small prizes or souvenirs
- Grades (should be handled with care!)

e. Build Game

At this stage the rules are designed. One should assemble physical props (like cards, boards, etc.) or write Java applets. Although this can take quite a lot of time, and even some money, good-quality instruments are reusable and exciting for players.

f. Test Game

This is one of the most important steps. Playtesters should consider and assess issues like:

- Fun (engagement);
- Ease of play;
- How long the game takes;
- The integration of learning objectives into gameplay (very important).

g. Run Game

There are some suggestions how to run the game in the most effective for learning purposes way.

- If the students play in teams, don't let them sort themselves into teams. Either assign them randomly or make sure that they are balanced in terms of experience with the subject.
- Players should give name to their own teams. If they balk, one can use a very effective means of forcing them to do that: just threaten to give some silly name for them.
- While running a game, try to prevent cheating and ensure, especially with a physical game, that safety issues are considered thoroughly.

3.6 Learner-centered design

It is widely accepted that an early and on-going user involvement into design of any kind of system created for user needs is very important. The aim is to gain knowledge about users' practice and experience of system use in order to achieve more effective design (Wilson et al. 1997). There are a variety of evaluation methods that

give a possibility to estimate a system in terms of effectiveness, efficiency and user satisfaction, but dealing with education systems we must shift and narrow these considerations. We must move away from user-centered design and look toward learner-centered design constructing learning environments that are adaptive, scalable and flexible (Thomas et al. 2003). While building such environments individual's creative energy is valued, and the game design takes into account players' willing rather than only considering their immersion.

One of the key problems in the design of educational game is balancing how much of the game is a game and how much of the game is learning. Designers who are involved in educational game projects should decide how to incorporate learning into games while still retaining the features that make games fun. As a result, there are many learning games with poor qualities which make games attractive. Most of existing edutainment products combines entertainment value of a bad lecture with educational value of a bad game. These are the challenges that are not easy to deal with and they can become even deeper when mobility is added into the design mix of playing and learning.

3.7 Conclusion

The main goal of this chapter was to give a comprehension of how gaming and learning can be combined in the best way. Different approaches and for different ages were considered in order to introduce a whole conception of integration of two issues: game and education.

4 Game design for mobile learning environment

Inasmuch as computers and the internet become essential educational tools, the technologies become more portable, affordable, effective and easy to use (Wood 2003). Mobile devices such as phones and PDAs have more reasonable price than desktops, and therefore represent a less expensive method of accessing the internet (though the cost of connection can be higher); moreover, recent tablet PCs allow mobile internet access with equal to desktop functionality. These factors make possible mobile educational schemes creation and educational game design for mobile environment.

This chapter is devoted to the specialization of educational game design in terms of its utilization for mobile devices and by mobile users. At the beginning we consider the definition and the main aspects of M-Learning, mobile game characteristics, requirements, and types of mobile games. Characteristic features of J2ME devices are outlined and, finally, the specifics, as well as benefits and disadvantages of mobile devices for education are given in detailed form.

4.1 Mobile Learning: Mobility & Education

“Mobile learning” (m-learning) is the term that implies the delivery of training by means of mobile and handheld IT devices (PDAs, mobile phones, laptops and tablet PCs) (Wikipedia 2005). Mobile Learners are looking for “just in time, just for me” lessons in small manageable formats that can be performed at any time suitable for learner.

M-learning is the follow-up of E-learning which on his part originates from D-learning (distance education) (Fig. 2).

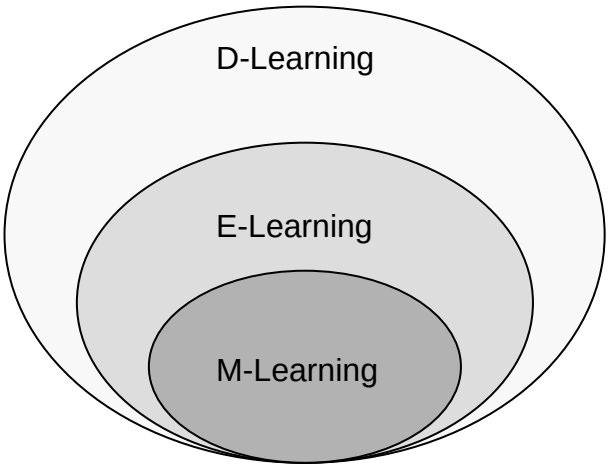

Fig. 2 A scheme of learning forms

Distance education (D-Learning) is a method of teaching that does not require students' physical presence at a specific location during the study. The communication and material deliverance is performed by means of regular mail, videos, audiotapes, CDs; as well as nowadays by e-mail, the Web, and video conferencing over broadband network connections.

E-learning is an approach to facilitate and enhance learning by means of personal computers, CDROMs, digital television, mobile devices and the Internet. It often includes email, discussion forums, and collaborative software. E-learning can also be considered as a distance learning support (this is performed through the use of WANs – Wide Area Networks), and as a form of flexible learning where just-in-time learning is possible. E-Learning supports tailoring the courses and materials to specific needs and asynchronous learning. If learning is performed exclusively online, this is called online education. When learning is distributed to mobile devices such as cell phones or PDAs, it becomes M-learning.

The rapid growth of information and communication technologies makes it possible to develop new forms of such kind of education. Today's students' knowledge of mobile devices makes the entrance of mobile learning (M-Learning) possible.

When organizing the content of M-Learning, one should answer the following basic questions:

- For whom do we develop an M-learning environment?
- What kind of educational information we need to provide?
- How do we develop the structure?
- For which mobile devices do we develop?
- Which tools/software do we use?

4.2 Mobile Game: Mobility & Play

Mobile devices, and especially mobile phones, become tightly integrated into the modern lifestyle (Yuan 2003). They are second only to keys and wallets which are the most common carried items. Mobile games are accessible to anyone, anywhere and anytime. In spite of the fact that mobile game is inexpensive, its wide distribution among all age categories makes this market massive and gainful. However, for designers and developers mobile game appearance entails a serious challenge: necessity to shift from console game to mobile device game. The difference is enormous due to the different audience, lifestyle and distribution models.

4.2.1 Mobile game requirements

To be a successful mobile game it should have one of the following characteristics:

Easy to learn: The main part of mobile games' target consumers is not professionals in computers, and they cannot spend hours mastering an operation manual and studying the rules of a $3 game. It is important to keep the game simple. It must be playable right after the downloading.

Interruptible: Multitasking is one of the basic characteristics of the mobile lifestyle. It is a natural situation, when mobile user has small free time intervals available between tasks (e.g. while waiting a taxi to arrive). The single device is used for communication, calendar management, games, messaging, and work data access. Therefore, a good mobile game should provide an opportunity to enjoy it in short time periods and allow users to switch easily between game and work modes.

Subscription based: The financial success of mobile games is in their large volume. The design and development of each particular game from very beginning till the final version is very expensive. Making money by means of mobile games producing implies utilization of the same game engine with multiple titles along similar basic storylines. Subscription-based games are the best way to make continuous revenue.

Rich social interactions: The game might quickly become boring for the player if he finds out its underlying pattern or if he has experienced all play ways. It is crucial to embed other human players in the subscription-based game in order to increase the intelligence and randomness of the game play. Most of today's multiplayer games that have rich social interactions are very successful.

Take advantage of mobile innovations: A lot of mobile technology research works were devoted to improving the usability and reliability of devices and networks. As a result, the mobile device hardware and network protocols are very different from the desktop/console world (e.g. Global Positioning System (GPS) extensions, SMS/MMS messaging). Good mobile games should take advantage of those innovative device features and network infrastructures.

Non-explicit content: Since all age and gender groups play mobile games it is important to avoid explicit violent or sexual content.

4.2.2 Mobile game types

Taking into account the requirements that were discussed one can infer that the most successful future mobile games are those that provide entertainment value to a wide

range of players in all social groups. In particular, the following types of games are expected to be very popular:

Multiplayer games: These are the games that can provide mobile access to established online game communities. Another opportunity is to create completely different social structure by means of utilization of mobile-specific features such as the multimedia messaging or location-based services. Creative game design and wise management are crucial to the success of this type of game.

Content-based games: The main objective of such kind of games is delivering multimedia entertainment content (such as celebrity photos, video clips, ring tones, or personalized sports games) to music/movie/sports fans. To be successful content-based games must provide high-quality content that justifies the subscription cost.

High-impact visual games: PC games have proceeded from 2D to 3D, and mobile games follow this trend as well. There exist several mobile 3D toolkits, but the problem is that 3D games have very high resource consumption. Besides game designer's expertise they require it also from both developers and graphic designers.

At the beginning of the mobile game promotion most designers and developers were enthusiasts with a desire to play on their devices and learn new skills. However, the more developers enter this space, the larger production scales it obtains and the greater number of professional designers, developers, architects, business dealers, lawyers, and artists involves. This is an inescapable and unchangeable process in evolution of any industrial growth. For developers this change poses both challenges and opportunities. While it is harder to develop and sell simple games, the employment opportunities that companies can offer for people are better and richer.

4.2.3 J2ME smart clients

Even speaking about the mobile game design but not development it is necessary to mention about the J2ME platform that is the most fameful platform widely accepted by developers, device manufactures, network carries and consumers. J2ME devices are smart and have some very important features that differ from the previous generations of mobile devices:

- The main benefit for user is that one can play the game without always being connected to the network. The offline mode is possible that is quite important in the regions with sporadic coverage in the conditions of expensive traffic. The ability to cache data and perform transactions with time delays reduces the traffic in wireless network and improves reliability of the application.

- Smart clients can use various protocols to integrate with game servers or peers (both wireless peers and Internet peers).
- Rich user interface supported by smart clients makes mobile games visually attractive for users.
- There is a possibility to access the features that are specific for mobile networks (e.g. MMS) or to use device extension features (e.g. GPS). It gives a rich opportunity to design and develop games that take all the advantages of the mobile lifestyle.
- Security provided by smart clients is stronger and more flexible because of advanced encryption and digital signature algorithms. Smart clients allow transferring sensitive user private data through the Internet and create effective online societies.

In a word, J2ME platform in comparison with other smart client platforms has a unique advantage: it is designed for mobility. J2ME applications run on various devices from numerous manufacturers. All major smart phone producers have decided to support the J2ME platform. This fact is extremely important in a situation of highly competitive mobile device business.

Mobile games are the future of gaming industry. Mobile device manufactures understand this tendency and have already produced devices that are specially designed for mobile gaming (e.g. Nokia N-Gage). J2ME has emerged as one of the most important technology platforms for those mobile gaming devices and smart phones.

4.3 Benefits and disadvantages of mobile devices for education

Various mobile devices such as PDAs, tablet PCs, and to some extent mobile phones or smart phones can be successfully used in many educational settings (Wood 2003). Most of these devices are useful both in administration, organization or teaching aid for instructors, and as learning support tools for students. The following list reflects some *benefits* of mobile devices' utilization in educational process:

- During the learning process students can interact with each other and with the teacher instead of sitting behind large monitors without seeing each other.
- It is much easier to deal with several mobile devices in a classroom than several desktops, because they require far less space and can be easily moved.

- PDAs or tablet PCs can store student's notes, e-books and all necessary educational information that gives a possibility not to carry bulky bags full of textbooks, files and papers.
- The students' handwriting skills can be improved with the help of the handwriting recognition software that is available for PDAs and tablets.
- Handwriting with the stylus pen is more natural than using keyboard and mouse.
- Stylus pens are much more natural for web browsing – one can click directly on links with the pen instead of using a mouse.
- Diagrams, maps and sketches can be drawn directly onto a tablet using standard software.
- During outdoor lessons students can take notes directly into the device in any form: typed, handwritten or by voice.
- Electronic data inputting is available in practical or outdoors lessons where desktops are not appropriate (e.g. science experiments or farms).
- Shared assignments and students' collaborative working can be realized by means of material sharing using infrared connection or through a wireless network (e.g. Bluetooth).
- Learning can happen anytime and anywhere, including at home, on the train, in hotels – in any place that you think is conducive for learning.
- Innovative mobile devices utilization in education process is a means of engaging learners. The teacher has much greater possibility to pique young peoples' interest in education if he does that with the help of mobile phones, gadgets and other game support devices.
- Such kind of education increases personal motivation to learning: student can take a device with him/her wherever he/she goes.
- Cost saving: mobiles and PDAs are cheaper than desktops.
- Mobile educational device make possible just-in-time learning – quick access to data and step-by-step guidance while performing any kind of task.
- SMS service can be used to deliver information to staff and learners more easily and quickly than phone calls or email (e.g. timetable changing can be

announced by SMS to the mailing list of all students and teachers who are engaged in this educational activity).

Nevertheless, there are some aspects in mobile device supportive education that embarrass learning process. In other words, there exist a number of *disadvantages*:

- Mobile devices' small screens limit the amount and type of information that can be displayed.
- The storage capacities are small, especially it concerns mobile phones.
- Mobility means working with batteries that have limited working time and require regular charging.
- Lack of common platform causes difficulties with creating a content that works everywhere (e.g. different screen sizes).
- Mobile devices can be more easily lost or stolen than desktops.
- Mobile devices much less robust and reliable than desktops.
- It is difficult to use moving graphics, especially with mobile phones, although 3G will eventually allow this.
- Mobile devices are more difficult to upgrade.
- Fast-moving market of mobiles can make so that devices will become out of date very quickly.
- Insufficient security level when accessing wireless networks via mobile devices.
- While using wireless network it is possible to lose a connection in case of increasing the number of active users.
- In order to use all devices effectively some teachers and students might require additional training.

