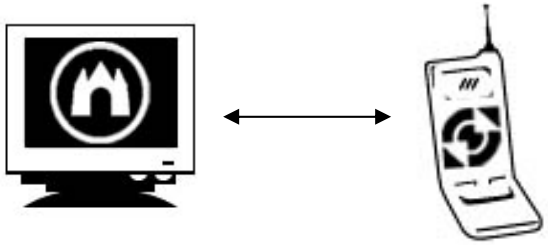
Master Thesis

Games Atelier

Learning environment for producing and playing location-based mobile games

by

Kirsten Veelo



Supervision:

Dr. Petra Fisser
Dr. Joachim Wetterling
Educational Science & Technology
Technological Applications in Education and Training
University of Twente Enschede

Drs. Henk van Zeijts
Creative Learning
Waag Society Amsterdam

February 2007 – August 2007

ABSTRACT

This study describes an open source environment, Games Atelier, in which students of the secondary school learn, both by producing and playing educational location-based mobile games. The study investigates possible functionalities, a conceptual design and validated design principles for the Internet-based environment, based on the needs of the students and their teachers.
Games Atelier exists of a community, a web-based environment and location-based mobile applications. The tools provided are real time communication, locative and tracing functionalities, a Content Management System and Web 2.0 social networks.

The location-based mobile games can be seen as lessons outside the classroom, which combine elements of constructivism and the didactical approaches collaborative, problem-based and game-based learning. According to constructivism effective learning takes place when students solve a problem by constructing an artefact, discoursing with peer students, and reflect on their learning activities. The students who create a game must understand the educational contents thoroughly in order to teach their peer students about the most important concepts. In this learner-centred approach, there is a bigger need for self-motivation. This can be achieved by integrating certain game elements, which are rules, gameplay, non-linear storyline, clear final goal and subtasks that contribute to reaching this final goal, challenging and pleasantly frustrating problems, levels, direct feedback, speed and competition.

Games Atelier motivates students to learn and play collaboratively in a home and a mobile team, the students are supported by gameplay, assignments, a digital map and mobile technology. The mobile team walks in an outdoor location, which serves as the problem context. They are traced within the web-based environment, so the home team can monitor them. The platform automatically sends complex, realistic and ill-structured problems to the mobile and the home team, based on the location of the mobile team. To solve these problems, the mobile team explores the rich real-world environment and record data. The home team explores the Internet. The system supports both teams by providing necessary information and cognitive tools to solve the problem, which cannot be found on location or on the Internet. Games Atelier stores the results of the learning activities in a trace video and organizes the answers on digital worksheets, so the students can reflect and the teacher can assess the results of playing the game. The answer sheet allows the students to download and reuse the data collected in the field.

The web-based environment consists of a teacher and student version, which is dynamically adjusted to the individual needs according to different educational levels. The system supports the students creating games collaborately by means of a project environment that provides information, cognitive tools, communication tools and features that support sharing documents between the mutual team members and the teacher. The project environment functions as a portfolio that provides useful collections of student work-in-progress and final products that can be assessed by the teacher. The environments are initiated and organized by the teachers, being supported by a project template. Based on the choices made and the supplied information in the template, the project environment dynamically adjusts to the personal needs of the project members. When creating location-based mobile games, the students are supported step-by-step by means of a game template. They can select a certain game genre and related gameplay, upload media that enhances the real-world environment, and write the storyline and assignments.
Within the community the students share finished games and individual game elements. When the games are played by peer students, they can comment and rate the game, so the artefact becomes more meaningful to the students.

FOREWORD

While conducting this research project I sometimes felt like being a character in a book of the author Michael Ende. Now and then I recognized myself in Bastian, first reading in the book 'the never ending story' about the city Fantasia, and later becoming part of the story himself in order to save the city. Games Atelier is a constructivist learning environment, in which students learn by making games and playing these games in an authentic environment. This research project has been a learning process for me, designing the program Games Atelier and conducting a research assignment in the authentic environment Waag Society. So writing this thesis sometimes felt like writing about my own learning process.
In a later stadium, I felt more like the street-cleaner Beppo, a character from Ende's book 'Momo', who sweeps the infinite street. Beppo sweeps patiently stroke by stroke. One day he looks back and the street is swept. I wrote this thesis page by page, and now I look back with great satisfaction.

First of all, I would like to thank all the people I worked with during this research project at Waag Society and University of Twente. Many thanks for your knowledge shared. Secondly, I would like to thank my boyfriend, parents and all other family members who supported me during the past two years. You are simply the best!