4.4 Conclusion

The key task of this chapter was to show how educational game changes when mobility is added to it. We can conclude that the main benefit that we have in such situation is location-independent learning process that can be performed at any time. Mobile educational device frees learner in space giving him an opportunity to explore the nature of the universe in reality. If besides this we have a gaming aspect mixed with mobile education, the value of such system can be hardly overestimated. One of

the most serious problems of mobile educational games is the restrictions that mobile devices' utilization imposes on the design process. Nevertheless, technological progress nowadays goes so fast that in the nearest future we can await an appearance of such mobiles whose limitative impact would be diminished up to almost indiscernible value.

As a result of investigation done in chapters 3 and 4 we can add a sub-step on the step of design treatment (game design procedure) which handles questions connected to mobile scopes and educational aspects.

5 Building an example of educational application

This chapter presents a concrete example of educational game design for mobile device. Game design is performed according to the principles described in the chapter 2. Nevertheless, as the designed game has specialization, i.e. has an educational purpose and is designed in the context of mobile learning environment, some steps are considered in more details, and some of them only briefly or even omitted. Every step is examined carefully and all the features of the designed application are constructed based on the game design sequence that is adapted to the goals of the current research.

The game model integrates mobile learning with science in game for PDA that is linked to call centers or dedicated websites. The developed application turns to the history of Joensuu – the main Finnish town of North Karelia. The exploration of the city is performed by the student who came to the city first time.

5.1 Goal and Topic

To have a clearly defined goal is of the great importance for the game design and this is the first thing that should be done. As Crawford fairly asserts, the goal should be expressed in terms of the effect it would have on a player. According to that we define the goal for the designed game: to make possible for user (player) to educate himself in an entertaining way at any place in any time. The game design will be organized around this goal, but we reserve a right to ourselves to adjust the goal in a process because of different circumstances such as unexpected information found during the research phase or designer's decision to bring in the game some new aspect. According to the goal, the topic of the game is city exploration by means of mobile device.

5.2 Design treatment

After we have defined goal and topic, we begin design treatment phase during which we perform a brief discussion of the game unique features, create a framework for future design work and retrieve all information necessary for the design process. Goal, topic and retrieved information are processed together in the mind and combined in one whole comprehension of the issue. Here we define game's genre and key features, make a description of the experience that is given to the player, outline game structure. This is a phase of generating numerous ideas. At this stage it is very important to obtain the comprehension of the game environment in order to create a game that gives an actual feeling of the real world.

The player's goal is to explore Joensuu. He starts to live here, begins working or studying. Player has resources: money and time. Besides that we can introduce some more parameters like mood, tiredness etc. that have influence on speed and quality of the goal reaching. For example, if player call to Mom or Dad in bad mood and ask them for money they could give not enough or give nothing. Or another case: with high level of tiredness it takes much longer time to reach some place and tiredness increases very fast (faster that acting with normal level or tiredness).

The student has to reach the goals as fast as possible and spend as less money as possible. Player starts with certain amount of money. It is supposed that the player has a real map of Joensuu (in case he or she plays on mobile phone in text mode only) or digital map should be available on device (in case player use smartphone or PDA). In order to complete the mission it is necessary to estimate distances between places (to imagine time of reaching them from current position).

Player should be provided with additional information (history, general information, etc.) about choice he or she chooses. For example, player after he/she has made choice of hotel should be given information about it. Besides he/she should be provided with opportunity to read information about all other choices in case the player wants to know prices at staying in other hotels also. Player is fined for really bad choices.

For example, let’s consider a case with Hotels. Player is gathering information about hotels and prices, and about convenience of hotels’ rooms. If he/she takes the cheapest room it is possible to consider that he/she does not have good rest because of not good service. Fine could be charged not in money directly, since it is not logical (we only save money staying in cheap hotels), but we pay with health, mood, in time of reaching places next day, probability of bumping into loquacious people. (When player ask somebody for information, formula of probability of positive or negative answer need to be calculated. If the player ask in bad mood it is possible that nobody wants to speak with him/her.) It is also possible that people even do not mind to talk, but they do not know English.

There is an internal map of Joensuu inside the game engine. All places the player could visit are marked out on the map to calculate distance between them during the game process. We are not sure of any choice of the gamer and we should be able to calculate distance, time, tiredness, etc. on the fly.

5.3 Preliminary design

For the designed game we have several parts to be introduced at the preliminary design phase.

5.3.1 Game from scratch

Here we discuss the domain model, collaborative activities that are intended to be promoted and the technological knowledge and skills to be developed.

First it is necessary to identify what to teach and what sort of information should be available. Can we use the game to teach the different languages (at least common expressions), history, strategy, economics, etc.?

The field of knowledge that is chosen for the game is history. History is a science that is suitable to teach during gaming process because firstly we can gather number of facts we want to teach, and after we already had this information we can represent it in some form that is better and easier for human's perception, for studying. Mathematics, languages, economics etc. could be taught in this way too, but history domain is easier to develop and implement the model of a game.

In this game design approach the player is provided with information about history of a city, particularly, a city of Joensuu. When history is set as a domain some other points should be considered:

- Which scenarios from the past, present and future could be included?
- Which historical figures should go in?
- What projects are considered for the future in the city?
- What are the main cultural artifacts?
- Which traditional customs characterize the city in the best way?

Besides we decide on characters and then outline their missions. Then include tools, objects and bits of information that are used to complete the mission.

The simplest version of the game is a virtual trip where the gamer is guided through a city. After the main guide line for the trip is ready some elements of game are added in this virtual trip. For example, the gamer is offered to solve a riddle or a puzzle to get next information or hint what to do in the city; but if the player doesn't want they should be provided with opportunity to skip solving. For skipping the player should be given some penalty points in order to motivate him/her not to skip all gaming moments and use his/her brain.

Games are like films. We create a narrative (game story) faithful to historical indicators. Joensuu in primitive times (some tribes living beside the river, in thick forests); the first settlers; commercial exploitation of the area (wood deposits); recent history; future Joensuu (likely scenarios in the future). Then we write a description of the way we would like to organize a game about Joensuu giving the main model (say, evolving economic situation), with typical stages (eras), characters (political, commercial, religious, etc.) and description of physical surrounding (buildings, tools, type of houses, roads, transport, animals around, people's customs etc.). They will be used to build the scenarios and to be included into different aspects of playing game. For example, primitive people might have to fight bears or other predators; or a young lady could gain points for sewing traditional dress or cooking a good traditional meal, etc.

We try to make a storyboarding model, i.e. a visual plan with topics linked to each other to have the entire picture (model) of the game. Then write detailed descriptions of each item on this model. It would be good to suggest, find, and invent some added features to normal games that promote sharing the game with others or communicating for getting information or advice. For example, many games have a dedicated website. Or if we develop a game for a PDA to be used by one going around Joensuu we could provide an advanced information access or guidance from expert people.

As implementation part a small variant of the game in text form for mobile phones is done using J2ME platform. It is like "How to get lost in Joensuu". Player starts from some exact point and further during exploring Joensuu he/she gets some information (like inscription on monuments) which he/she should send to the game server. Server will provide gamers with further information after proper piece of information is received.

5.3.2 Choosing the type of the game

We should provide users or gamers with a piece of information during the gaming process. It would be difficult to concentrate on mental activity for gamer in action game like "Quake" or "Doom", or racing along streets like in "Need for speed", where gamer needs to react fast to events in the environment. It would be as an option in the game for future development. But generally we have to give the player a possibility and time to think.

The choice of type of the game is between:

- A strategy game like "Age of Empires" or quest game like "Neverhood". Strategy gives us good general view. So we can present developing of a city as a whole process. It could be like side view on growing of the city. Plenty of personages might be involved in process, and gamer is able to manage many of them.
- In case of quest gamer is acting from face of one personage and interact with other personages. User could have conversations in which he or she gets information, should answer to questions and decide what to do further, but mainly user should decide where to go and with whom and how to communicate.

Though, if we want to teach history but not to make it we don't need to give to gamer a possibility to change it (virtually), we just provide him/her with an opportunity to explore history of city. For this reason the quest type of game seems to suit better.

We can use adaptive learning in case of quest. We have some conversations but interlocutor doesn't give the gamer all information available before player has done something. It would provide an adaptation for user's knowledge, present the level of awareness. From these points of view the quest type would be more preferable as well.

Once we have chosen quest we define missions and main stream of each mission. There will be three different missions in the game. One is devoted to the very beginning of city. Here we can teach user about when and why the city was established, by whom, describe the place of establishment, mention situation in the world contemporary to the time of starting the city, describe advantages and disadvantages of the place of establishment. Second mission is about time when city was doing well yet. Here we can focus on some important or just interesting situation, time or affair in city's life. For example, the second mission in exploring Joensuu could be devoted to the time of World War II. And third mission could be about present time. Gamer will explore city in its current state. Find out about places of interests, people in the city, firms and education institutions, current economic situation and so on.

It is necessary to keep in mind time spent for each action by player; and even if a mission is incomplete you must say him/her – it is evening already (you have to show virtual clock to the player from time to time).

5.4 Design phase

At this stage we have to create a description of three independent structures: the I/O structure, the game structure and the program structure.

5.4.1 I/O structure

I/O structure consists of input and output. The devices that are used for playing the game are mobile phone or PDA; therefore, the I/O structure should be designed in compliance with the specifics of the used technology. In the same way like computer mobile device has two general means of output: graphics and sound. As we already discussed in chapter 3, graphics is more important because humans are more oriented towards hearing. Due to this fact, the designer of the game for mobile device meets a great amount of difficulties. The reason is that small screen limits the amount of data that can be displayed and restricts the possibility to create complicated graphical elements. The type of information displayed by the mobile device is preferably textual. The same problem concerns sound: comparing to the computer mobile device has poorer sound possibilities (it is mono, it has not so wide frequency bound, and so, the sound quality is much worse).

Crawford claims that graphics and sound are only the means of communication between the player and the game, and nothing more. It should be functional and meaningful and should serve like deliverer of the critical information. The uniqueness of such solution seems doubtful. Latest technologies allow the use of the best quality graphics and sound in computer games, and their utilization only make the game more exciting and enjoyable, but only if this is not a case of dissembling bad game design over the amazing graphics. It is obvious that current mobile technologies cannot provide the means of excellent graphics and sound, but the wise output structure design can provide the player with all necessary possibilities to comprehend the information in a best way.

There is only one way for the player to input the information when he uses a mobile device (let's take a mobile phone) for these purposes: buttons. This restricted possibility demands special attentiveness and thoroughness from the game designer. Each "action-button" correspondence should be well thought-out in order to make an input structure of the game such that not to frustrate and anger the player with its inability to realize human's desire.

5.4.2 Game structure

The main task at this phase is to deliver a game's goal and represent a topic. The designed game is done to provide the gamer with basic knowledge of a city he/she chooses. “Joensuu exploitation” is developed for mobile devices, thus, it is possible to play almost everywhere and in any time. It is possible to use map of a city from a dedicated server and store game results on the server chart (in case the device where the game is started provides the gamer with connection to the Internet).

Developing of this game has second aim: to create a domain model for possible future implementations of the games related to “Joensuu exploration” for other cities.

Scoring

Gamer has two main resources: time and money. Final score of the game is calculated based on amount of money and time spent.

There are mood and other parameters of the personage of the game. These parameters and their changing during game process are taken into account as well.

Formula 1 is used for calculating final score out of spent money, time and final parameters of mood and tiredness.

$$R = T * M – t + m \quad (1)$$

Where:

R – final result;

T – virtual time spent for achieving all goals;

M – money spent for achieving all goals (in euro);

t – tiredness;

m – mood.

Parameters mood is possible to be either positive or negative, zero means the hero is in normal mood. Min value for mood is -100, max value for mood is 100. Tiredness can be from 0 to 100. Hundred for tiredness means the hero is absolutely exhausted.

Narrative

You are playing as a not reach Canadian student – Gogy. You come in Joensuu for an exchange program in computer science. Languages you are able to speak are French and English, so you do not know Finnish and some time you meet people who do not speak any languages you know.

Story starts at the railway station where you come late evening with small sum of money, rucksack and trunk. You need to stay somewhere overnight because you know nobody in the city and you have no place to live here yet.

The first mission you have is finding temporary place to sleep. There is number of hotels in Joensuu and you should decide in which hotel to stay. You have a list of hotels with addresses. You can decide at random in what hotel to go or to drive (you need to hire a taxi in this case), but driving would possibly be not the best choice. You have number of choices how to gather the information you need. Choices are like: ask people, go in some hotels by yourself, take a taxi, etc. Of course each choice costs you some money, time and efforts.

Ones you have chosen a hotel and a room there, you are withdrawn time for sleeping, money for the room but your other parameters like mood and tiredness are changing according the choice you have done. Good hotel with expensive rooms would take more money but you are having there better rest than in other places, so your mood take a turn for the better.

After you have finished the first mission with hotels you are provided with number of new missions. You should always keep in mind your goal which is starting to study without wasting extra time for accommodation and other things.

Next aim you have is to pick up keys from your room; for this purpose you need to go to accommodation organization (Joensuun Elli). It is supposed you arranged a room before you came to Joensuu. Next step is to register in the university, find out where to eat and to drink, get account in local bank, send postcard to your parents, get connection to local mobile operator, etc.

Since you know that you reserved a room in a local accommodation organization you go there next day to pick up your keys. All formal things are negotiated by mail before you come to Joensuu so that you have no problems with place to live. You returned to the hotel you stayed, take your luggage, take a taxi and go to your room.

Further you should register at your university. To be registered you need to have a photo. Of course you have forgotten to pick it up and now you need to be photographed. You go to the local police station and get photos you need.

Have finished with registration you felt starving and decided to go to a café (e.g. Pizza Rax). After supper you go to bank and pay a bill for registration.

Next thing you have to do is to get a student card in Student Union organization because you want at least to have a dinner in university’s restaurant with a discount.

Enough for one day. You go home, unpack you luggage and go to bed.

Next day you have a small breakfast and decide to go to swimming pool after you have gone to international meeting and have participated in basic finish language courses. By the by, on the courses you are taught some useful Finnish phrases.

One more mission you have is shops trip. But there is no problem with it. You just need to find Kauppakatu street where enough shops are placed to supply you with everything you need.

Last mission you have is to visit couple places of interests in Joensuu.

Requirements

The gamer should be provided with mobile phone with high resolution screen (for example from Nokia imaging line (Nokia Imaging 2004) or analogs of other producers) or PDA with ability to connect to the Internet.

These demands are not obligatory. High resolution screen is necessary for showing the map of the region (city). In case the player has the paper version of the map in his/her hands, routine gray scale screen could be used. Another requirement of having connection to the Internet is possible to be excluded if the player does not use on-line map and the player does not want to use any services from dedicated website.

Further in this description the simplest version of the game will mostly be described. Although some extended features will be mentioned.

5.4.3 Playing the game

Here the basic playing lines are described in details.

Welcoming screen

After the player has started the game the welcoming screen is shown. Preliminary view of the welcoming screen is on Fig. 3.

Fig. 3 Welcoming screen

Game mode

The gamer is given two choices at start of the game (see Fig. 4, 5 and Appendix 1, list 1 and 2).

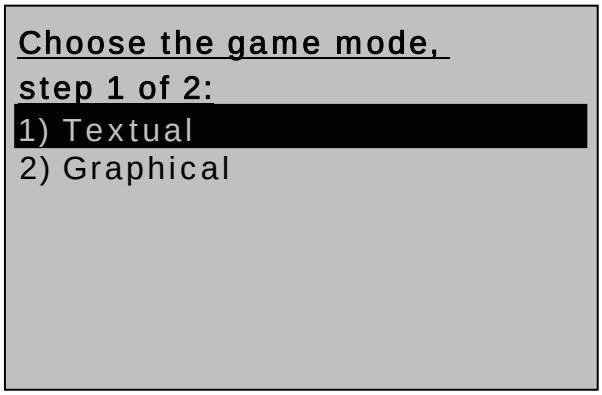

Fig. 4 Choosing mobile device parameters, step 1

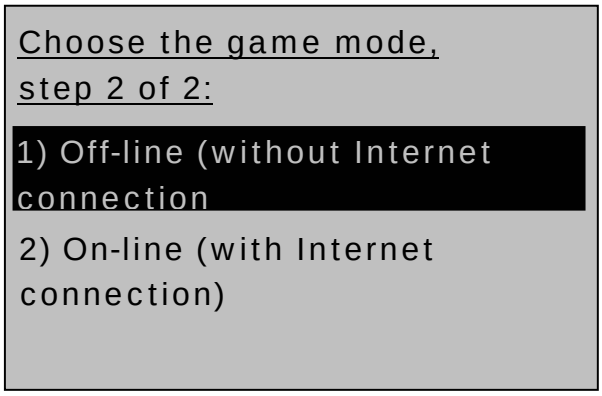

Fig. 5 Choosing mobile device parameters, step 2

These choices are important for providing the user with additional information and media environment such as photos of places or digital map. All lists of choices and list of actions are presented in Appendices 1 and 2. Examples of lists view are shown at the pictures but entire lists for game implementation are in the Appendices.

Choosing a city

Choosing a city is not the feature which has to be implemented in this variant of the game. But for domain model it is important issue. This question is even not logical (because the name of the gameis “Joensuu exploration”), but one should remember that one of the aims of developing this game is to create a domain model. In general, the game can be extended by adding a list of cities to explore; and in this case the question of choosing a city comes to be logical and important. Example of choosing the city list is shown at Fig. 6 (Appendix 1, list 3).

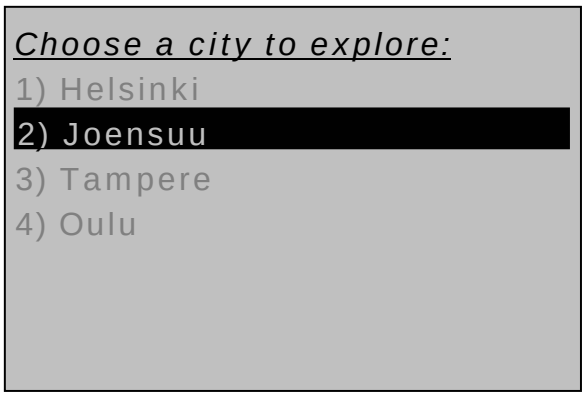

Fig. 6 Choosing a city

Briefly about history of the city

As far as the game is educative we should provide the user with information about the city during gaming process. When the gamer has chosen the city the information about the city (Hyper dictionary 2005) should be provided to the user.

By default user is given couple screens of historical information with ability to get more information by choosing “more information” item in the list of choices following after the text. (Fig. 7-9)

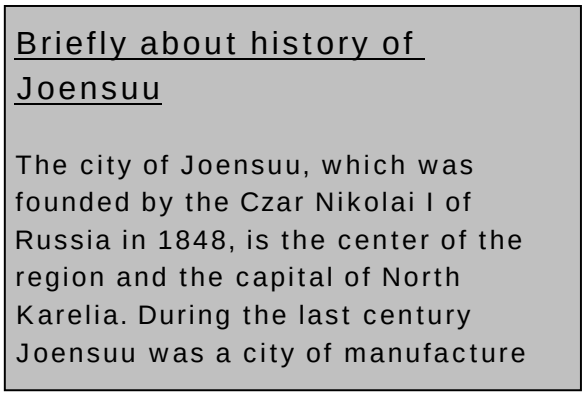

Fig. 7 Historical information, screen 1

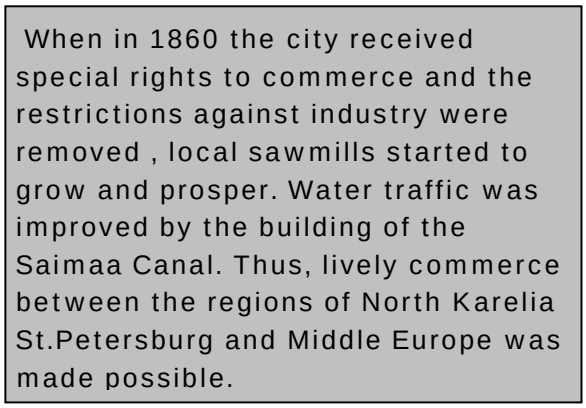

Fig. 8 Historical information, screen 2

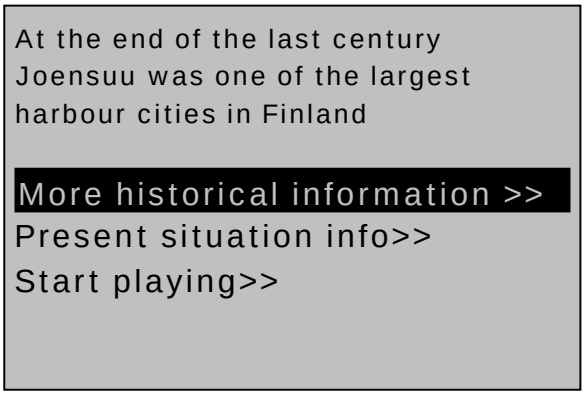

Fig. 9 Historical information, screen 3

By choosing the option - “More historical information” the gamer is provided with information which you can find in the Appendix 2, screen 2.

Description of present situation: place, personage, goals...

During this step the next descriptions are given to the gamer:

- Personage – who is the main hero and his brief history (Fig. 10)
- Place – where the personage is (Fig. 10, 11 and 12)

- Goals – what should be done (Fig. 13)
- Resources – what resources the personage have and how they could be used and recovered (Fig. 14)

Who are you:
You are a Canadian student - Gogy, who comes to Joensuu by an exchandge program.
Where are you:
You are at railway station (Itäranta 12, PL 88, 80101 Joensuu)

Fig. 10 Personage and starting place description

Your train is behind you. On the left hand the railway station building. Almost in front of you (in about 50 meters) taxi station.

Fig. 11 Starting place description

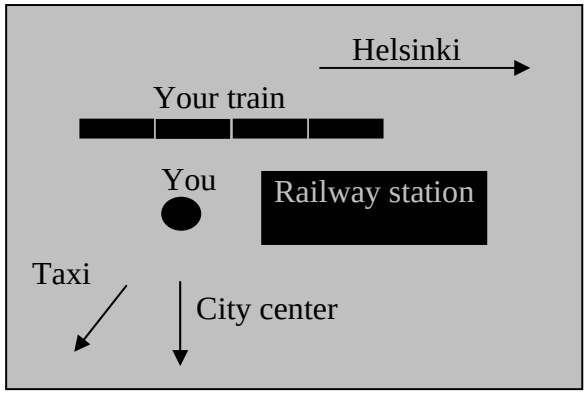

Fig. 12 Starting place image

Your general goals are:
- Starting to live in Joensuu
- Starting to study in the University of Joensuu
- Explore Joensuu

Fig. 13 Goals

Your resources are:
- Time
- Money

Also changeable parameters:
- Mood (has influence on time)
- Tiredness (has influence on mood and time)

Fig. 14 Resources

Choosing a mission

On this stage the gamer has to choose a mission. In the beginning the gamer has only one mission to start – Hotels mission. It is supposed that Gogy comes to Joensuu in time when he has no time to do anything else except finding a place to stay for a night.

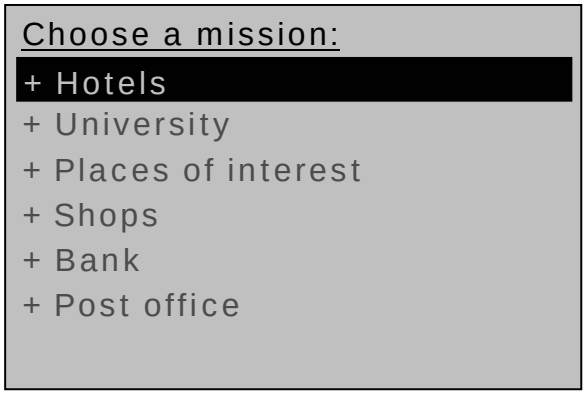

Fig. 15 Mission list. All missions except Hotels are not available.

After user has completed the first mission he is offered with a list of new missions. It is so called adaptive learning (Hyper dictionary 2005). First we provide the user only with basic information and as far as his/her knowledge level is growing we offer more information to percept and elaborate. We do not forbid the user to repeat playing any mission but it takes extra time and money of the user. Screen view of a short list of possible missions is shown at Fig. 15 (Appendix 1, list 4).

Ones a mission is chosen the gamer has two choices:

- General information – provide user with additional information about chosen mission.
- Start mission – gives an opportunity to start mission.

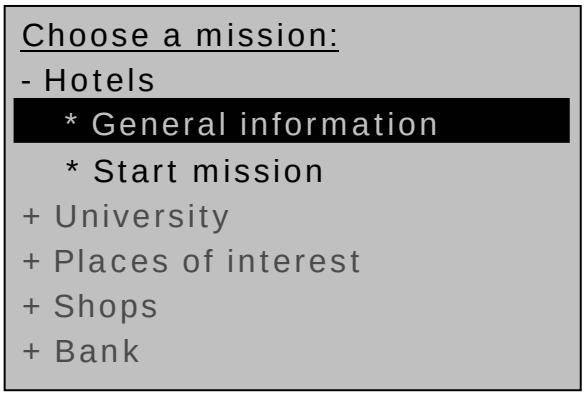

Fig. 16 Mission list. General information and Start mission choices.

Example of this step is shown at Fig. 16 (Appendix 1, list 4).