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1 INTRODUCTION

The following chapter introduces the research project Games Atelier. First, the research themes location-based mobile games, mobile learning and game-based learning will be introduced, because these themes are related to the study. This research project is commissioned by the organization Waag Society and part of the design project Games Atelier, as conducted by this organization. The design project will be introduced, which leads to the problem statement to be investigated in this thesis. Furthermore, the research method and design approach used to investigate the problem will be introduced and eventually the contribution to the research area Educational Science and Technology and practice will be illustrated.

1.1 INTRODUCTION: LOCATION-BASED MOBILE GAMING

Location-based mobile gaming is a relatively new way of using media in educational settings. This study describes the possibilities of location-based mobile gaming in secondary schools, with a specific focus on the construction of an open source game environment in which users learn, both by producing and playing mobile educational games.
Within this general Internet-based digital environment, the user can add digital content to the physical location of a city or area. This environment is called Games Atelier and serves as a toolkit for teachers and students to make mobile games which can be integrated in the curriculum of the school. Within this environment, users can create, play or view a mobile game, with web-based and/ or mobile applications. A home team, using the web-based environment and a mobile team, using mobile applications (a mobile phone for instance), then collaboratively learn and play. The mobile team is walking at a certain location and is traced within the web-based environment. The platform will send assignments to the mobile application and to the web-based environment automatically, after which the mobile and home team have to solve this assignment collaboratively. Also, they have to record or search for information, pictures or movies. Afterwards, the results can be viewed on the Internet.

This thesis gives more information about learning with location-based mobile games, including the didactical approaches “learning outside the classroom” and “game-based learning”. The research project investigates the possible design of web-based digital environment that supports learning by creating, playing and viewing location-based mobile games. The environment is designed according to the user-centred design approach for interaction design. Complementary research is conducted according to the developmental research approach. The research project results into a prototyped web-based application and the design principles for the learning environment that supports creating, playing and viewing location-based mobile games.

1.2 MOBILE LEARNING AND GAME-BASED LEARNING

The project Games Atelier relates to the Educational Science and Technology themes of mobile learning and game-based learning.

Mobile learning and game-based learning are relatively new within Educational Science and Technology. Interesting is that the project Games Atelier combines several aspects which are regarded as important aspects of constructivism, an approach in which users learn by means of collaboration, producing their own and meaningful artefacts which increase the active attitude of students, learning within an authentic context, individualized learning and learning by reflection.

Mobile learning enables flexible learning in a meaningful and authentic context. This can be recognized in the Games Atelier project. Within this project a mobile device will be used to collect information from the environment by means of video, photo, text-based or voice-recording. The learners receive instructions or assignments just in time, linked to the location where the learner is at, and collaboration between students

is facilitated through mobile and Internet-based applications. Learning can be personalized, because the instruction is based on the personal location and history of the learner and the learner collects information based on the personal location.

The opportunities of games and producing games as a learning method are recognized within the professional field of education since a couple of years and demands for this new learning method are increasing. More students use gaming as a learning method, and gaming is part of the personal environment of the learner (Van Zeijts, 2006). Using gaming as an acknowledged learning method will be motivational for students. Eventually this could decrease the number of students leaving schools before graduation.

By producing an educational game, users learn certain skills and knowledge about designing and programming educational games. Also, by integrating the content of a relevant subject within the educational game, the students should master the subject's content in order to develop the educational games themselves. Learning will become meaningful to them, because the game is really used and played by other 'colleague students'.
Because gaming is part of the personal environment of the students, the learning method fits closely to the personal multimedia environment and skills of the students. The students learn by reflecting, while they discuss the results of the game afterwards within the classroom environment. Which choices did they make, which challenges came along? The students learn from each other and this is important for conscious experiencing and learning (Van Zeijts, 2006).

This first short introduction about mobile- and game-based learning shows that location-based mobile gaming integrates several aspects which are regarded as important aspects of constructivist learning theories, for example learning outside the classroom environment and collaborative learning. Location-based mobile games use mobile technologies, which enables flexible learning in a meaningful and authentic context. Elements of videogames are applied to increase the students' intrinsic motivation during the learning experience. In Chapter 3 this will be further explored.

1.3 GAMES ATELIER, DEVELOPING LOCATION-BASED MOBILE GAMES

This research project is part of the project Games Atelier at Waag Society in Amsterdam. The mission of Waag Society is to make new media available for groups of people that have little access to computers and Internet, and increasing their quality of living. Waag Society is actively involved in networked art, education, health care and Internet related issues like bandwidth and copyright. The society will be described more elaborately in Chapter 2.

In Games Atelier, students from secondary schools produce educational location-based mobile games, which will be played in their own context and environment.

The main goal of Games Atelier is the construction of a new didactical learning method, an open source game environment in which users learn, both by producing and playing location-based mobile educational games. The technology used will be Internet, GPS-technology[1] and mobile phones (UMTS[2]), combined with the software GeoWorx, which is developed by Waag Society and includes multi-user gameplay and Geotracing functionalities. The educational location-based mobile game is an active and modern form of collaborative and constructive education, by means of attractive media technologies.

[1] GPS: Global Positioning System, a worldwide radio-navigation system formed by 24 satellites and ground stations.
[2] UMTS: Universal Mobile Telecommunications System, a third-generation broadband, packet-based transmission of text, digitized voice, video, and multimedia at data rates up to 2 megabits per second.

The program Games Atelier exists of two main elements, which are the mobile and the web-based platform. Waag Society will develop the general Internet-based digital environment, by which the user can add digital content to the physical location of a city or area. This environment is called Games Atelier and serves as a toolkit for teachers and students to make location-based mobile games which can be integrated in the curriculum of the school. Within this environment, users can create, play or view a mobile game, with web-based and/ or mobile applications. A home team, using the web-based environment and a mobile team, using mobile applications, than collaboratively learn and play. The mobile team is walking at a certain location and is traced within the web-based environment. The platform will send assignments to the mobile application and to the web-based environment automatically, after which the mobile and home team have to solve this assignment collaboratively. Also, they have to record or search for information, pictures or movies. Afterwards, the results can be viewed on the Internet.
The games produced within the platform will be sufficient for different subjects within the curriculum of the secondary school. It is important that the games created will satisfy the learning objectives as stated by the schools and government. The students will develop games under supervision of the teachers. The platform will not be adjusted to specific subjects within the curriculum. By developing the educational game within Games Atelier, the students will acquire technical and creative skills, besides social skills and knowledge about the specific subject.

1.4 PROBLEM STATEMENT

This research project is assigned by Waag Society, the organization that will design, develop and implement the learning environment Games Atelier. The main goal of the research project as described in this thesis is to determine the functionalities and user interfaces that are most suitable for the target users of Games Atelier. Within this web-based environment, students and teachers of the secondary school create, play and view location-based mobile games.

The program Games Atelier enables flexible learning in a meaningful and authentic context. Flexible learning is a movement away from a situation in which key decisions about learning dimensions are made in advance by the teacher (teacher-centred instruction), toward a situation where the learner has a range of options from which to choose (learner-centred instruction) (Collis & Moonen, 2001). Implementing flexible learning in practice is complex and contains some challenges from students' and teachers' perspective. In a flexible learning situation, the student becomes more independent, makes his own choices and steers his own learning process. Not all the students enjoy this freedom. Some students prefer the teacher to tell them what to do. There is a bigger need for self-direction and self-motivation. The initiative for learning activities lies with the students instead of the teacher (Collis & Moonen, 2001; Veen & Jacobs, 2002). Using gaming as an acknowledged learning method could be motivational for students. The motivational characteristics of gaming will be investigated in order to apply these characteristics in the games being created in Games Atelier.

Flexible learning costs the teacher more time and effort than standardised learning approaches. The more options the student has to choose from, the more demands and thus challenges there are for the teacher (Collis & Moonen, 2001). The teacher should provide the students with all the possible choices, and monitor and respond to the individual learning process of the students. Research will be conducted to determine which choices the students can make when creating and playing the game and which options should be chosen by the teacher.

When flexibility is implemented in practice, an important step is operationalisation the flexibility options of the teachers and the students (Collis & Moonen, 2001). The general goal of developing a didactical approach should be translated into goals stated in specific and operational terms. This operationalisation is critical in the selection of the most-appropriate technologies for the new learning environment. During this

research project the design opportunities will be investigated, by means of user and literature studies, in order to state clear goals for design and development of the program Games Atelier.

The program should contain specific functionalities and user interfaces that are adapted to the needs, capabilities and goals of students and teachers of the secondary schools in the Netherlands. The research project will result in a conceptual design of the learning environment and three prototypes: a location-based mobile game, three moodboards with visual characteristics of different game themes, and a final prototype of the web-based environment Games Atelier. Eventually, validated design principles for both the location-based mobile games and the Internet-based environment will be stated.

Based on the setting as described above the main research question and five sub questions are formulated for this study. These questions will be answered during this study.

Main research question

What are the design principles for an effective Internet-based learning environment in which students and teachers of secondary schools in the Netherlands can create, play and view educational location-based mobile games?