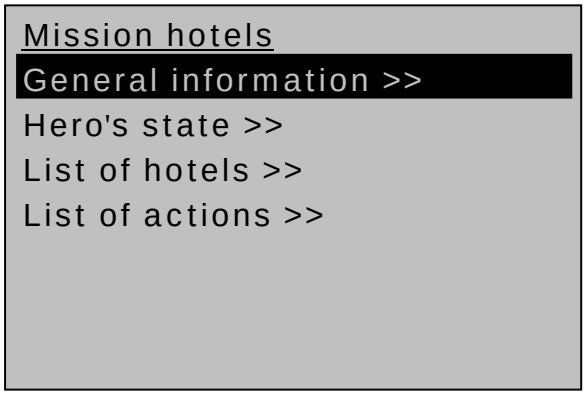

Fig. 17 Mission hotels, screen 1

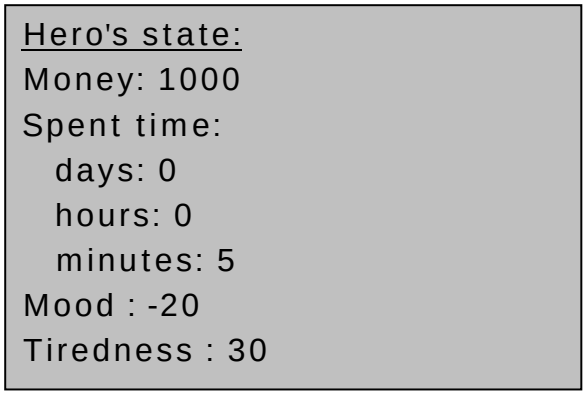

Fig. 18 Hero's state

After the player has chosen start mission he/she should be provided with link to have a look on general information about started mission in case he/she has not viewed it yet (Fig. 17; Appendix 1, list 5). Besides user should be given the information about present location, time of the day, money, mood and tiredness parameters (Fig. 18; Appendix 2, screen 3). Information about location, time, mood etc. should be shown to the gamer in the end of each mission also.

Mood and tiredness has initial values different from zeros because you have done quite long trip from Helsinki.

Mission hotels

First what the hero needs is where to stay for the first time. There are at least three hotels in Joensuu: Sokos, next to the railway station; Atrium, near Central Square; hotel on Lansikatu. First mission for the person who is playing the game is to find out where to stay for the night (or where is the best not expensive room). He or she is not

confined in methods of getting information. Player could go around all hotels on foot, he can take a taxi, he can ask people or a taxi driver what the cheapest hotel is. Each choice costs player some time and money. Player should always keep in mind that he or she has limited money and time.

If you do not have an Internet connection (it means you are not able to visit on-line map service (Map of North Carelia of Finland 2004)) you should have routine paper map of the city. The map is needed for estimating distances to destinations and the distances between them. For example, in this mission you decide not to go to the nearest hotel because often the hotel closest to railway station is not cheap, but you are student and can not afford an expensive room.

General information provided to the gamer you can find in Appendix 2, screen 4.

You are given a list of hotels (Fig. 19; Appendix 1, list 6) with ability to view addresses (Fig. 20; Appendix 1, list 7), it is public information. But prices in the hotels not always available even on official web pages of the hotels (even though some hotels like Sokos provide price information through the Internet). Thus, you should decide where to stay at random or go to some hotels or ask somebody for help.

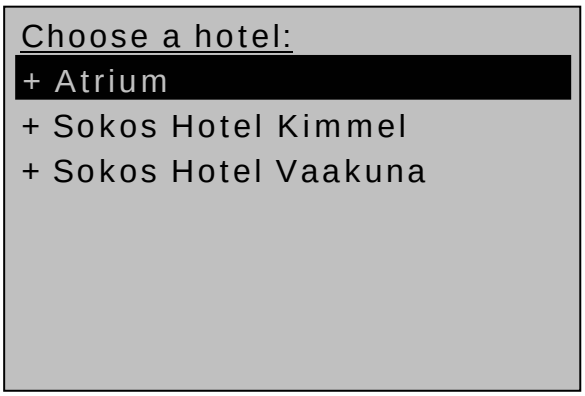

Fig. 19 List of hotels

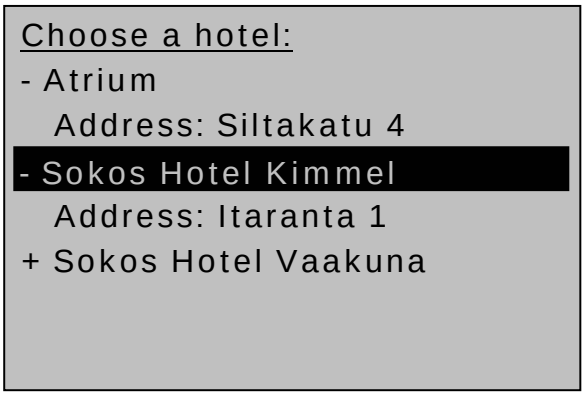

Fig. 20 List of hotels with additional information

Actions list – this list provide the gamer with ability to get information and to perform some actions like walking to a hotel by foot. After an action is chosen some dialog could be started or final result of the action is shown on the screen after a small delay (to imitate executing of the action a little). List of possible actions is shown at Fig. 21.

Content of the list of actions depends on mission and place. Entire list of actions for different places and missions is in the Appendix 1 – lists of actions for different places and missions.

Having chosen “Choose a hotel to go by foot” variant the gamer provided with list of hotels. He/she is able to choose a hotel according to its address (the player can estimate distance with a map of the city) and go there. This choice does not take any money but it takes much more efforts than driving by taxi and it is possible to make a bad choice (too expensive for example). Taxi drivers are always well informed about accommodation, prices, etc. There is a taxi station near the railway station. May be it is better to go there and ask somebody.

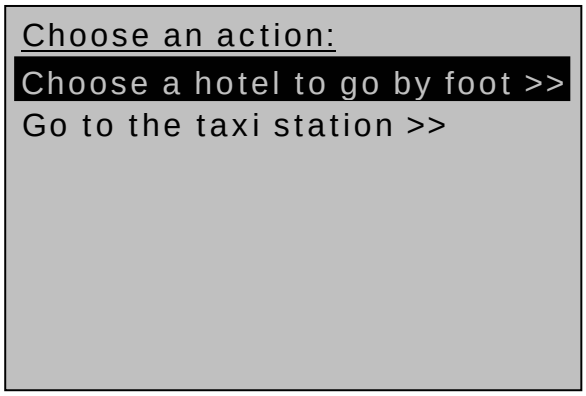

Fig. 21 List of actions on railway station for the Hotels mission.

On the taxi station you see number of taxis. You can come to one driver and ask him/her about accommodation for the night. On the taxi station you have a list of actions presented on Fig. 22 (Appendix 1, list 9).

Choice “Hire a taxi” is similar to “Go to a hotel by foot” but it takes less time and more money.

Having chosen “Ask driver a taxi” you enter to a small conversation. You will have answers depends on your question. For example, if you are polite it is more possible to get entire and helpful answer. But if you are rude you can not to have any answer at all. Example of a conversation is on Fig. 23-26 (Appendix 1, lists 7-11; Appendix 2, screens 5-12). The answer’s number you get from the taxi driver is calculated by formula 4.

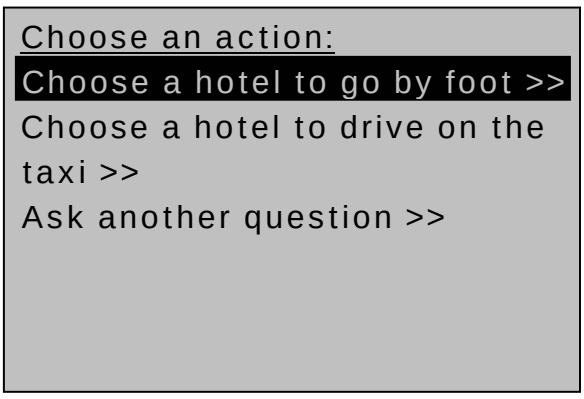

Fig. 22 List of actions at the taxi station.

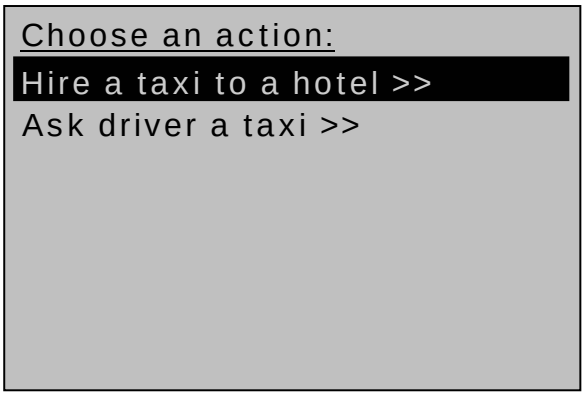

Fig. 23 List of actions on the taxi station

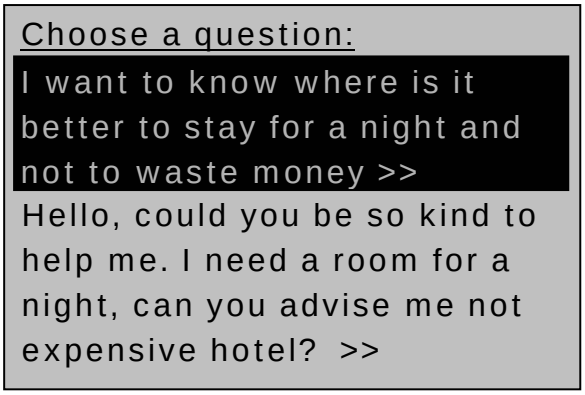

Fig. 24 List of questions to a taxi driver

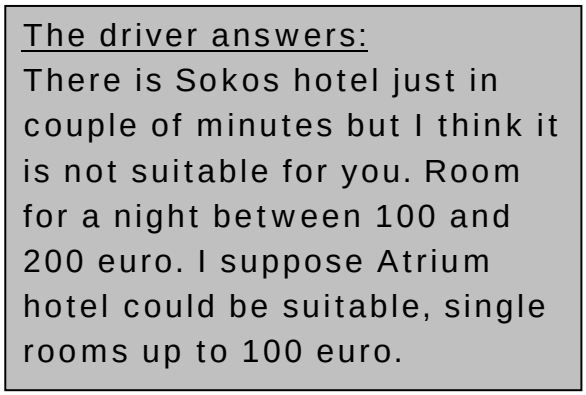

Fig. 25 Example of the taxi driver you have asked

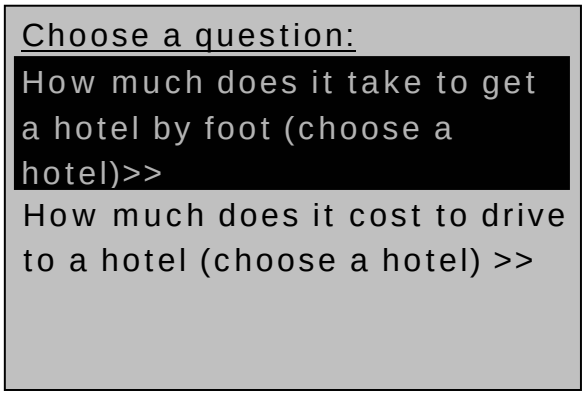

Fig. 26 List of question to the taxi driver

“Ask another question” on Fig. 25 (Appendix 1, list 7) follows the list on Fig. 26 (Appendix 1, list 11). There the gamer chooses the hotel to go or to drive and after the hotel has chosen the answer of the driver is shown on the screen (see Appendix 2, screens 8-12).

Having finished with the driver you come to the chosen hotel. You are withdrawn some money and time. If you go by foot it is possible your mood is down and your tiredness is rise.

Formula 2 shows dependences of mood out of tiredness. Mood is recalculated every hour.

$$m = \text{if}(t > 50) \text{ then } m = m - 10 \qquad (2)$$

Where: m – mood; t – tiredness.

Tiredness could be changed because of long walk, bad sleeping, etc. Formula 3 shows examples of rules of changing the tiredness parameter.

$$\begin{aligned} t = {} & \text{if}(\text{sleeping bad}) \; t = t - 10 \\ & \text{if}(\text{walk more than 30 minutes}) \; t = t - 5 \\ & \text{if}(\text{walk more than 30 minutes with luggage}) \; t = t - 15 \end{aligned} \qquad (3)$$

In the hotel you should find out real prices and available rooms. You have a talk with the hotel receptionist (see Fig. 27, 28; Appendix 1, list 12; Appendix 2, screens 13-16). It is possible that there are no rooms available or rooms left are too expensive and you are advised to go to another hotel or should take expensive room and spend extra money.

Lists 13-16 in the Appendix 2 contain prices. Exact price should be derived out of table 1 according to the hotel you have come.

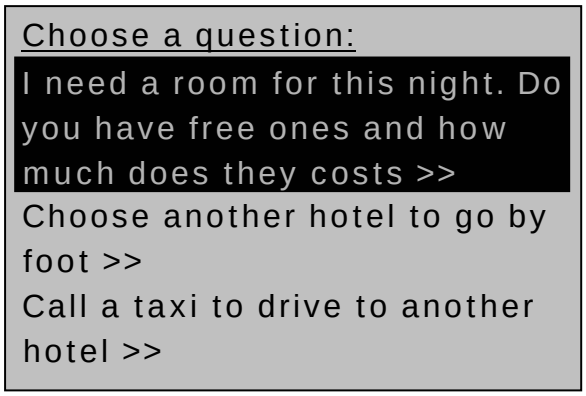

Fig. 27 List of questions to the receptionist

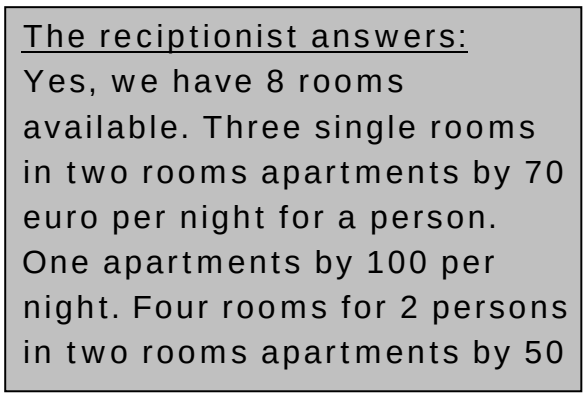

Fig. 28 Example of the receptionist you have asked

Table 2 Prices for rooms in hotels in Joensuu

Hotel	Prices (euro per person)					
	Single apartments		Single superior apartments		Double apartments	
	Work day	Weekend	Work day	Weekend	Work day	Weekend
Atrium	74	64	91	75	101	75
Sokos Kimmel	114	114	132	132	156	156
Sokos Vaakuna	100	78	-	-	116	78

The answer's number you get from receptionist is calculated by formula 4.

$$N = random(4) \quad (4)$$

Where: N – number of the answer, random(4) - return random number from 1 to 4.

In the end of the mission (in the morning) you are shown the information screen (see Pic. 15).

Mission shops

You need to explore where the shops are. So you should first find Kauppakatu street on your map and reach it. General information about the mission is shown at Fig. 29.

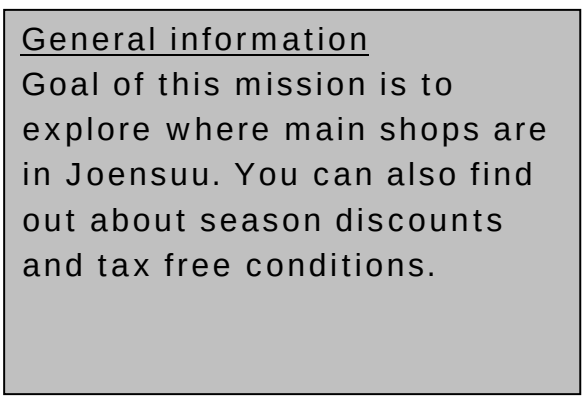

Fig. 29 Mission Shops, general information

Mission bank

To register in the university and to live by normal life you need to get a bank account. So you have to go to office of Nordea bank on the main square. Thorough design of this mission is part of future work.

Mission University

In this mission student should register in the university. This mission is represented by flow-chart (see Fig. 30).

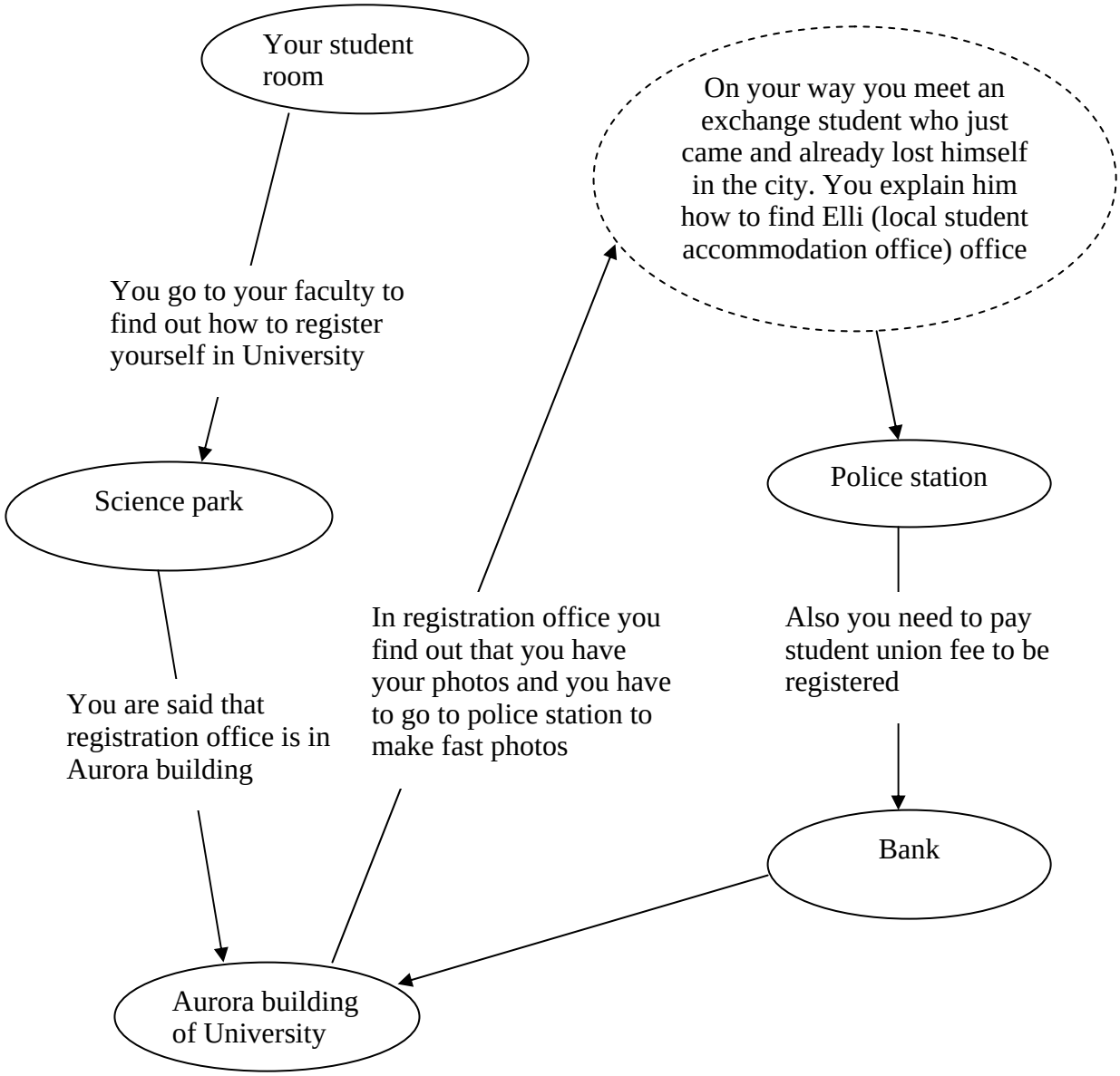

Fig. 30 Flow chart of University mission

This general graphical representation of the mission (which possibly could be provided for all missions in the game) represents in high level the events in the mission and their general sequence. This presentation of the mission could be used for discussions with creative group how the mission could be rendered for the user, which features to include. Also flow chart could be useful for working with development group. Even through the engine of the game is based also on charts of state and their connections (see Appendix 3) this flow chart is useful for adjusting the engine for particular mission.

5.4.4 Extended features

- We can connect the game to a server in the Internet for making a chart of player results.
- Comparison of players' results could be done in this way: in the end of the game we recalculate money, spent time and other parameters into some abstract value and compare results by this value. The best players could be called "smart poor student". We can encourage somehow else the best players.

5.5 Graphical mode

The textual mode was chosen as the main design approach for the current application and was described in detail. However, the contemporary demands to the game design and development imply utilization of innovative ways of displaying data to the player. Therefore, it is no less important to introduce the design of graphical mode for the application which can be represented in two different ways depending on the chosen format: 2D or 3D.

5.5.1 3D vs. 2D

While playing a game one can desire to explore an amazing environment, to imagine himself immersed in a game as a character he is controlling (Zelda 2004). The introduction of the 3D era has made such features possible to experience in games. In order to understand the possibilities of 3D graphics in games it is necessary to consider the difference between 2D and 3D. Both of them are the ways of representing the data to the player, both are viewed on a 2D screen (Howland 1998). The primary difference is in information storage: 2D images are stored as pre-drawn image files, while in order to display 3D image it is necessary to store information about the object. 3D objects can be viewed from any angle on the screen, while to view an object drawn from a 2D image from more than one angle it is needed to have

its pre-drawn 2D images from different angles. Moreover, in case one need to animate 2D object it would take several times more resources comparing to the animation of the object saved in 3D format.

To understand what kind of format is more suitable for the designed application, it is useful to discuss, at least briefly, the advantages of both 3D and 2D.

The main advantage of the 3D format is its flexibility. It can be considered in three different senses: (1) The presented to the player environment: in 3D games the world can be drawn from any angle. (2) The animation of the 3D objects: there is a possibility to assign the deformation and movement rules for 3D objects. (3) Simplicity of object creation: 3D objects can be made simply by using mathematical equations or by placing primitive objects together to create a new object on the fly.

2D format images have some advantages as well: (1) 2D images can be drawn in more detail (with more curves, faces and points) than 3D. This advantage can have a great significance if the game does not require rotating views. (2) 2D images are relatively fast to draw and process because all the graphics is pre-made. (3) It is faster to develop 2D display engines. (4) Many novice players or non-gamers find it easier to play in, understand and control the 2D interface better. This is a crucial fact especially for educational games and for the games that are designed for mobile devices since the input is limited even more that for computer.

So, when designing a game and choosing its format, it is necessary to decide, how the game is going to look like and how it will be controlled. If the game needs a lot of flexibility, animations and there is enough time and resources, then 3D display engine would be the best choice. If flexibility is not the primary condition, if the game needs to have best-quality images and a short development time, then one should choose 2D. The point is not to look what is better – 3D or 2D – but to find out, what format will satisfy the needs of the game in the best way.

In spite of the fact that 3D games have a great popularity today, there are a lot of voices in favour of 2D games as much more fun, enjoying and challenging (Zelda 2004). After 3D format became possible to use for games game designers has started to pay more attention to creation of the fabulous environment which player can explore and experience. Due to this, the gameplay that has a great importance for 2D games became the minor aspect in 3D (Laramee 1999a). The rise of 3D gaming caused the increased importance of story. 2D games are felt much more like games itself, while with 3D in some cases player, instead, has an "access" to a different world, the chance to see himself "in the game" (Zelda 2004).

For the designed application both 2D and 3D approaches are outlined. Each design has its benefits and disadvantages; and depending on the available resources and current needs any of them can be realized.

5.5.2 2D approach

But there is a possibility to choose a graphical mode in the application (this is made at the first step, in the beginning of the game, see Fig. 4). In case of graphical mode the basic requirement is availability of the power mobile device (smart phone or PDA) with the color depth 16 bits.

Fig. 31 represents an example of graphical mode screens for the mission Hotels.

Fig. 31 Graphical mode

The right part of the screen displays the information about the player: his picture and characteristics that describe his state: amount of money and current time (in the right upper corner). The left part of the screen represents changeable information: it displays the current mission and location (e.g. the sign in the left upper corner at the Fig. 31 indicates that player is currently at the Taxi station while passing the mission Hotels) and the person he speaks to. The upper part of the screen forms the *statistics panel* which includes the most necessary information for the player during the game: his location, current mission, the amount of money available and time. It is also possible to include to statistics panel such characteristics like energy (which changes depending on amount of physical efforts for performing any kind of action) and mood (which depends on how much the character likes the action he is performing). Each option chosen by the player demands different amount of money, time and energy which are visible for the user while making choice. According to the player's decision the statistics parameters are changed. It is possible to represent these parameters in form of statistic bars which change their color depending on the current situation (e.g. if you are full of energy, the bar is completely filled and has a green color; but if you are exhausted, the bar is almost empty and red).

The conversation between the player and the character he meets displayed in form of text messages that appear on the screen (Fig. 32).

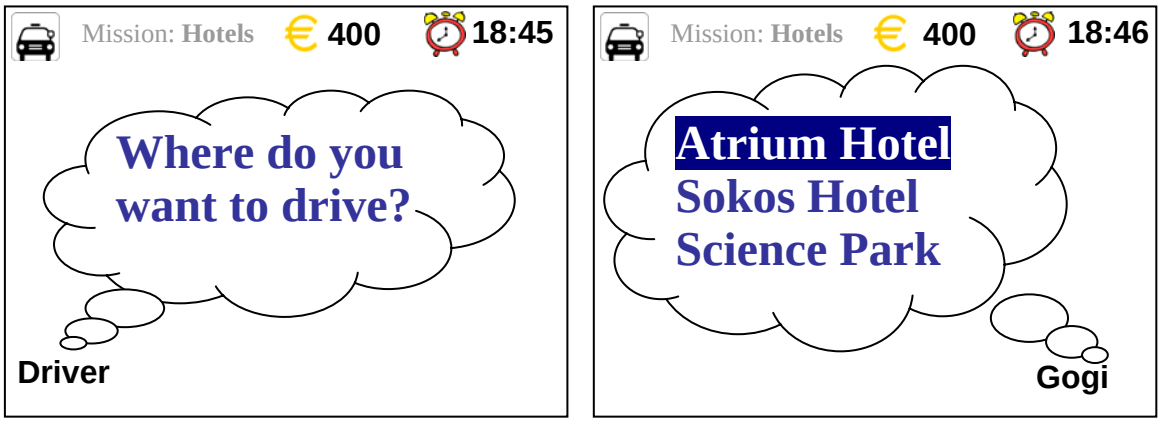

Fig. 32 Conversations

Statistics panel is the only part that is permanently visible to the player independently on the happenings on the screen. The player's questions and answers are represented in form of lists (for example at the Fig. 30 player can choose the hotel he would like to drive). Players answer defines the next step in the game.

If the mission is over, he can start a new one. In this case the indication in the left upper corner will be changed according to the mission and location from which this mission begins. If, for instance, mission "Bank" begins, the taxi sign will change to the euro coins image (show that his location is being the bank) and the word "Bank" will appear instead of the word "Hotels".

Graphical mode gives a possibility to have an electronic map of the explored city in the device memory. In this case player has an option of viewing his current position at the map as well as the entire set of directions he can go in order to complete the mission. In order to reach some place student must point it on the map, this action throws pop-up menu with possible means of reaching the place (the preferred way is chosen by default). Fig. 33 shows an example of the map.

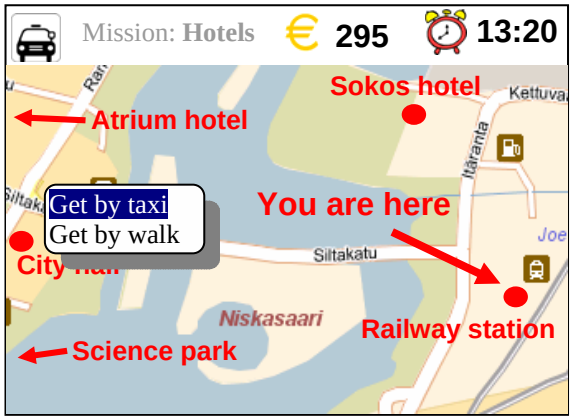

Fig. 33 City map

5.5.3 3D approach

This approach is based on 3D graphics and animations. The way of introducing it in current work is describing the main line of the game and basic features.

The game begins from introductory video that is represented in form of short animation. It shows the name of the game and leads to the next short animation about the missions. Each mission name is represented in form of button and has a short textual description that pops up when pointing to the appropriate button. Clicking the button means choosing the mission which starts with another short video and immerses the player into the game (for example, at the beginning of mission "Hotels" player finds himself at the railway station). The game guidelines are given in form of animation which ends with city map appearance where player can find all the places he needs to visit. Right after clicking the point (e.g. hotel "Sokos") the pop-up menu appears suggesting the way of getting there (by taxi or by foot). Appropriate statistics for each way (cost, time, …) is given on the panel. After user makes his choice, he is shown an animation in third person perspective of either the taxi or walking person. In case of first person perspective it the animation can represent the view of the oncoming and augmentative hotel.

After reaching the hotel player clicks on the hotel "hot point". This action executes the animation at the reception desk where player chooses a room. The action of taking a key activates an animation of moving to the room. Mission "Hotel" is finished. The next step depends on player's choice. After completing a mission player can start any other, but he should remember that some of them are not available until some actions are done. For example, player cannot get a student card until he register at the University. Mission ends while meeting some event – different for every mission. From here we can conclude that student can come to the same mission from different entry points. This opens a possibility for the player to experience the game several times in different ways.

One more point that might be included in the design of such kind of game is unexpected events which break the general flow of the game. For example player can meet some other student who has got lost in the city and asks for a help. Such points are interesting to experience for the player, they make the game such that one would play to enjoy the game, but not to win.

5.6 General flowchart

General flowchart of the game (Fig. 34) represent sequences of actions on the highest level of the game like introductory video, choosing a mission or ending a game.

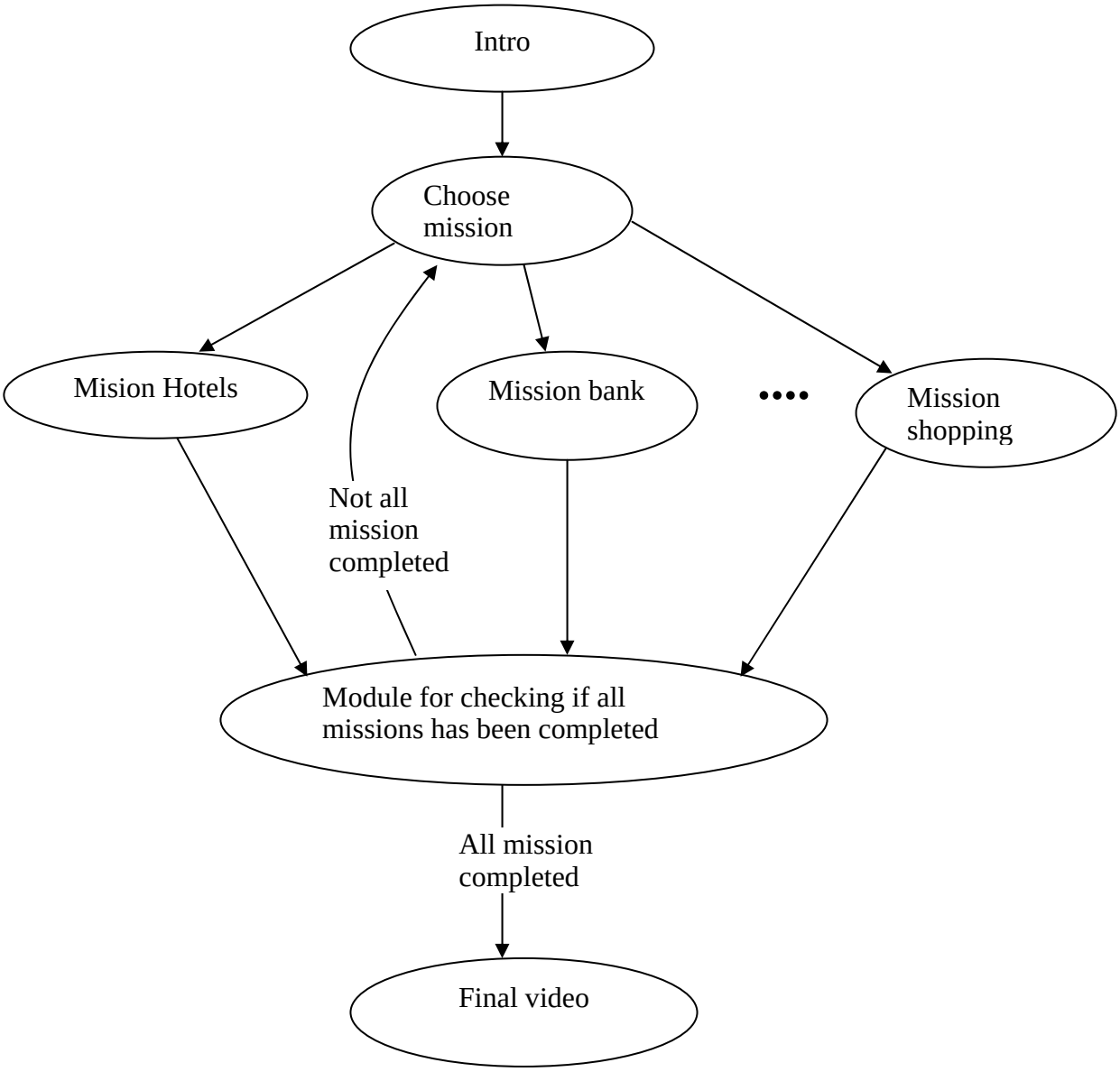

Fig. 34 General flow chart

There is also a map of the game which represents the graph of possible places or positions in Joensuu which should be visited by main personage during the game. It also contains cost ranges of moving between different locations. All time ranges are given for walking; driving by a taxi would not take more than 10 minutes to any position from anyone. Money ranges are given for taxies. It's clear that walking is for free.

Appendix 3 contains several maps of the game which differ depending on the current position of the player. When the player is at the position for which there is no separate map, it means that he can leave it only using the way he came into it.

The map of the game is created mostly for game developers, but on the game design stage by game designer.

5.7 Implementation description

The third part of the game design phase is program structure. Implementation of the game was done partly. It includes the simplest version of the game interface. The program is written using J2ME technology. CLDC and MIDLets API have been used. The listing of the program can be found at the Appendix 4.

The content of the implemented part is fully compatible with the Description of City Exploration game part. Game engine is a part of future work process.

Fig. 35 illustrates several screenshots of program implementation of designed game.

Fig. 35 Screenshots of implemented game interface

5.8 Conclusion

This example of game design is does not pretend to be prefect in following all the rules mentioned while describing the methodology of the game design process. The key point was to show in practice at least some game design rules. Besides restrictions imposed by mobile environment were taken into account.

6 Summary

Designing a game is always a challenge. Designing an educational game for mobile environment is the challenge that demands plenty of work, investigation activity, imagination, inspiration, creative thinking support and persistence from the game designer.

This paper had an aim to consider the game design process, formalize it and give some points for game designers to take into account. Besides the game design process was examined from educational point of view and in mobile environment scope.

The general problem considered in this thesis was how to design game based educational applications for mobile environment. One of the first questions considered in this thesis was "What is game?" During the consideration of presently available game definitions it was found out that no one suits to our view to the question under consideration. We have introduced our own definition of the game through its elements based on studied game definitions. As we consider a specific type of the game that has a specialization for educational purposes and is designed for mobile devices, it was necessary to introduce two peculiar characteristics: educativity and mobility. *Mobility* is a combination of several estimations: mobility level (within the limits of one room, one building, one town, country, world), mobile technologies utilization (mobile phones, PDA, or some kind of complex system designed specially for the game purposes), place type (indoor/outdoor, city/countryside, dry land/sea, etc.). *Educativity* is a set of constituents: educational level (how much education itself the game comprises), field of education (history, music, astronomy, etc.), difficulty (can be divided for example by players' age).

Another important problem of the research work was to define the steps of the game design procedure. Different researches present their own view to this question. The game design procedure presented in this thesis was compiled after investigation and revision of several approaches. The task was also to make a specialization of these steps for educational purposes in scopes of mobile learning environment. Significant part of this work was devoted to the investigation of the interconnections of the playing and learning in scopes of mobile environment. It has been found out that the original motivation for playing games is learning, besides, the education process flows much easier and more effective during the play. Mobile environment imposes some limits on game design, game itself and game players (small display size, limited input for player, etc.). However, mobility gives plenty of opportunities to utilize

(e.g. ability to study at any time in any place). Mobile environment specifics and educational aspects should be taken into consideration while designing process. Based on this we introduce a new sub-step on the step of design treatment (game design procedure) which handles questions connected to mobile scopes and educational aspects.

Theoretical research served as a basis for designing a practical application. While performing design of the game we've got a new understanding of some theoretical points (like definition of the game and game design steps) which were adjusted accordingly, and these changes have been described above. Besides, some practical points of edutainment mobile applications were got, and they are outlined below.

The importance of game flowcharts construction was discovered and it seems to be essential not only for game designer alone but for the whole design team. Since this point reveals itself at the late stage of this work, we provide not the full set of game flowcharts but some of them.

Besides, while considering the graphical mode of the game we have come to the idea that it is more convenient for such kind of applications (at the present moment) to use 2D format. This format is more suitable because we are not going to have the views to the object from different angles. Moreover, as far as we design the game for mobile devices, we take into account that such devices mostly do not have special graphical cards which perform complex mathematical operations for creation of the 2D representation (on the screen of the computer or mobile device we always have 2D image) of the 3D objects from different angles.

For testing purposes a part of designed application was implemented using J2ME platform.

The research field of the thesis is obviously huge and many-sided. This work could hardly be considered as finalized regardless on volume of done work and investigation stage. Surely it is possible to make some improvements, like reorganization of the thesis in a way that theoretical part would be not separated form practical (even though some major theoretical definitions must be provided first), but in a way when we constantly refer to the theoretical works while designing the game.

Undoubtedly the research could be continued. The possible directions of further work could be devoted to further design and implementation of presented application (even its theoretical aspects) and to deeper exploration in area of mobile applications usability.

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Appendices

Appendix 1. Lists of choices

General lists

Choose the game mode, step 1 of 2

- Text mode
- Graphical mode

List 1 – Choosing the game mode - Screen

Choose the game mode, step 2 of 2

- Off-line (without Internet connection)
- On-line (with Internet connection)

List 2 – Choosing the game mode - Internet connection

Choose a city to explore

- Helsinki
- Joensuu
- Lappenranta
- Oulu
- Tampere
- Turku

List 3 – Choosing a city to explore

Choose a mission

- Hotels

    General information >>

    Start mission >>

+ University

+ Shops

+ Bank

+ Places of interest

List 4 – Choosing a mission

Mission hotels

General list of choices

- General information >>
- Hero’s state >>
- List of hotels >>
- List of actions >>

List 5 – General list of choices

Railway station

- Choose a hotel to go by foot >>
- Go to taxi station >>

List 6 – Railway station, list of actions

Taxi station

- **Choose a hotel to drive by taxi >>**
- **Choose a hotel to go by foot >>**
- Talk to a taxi driver >>
- Ask another question >>

List 7 – Taxi station, list of actions

Choices in bold text are shown all the time, others depend on situation.

Choose a hotel

- Atrium
  - Address: Siltakatu 4
- Sokos Hotel Kimmel
  - Address: Itaranta 1
- Sokos Hotel Vaakuna
  - Address: Torikatu 20

List 8 – Choosing a hotel

Taxi station

- Hire a taxi to a hotel >>
- Ask driver a taxi >>

List 9 – Choose an action on the taxi station

Choose a question

- I want to know where is it better to stay for a night and not to waste money >> *appendix 2, screen 5*
- Hello, could you be so kind to help me. I need a room for a night, can you advise me not expensive hotel? >> *appendix 2, screen 6*
- Do you know where is the less expensive rooms for a night in Joensuu? >> *appendix 2, screen 7*

List 10 – Questions 1 to a taxi driver

Choose a question

- How much does it take to get the hotel by foot (choose the hotel) >> *List 8*
- How much does it cost to drive to the hotel (choose the hotel) >> *List 8*

List 11 – Questions 2 to a taxi driver

Choose a question

- I need a room for this night. Do you have free ones and how much do they cost >> *appendix 2, screens 13-?*
- Choose another hotel to go by foot >> *list 8*
- Call a taxi to drive to another hotel >>

List 12 – Questions 1 to the receptionist

Appendix 2. Information screens

General lists

Briefly about history of Joensuu

The city of Joensuu, which was founded by the Czar Nikolai I of Russia in 1848, is the center of the region and the capital of North Karelia. During the last century Joensuu was a city of manufacture and commerce. When in 1860 the city received special rights to commerce and the restrictions against industry were removed , local sawmills started to grow and prosper. Water traffic was improved by the building of the Saimaa Canal. Thus, lively commerce between the regions of North Karelia St.Petersburg and Middle Europe was made possible. At the end of the last century Joensuu was one of the largest harbor cities in Finland.

Screen 1 – Briefly about history of Joensuu

More historical information

Throughout the centuries Karelian traders have traveled along the Pielisjoki River. The river has always been the lively heart of the city. Canals, which were completed at the end of 1870, increased the river traffic. Thousands of steamboats, barges and logging boats sailed along the river during this golden age of river traffic. The Pielisjoki River has also been an important log-raft route, providing wood for the sawmills and for the whole lumber industry.

During the last few decades, the small agrarian town has developed into a vital center of the province. Success in regional annexations, the establishment of the province of Karelia and investments in education have been the most decisive actions in this development. The University of Joensuu has in twenty-five years grown to have five faculties. The Universities is one of the secrets for the vitality of the city and of all North Karelia. Diversified international cooperation in science, industry and commerce benefits the whole region.

The nearness of the eastern border has been an important factor in the history of the city. The Republic of Karelia is once again a significant area for cooperation with nearby regions in Russia. Export companies in Joensuu continue traditions in foreign trade of the last century. The city itself gives many possibilities for different kinds of activities. High-quality cultural events and clean nature increase the attractiveness of the city.

Screen 2 – More information about history of Joensuu

Hero's state

Money : *present amount of money*

Spent time:

days: *number of spent days*

hours : *number of spent hours*

minutes : *number of spent minutes*

Mood : *value of mood variable, from -100 to +100*

Tiredness : *value of tiredness variable, from 0 to 100*

Screen 3 – Hero's state information

Mission hotels

Mission hotels - general information

You have to find a place to spend this night. You are given number of hotels with supplement information like address, room information. Using map and asking virtual heroes you should decide where to stay.

Screen 4 – General information about mission hotels

The driver answers

No, I`m sorry I do not know.

Screen 5 – The driver`s answer 1

The driver answers

There is Sokos hotel just in couple of minutes but I think it is not suitable for you. Room for a night between 100 and 200 euro. I suppose Atrium hotel could be suitable, single rooms up to 100 euro.

Screen 6 – The driver's answer 2

The driver answers

There is a small hotel on Lasikatu street, rooms are about 50-100 euro.

Screen 7 – The driver's answer 3

The driver answers

It takes about 3 minutes.

Screen 8 – The driver's answer 4

The driver answers

It takes about 10 minutes.

Screen 9 – The driver's answer 5

The driver answers

It takes about 30 minutes.

Screen 10 – The driver's answer 6

The driver answers

It costs about 6 euro.

Screen 11 – The driver's answer 7

The driver answers

It costs about 9-10 euro.

Screen 12 – The driver's answer 8

The receptionist answers

Yes, we have 8 rooms available. Three single rooms in two-rooms apartments by 70 euro per night for a person. One apartments by 100 per night. Four rooms for 2 persons in two rooms apartments by 50 euro per person. What room would you like to choose?

Screen 13 – The receptionist's answer 1

The receptionist answers

You are lucky. There is only one room left. It is single apartments. Price is 100 euro per night.

Screen 14 – The receptionist's answer 2

The receptionist answers

I'm sorry, but we don't have any free rooms at the time. You should find out if there are free rooms in other hotels.

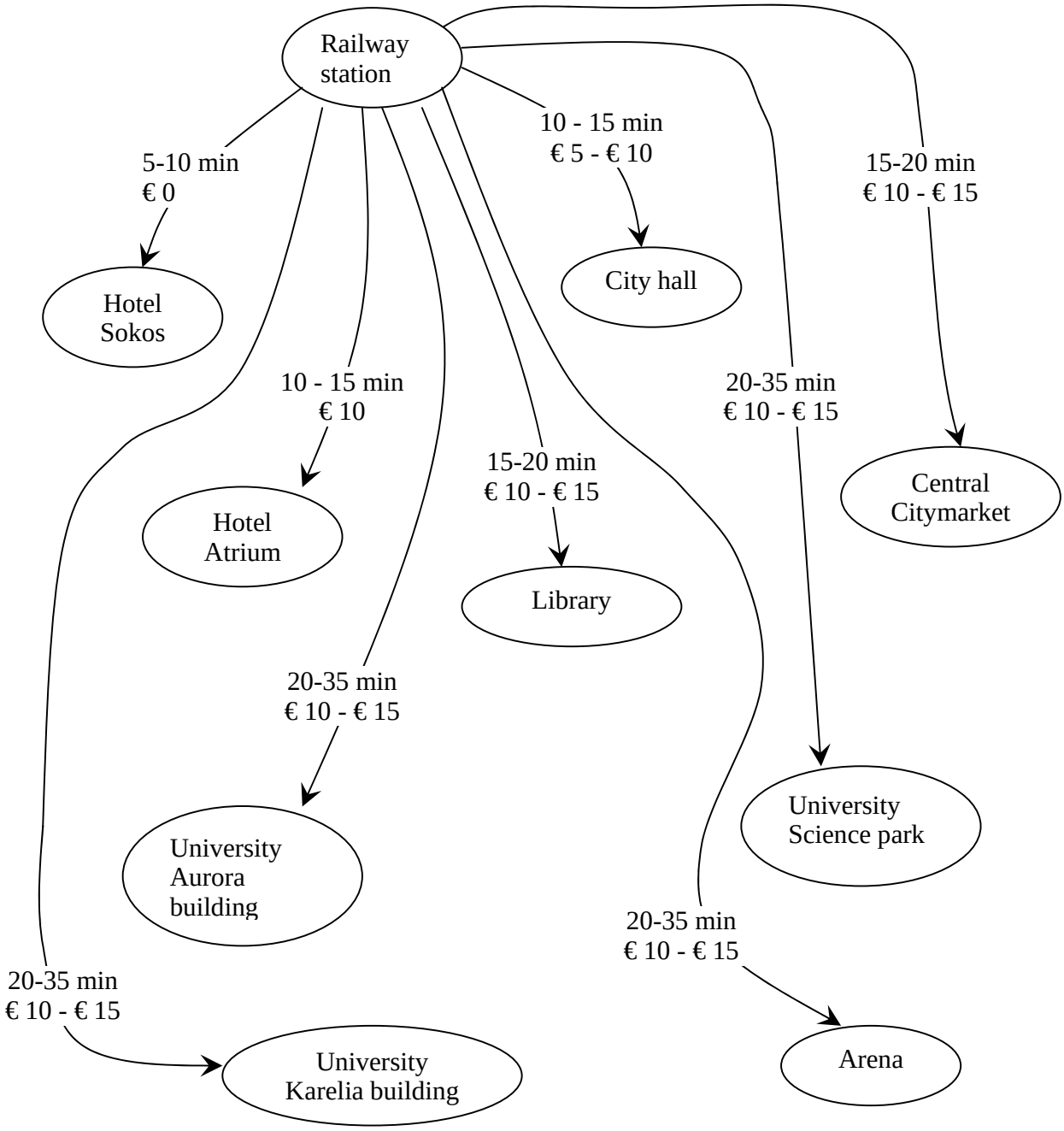
Screen 15 – The receptionist's answer 3

The receptionist answers

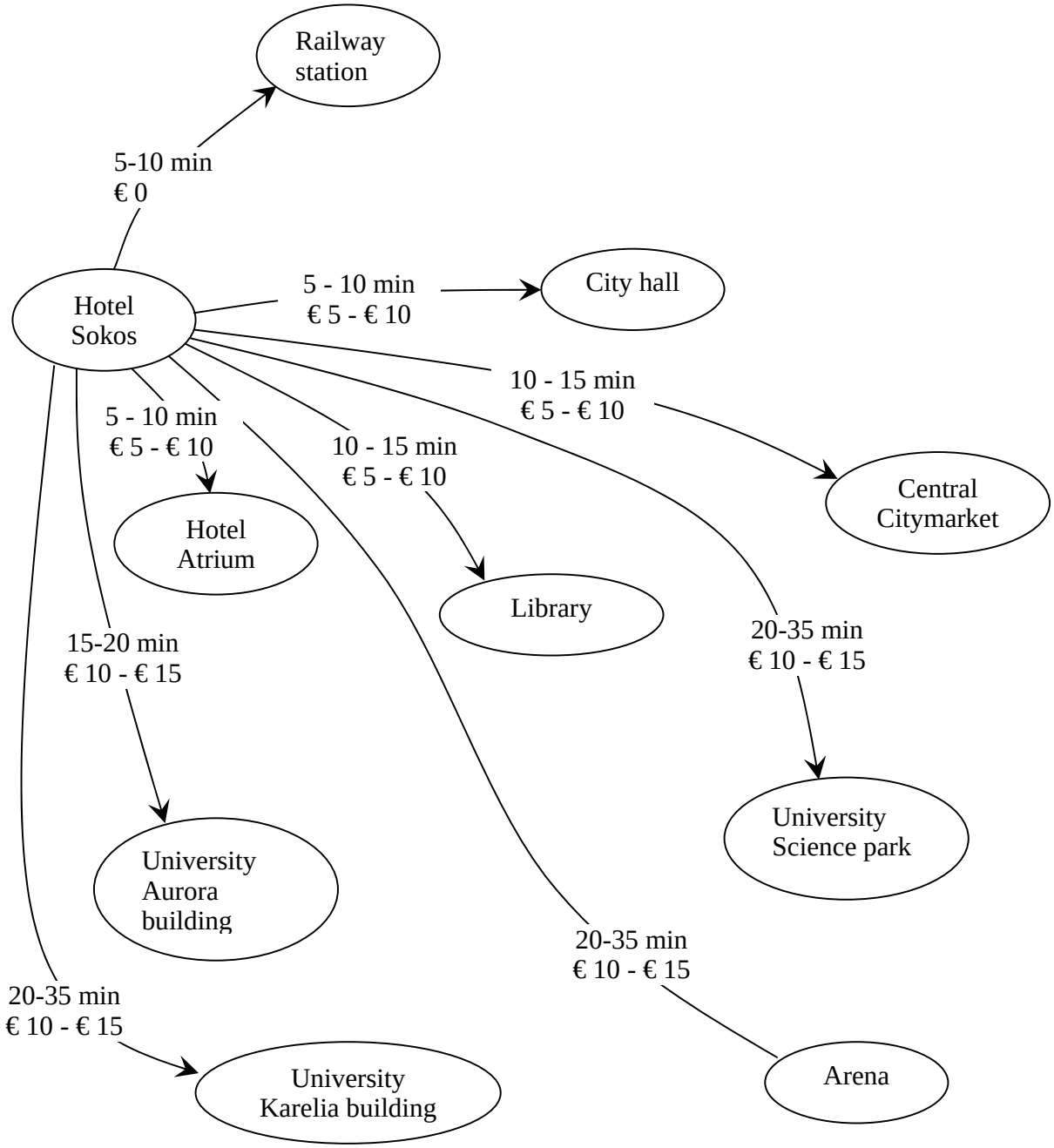
We have one room in two rooms apartments. Price is 70 euro per night.

Screen 16 – The receptionist's answer 4

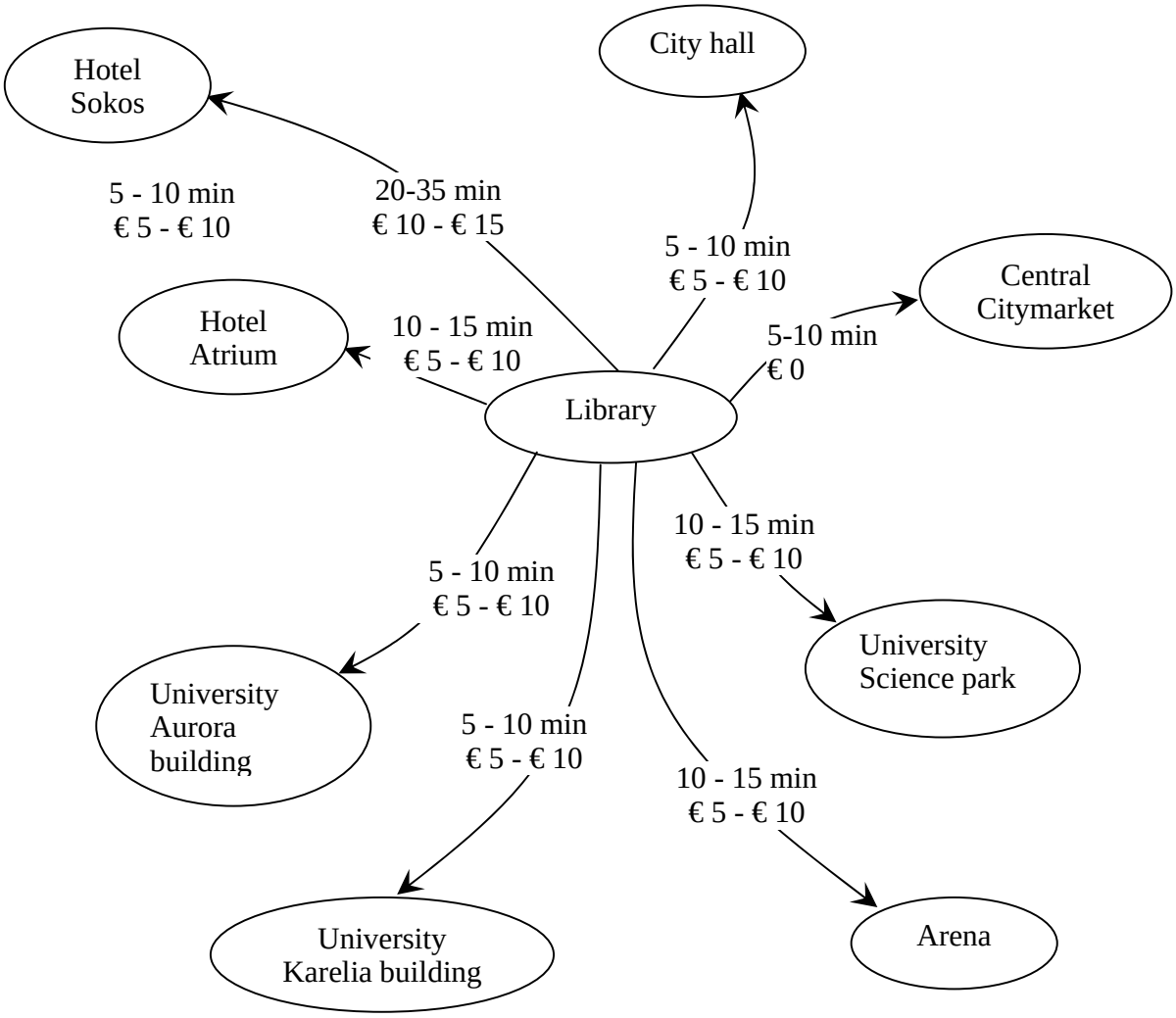
Appendix 3. Game maps



Map of possible moves from Railway station



Map of possible moves from Sokos hotel



Map of possible moves from Library

Appendix 4. Program listing

```
/*******************************************
 *                                         *
 *      Basic user interface implementation  *
 *      of the City Exploration game         *
 *                                         *
 *     University of Joensuu               *
 *      Department of Computer Science       *
 *                                         *
 *      Author: Igor Razumnyy               *
 *      Date:   04.06.2005                  *
 *      E-mail: irazum@cs.joensuu.fi         *
 *                                         *
 *******************************************/


import javax.microedition.lcdui.*;
import javax.microedition.midlet.*;

public class CityExploration extends MIDlet implements CommandListener {
  //System variables
  private Display mDisplay;
  private String currentMenu = new String("");
  private String previousMenu = new String("");

  //Game user interface variables
  private List gameModeList_1;
  private List gameModeList_2;
  private List cityList;
  private List gameStartList_1;

  private String briefHistoryJoensuu = new String (
  "The city of Joensuu, which was  founded by the Czar Nikolai I of Russia in 1848" +
  "is the center of the region and the capital of North Karelia. During the last" +
  " century Joensuu was a city of manufacture and commerce. When in 1860 the city" +
  " received special rights to commerce and the restrictions against industry were removed," +
  " local sawmills started to grow and prosper. Water traffic was improved by the building" +
  " of the Saimaa Canal. Thus, lively commerce between the regions of North Karelia" +
  " St.Petersburg and Middle Europe was made possible. At the end of the last century" +
  " Joensuu was one of the largest harbor cities in Finland");

  private String moreHistoryJoensuu = new String (
  "Throughout the centuries Karelian traders have traveled along the Pielisjoki River." +
  " The river has always been the lively heart of the city. Canals, which were completed" +
  " at the end of 1870, increased the river traffic. Thousands of steamboats, barges and" +
  " logging boats sailed along the river during this golden age of river traffic." +
  " The Pielisjoki River has also been an important log-raft route, providing wood" +
  " for the sawmills and for the whole lumber industry." +
  "During the last few decades, the small agrarian town has developed into a vital center" +
  " of the province. Success in regional annexations, the establishment of the province of" +
  " Karelia and investments in education have been the most decisive actions in this
development." +
  " The University of Joensuu has in twenty-five years grown to have five faculties. The
Universities" +
  " is one of the secrets for the vitality of the city and of all North Karelia. Diversified" +
  " international cooperation in science, industry and commerce benefits the whole region." +
  "The nearness of the eastern border has been an important factor in the history of the city." +
  " The Republic of Karelia is once again a significant area for cooperation with nearby regions"
+
  " in Russia. Export companies in Joensuu continue traditions in foreign trade of the last
century." +
  " The city itself gives many possibilities for different kinds of activities. High-quality" +
  " cultural events and clean nature increase the attractiveness of the city.");

  private String gameInfoScreen1 = new String (
  "Who are you:\n" +
  "You are a Canadian student - Gogy, who comes to Joensuu by an exchandge program.\n" +
  "\nWhere are you:\n" +
  "You are at railway station"
  );

  private String gameInfoScreen2 = new String (
```

```
"Your train is behind you. On the left hand the railway station building. Almost in" +
" front of you (in about 50 meters) taxi station."
);

private String gameInfoScreen4 = new String (
"Your general goals are:\n" +
"- Starting to live in Joensuu\n" +
"- Starting to study in the University of Joensuu\n" +
"- Explore Joensuu"
);

private String gameInfoScreen5 = new String (
"Your resources are:\n" +
"- Time\n" +
"- Money\n" +
"\nAlso changable parameters:\n" +
"- Mood (has influence on time)\n" +
"- Tiredness (has influence on mood and time)\n"
);

Form historyInfoF = new Form("Briefly about history of Joensuu");
Form historyInfoExtendedF = new Form("More about Joensuu");
Form StubF = new Form("Not implemented");
Form GameInfoF = new Form("");

public CityExploration() {
}

public void startApp() {
     Command exitCommand = new Command("Exit", Command.EXIT, 0);
  Command okCommand = new Command("OK", Command.OK, 0);
  Command backCommand = new Command("Back", Command.BACK, 1);
  Command nextCommand = new Command("Next", Command.OK, 0);

  StubF.addCommand(backCommand);
  StubF.setCommandListener(this);

     gameModeList_1 = new List("Choose the game mode 1", Choice.IMPLICIT);
     gameModeList_1.append("Text", null);
     gameModeList_1.append("Graphical", null);
  gameModeList_1.addCommand(exitCommand);
  gameModeList_1.addCommand(okCommand);
  gameModeList_1.setCommandListener(this);

  gameModeList_2 = new List("Choose the game mode 2", Choice.IMPLICIT);
  gameModeList_2.append("With connection to the Internet", null);
  gameModeList_2.append("Without Internet connection", null);
  gameModeList_2.addCommand(exitCommand);
  gameModeList_2.addCommand(okCommand);
  gameModeList_2.setCommandListener(this);

  cityList = new List("Choose a City to explore", Choice.IMPLICIT);
  cityList.append("Helsinki", null);
  cityList.append("Joensuu", null);
  cityList.append("Oulu", null);
  cityList.append("Tampere", null);
  cityList.addCommand(exitCommand);
  cityList.addCommand(okCommand);
  cityList.setCommandListener(this);

  historyInfoF.append(briefHistoryJoensuu);
  historyInfoF.addCommand(exitCommand);
  historyInfoF.addCommand(okCommand);
  historyInfoF.setCommandListener(this);

  gameStartList_1 = new List("Choose the next action", Choice.IMPLICIT);
  gameStartList_1.append("Read more information about Joensuu", null);
  gameStartList_1.append("Start to play", null);
  gameStartList_1.addCommand(exitCommand);
  gameStartList_1.addCommand(okCommand);
  gameStartList_1.setCommandListener(this);

  historyInfoExtendedF.append(moreHistoryJoensuu);
  historyInfoExtendedF.addCommand(exitCommand);
```

```
  historyInfoExtendedF.addCommand(okCommand);
  historyInfoExtendedF.setCommandListener(this);

  GameInfoF.append("");
  GameInfoF.addCommand(exitCommand);
  GameInfoF.addCommand(nextCommand);
  GameInfoF.setCommandListener(this);

  mDisplay = Display.getDisplay(this);

      ChooseGameMode1();
}

public void Stub() {
      mDisplay.setCurrent(StubF);
      currentMenu = previousMenu;
}

public void pauseApp() {
  mDisplay = null;
}

public void destroyApp(boolean unconditional) {
    notifyDestroyed();
}

public void ChooseGameMode1() {
      mDisplay.setCurrent(gameModeList_1);
      previousMenu = currentMenu;
      currentMenu = "GameModeMenu1";
}

public void ChooseGameMode2() {
      mDisplay.setCurrent(gameModeList_2);
      previousMenu = currentMenu;
      currentMenu = "GameModeMenu2";
}
public void ChooseGameMode3() {
      mDisplay.setCurrent(cityList);
      previousMenu = currentMenu;
      currentMenu = "GameModeMenu3";
}

public void ShowHistoryInfo() {
      mDisplay.setCurrent(historyInfoF);
      previousMenu = currentMenu;
      currentMenu = "historyInfoBrief";
}

public void gameStartList_1Do() {
      mDisplay.setCurrent(gameStartList_1);
      previousMenu = currentMenu;
      currentMenu = "gameStartList_1";
}

public void ShowMoreHistoryInfo() {
      mDisplay.setCurrent(historyInfoExtendedF);
      previousMenu = currentMenu;
      currentMenu = "historyInfoExtended";
}

public void ShowGameInfoScreen1() {
      GameInfoF.deleteAll();
      GameInfoF.append( gameInfoScreen1 );
      mDisplay.setCurrent(GameInfoF);
      previousMenu = currentMenu;
      currentMenu = "gameInfoScreen1";
}

public void ShowGameInfoScreen2() {
      GameInfoF.deleteAll();
      GameInfoF.append( gameInfoScreen2 );
      mDisplay.setCurrent(GameInfoF);
      previousMenu = currentMenu;
```

```
        currentMenu = "gameInfoScreen2";
    }

    public void ShowGameInfoScreen3() {
        GameInfoF.deleteAll();
        GameInfoF.append("Where you are:\n");
      try {
          Image image = Image.createImage("/icons/jts.png");
                GameInfoF.append(image);
      } catch (java.io.IOException x) {
                // just don't append the image.
        }

        mDisplay.setCurrent(GameInfoF);
        previousMenu = currentMenu;
        currentMenu = "gameInfoScreen3";
    }

    public void ShowGameInfoScreen4() {
        GameInfoF.deleteAll();
        GameInfoF.append( gameInfoScreen4 );
        mDisplay.setCurrent(GameInfoF);
        previousMenu = currentMenu;
        currentMenu = "gameInfoScreen4";
    }

    public void ShowGameInfoScreen5() {
        GameInfoF.deleteAll();
        GameInfoF.append( gameInfoScreen5 );
        mDisplay.setCurrent(GameInfoF);
        previousMenu = currentMenu;
        currentMenu = "gameInfoScreen5";
    }

    public void commandAction(Command c, Displayable s) {
      String label = c.getLabel();

      if (label.equals("Exit")) {
                destroyApp(true);
      } else if( currentMenu.equals("GameModeMenu1") ) {
                ChooseGameMode2();
      } else if( currentMenu.equals("GameModeMenu2") ) {
                ChooseGameMode3();
        } else if( currentMenu.equals("GameModeMenu3") ) {
                        List down = (List)mDisplay.getCurrent();
                        switch(down.getSelectedIndex()) {
                                case 1: ShowHistoryInfo();break;
                                default: Stub();
                        }

        } else if( currentMenu.equals("historyInfoBrief") ) {
                        gameStartList_1Do();
        } else if( currentMenu.equals("gameStartList_1") ) {
                        List down = (List)mDisplay.getCurrent();
                        switch(down.getSelectedIndex()) {
                                case 0: ShowMoreHistoryInfo();break;
                                case 1: ShowGameInfoScreen1();break;
                        }

        } else if( currentMenu.equals("historyInfoExtended") ) {
                        gameStartList_1Do();
        } else if( currentMenu.equals("gameInfoScreen1") ) {
                        ShowGameInfoScreen2();
        } else if( currentMenu.equals("gameInfoScreen2") ) {
                        ShowGameInfoScreen3();
        } else if( currentMenu.equals("gameInfoScreen3") ) {
                        ShowGameInfoScreen4();
        } else if( currentMenu.equals("gameInfoScreen4") ) {
                        ShowGameInfoScreen5();
        } else if( currentMenu.equals("gameInfoScreen5") ) {
                        Stub();
        }
    }
}
```