Sub questions

1. What are the main characteristics of mobile and game-based learning?
2. What are the characteristics of effective educational location-based mobile games?
3. How can the users be supported in creating, playing and viewing the educational location-based mobile game?
4. What are the user needs, user experience goals, usability goals and user, usability, context and functional requirements of the target users for creating, playing and viewing location-based mobile games?
5. How can the user needs, user experience goals, usability goals and user, usability, context and functional requirements be translated to the functionalities and GUI of Games Atelier?

The first and second sub question investigates the literature about location-based mobile games, and the didactical approaches mobile and game-based learning. This exploration leads to design principles for the location-based mobile games. When creating location-based mobile games, teachers and students must understand how to develop games that support effective learning and the program should support them step-by-step.
The third sub question investigates how a learning environment can support students in developing these games and what support they need for these learning activities. Similar electronic programs will be analysed that support students creating similar artefacts, such as games. This investigation leads to design principles for the Internet-based learning environment.
The fourth sub question involves the user and context analysis, and the fifth sub question relates to the conceptual design phase of the programs, both according to the user-centred design approach for interaction design. This investigation results in the prototypes and conceptual model of Games Atelier, which reflect the requirements of the intended users.

To answer these questions in this research a specific design approach and research method is chosen. This will be described in the next section.

1.6 RESEARCH METHOD

The program will be designed according to the user-centred interaction design approach. To guarantee that the design that results from this research project generates validated design principles, the developmental research method will be followed. This research method prescribes to embed the design rational for the product in recent literature.
The user-centred interaction design approach and the developmental research method are chosen for this project, because both approaches focus on the design and development of interactive products and are suitable for the design of an innovative and complex product. According to both methods, the development of the program follows iterative cycles of analysis, development and evaluation. The user-centred design approach involves users from the start of the research project and focuses on user needs rather than technical concerns.
This research project focuses on the user and context analysis, and the conceptual design of the program Games Atelier. From the start of the design project, prototypes will be developed that reflect the needs and requirements of the students and teachers. At the beginning, these prototypes are very simple, but following iterative cycles, the prototypes evolve in more sophisticated versions that more and more reflect the proper requirements of the target group.

1.7 ASSUMPTIONS

The following assumptions are stated by Waag Society and are the leading basis for this research project and the design of the learning environment Games Atelier.

According to the Waag Society the digital Internet-based environment Games Atelier can offer an active and modern form of collaborative and constructive education, by means of attractive media technologies. Some assumptions and claims are included in the project, concerning the preference of modern students and teachers for constructivist learning environments, support of learning outside the classroom environment by mobile technologies and the motivating capabilities of games.

Within the behaviourist tradition, students are used to follow classes passively, consuming lessons without active participatory of their own. Constructivist learning theories argument that active learning leads to more effective learning and motivated students (Jonassen, Hernandez-Serrano & Choi, 2000). The traditional learning methods are adjusted to the behaviourist learning theories, but modern teachers who want to teach following the learner-centred method needs didactical methods which supports the active learner centred teaching. Games Atelier will be designed to support the active learning centred teaching practice. Constructivist learning theories are discussed more elaborately in Chapters 3 and 5.

Education in the Netherlands normally takes place inside the classroom environment. Some themes and subjects, like history and geography can be educated more effectively outside the classroom environment in the real world. Visualisations and clear examples of principles being taught by the teacher can be found in the outside world. The teachers already go outside to teach these principles, supported by means of paper-based learning materials. By means of mobile technologies, the interaction with the authentic locations can be much richer and easier.

Using gaming as an acknowledged learning method will be motivational for students. Students that are motivated to learn, learn more effective. It is important to implement effective learning methods that can also be fun. More students use gaming as learning method, and gaming is part of the personal environment of the learner (Van Zeijts, 2006). Good educational computer games motivate students to learn and make learning fun. Games Atelier uses the motivational aspects of games, in combination with modern technologies, like mobile and wireless devices, GPS and Internet. Mobile phones are accessories that are

very popular among students. Also, producing their own learning materials should be motivating for students and enhancing the learning effects. Intrinsic motivation is discussed more elaborately in Chapter 5.

1.8 RELEVANCE OF THE PROBLEM FOR SCIENCE

The research project's goal is to come to clear stated design principles in order to develop the learning environment Games Atelier as described. These design principles will be formed by means of a development and user-centred research and design approach. The program will be developed in close cooperation with the target users, the students and teachers of the secondary school. The design will also be informed by state-of-the-art literature according to the topics as mentioned in the literature review. According to this approach, a validated set of design principles may be extracted from this research project.
Because learning by means of mobile location-based games is a relatively new area in the field of educational science and technology, the design principles, but also the design and research approach will be informative for researchers interested in designing a similar learning environment to support learning by creating and/ or playing mobile location-based games.

1.9 RELEVANCE OF THE PROBLEM FOR PRACTICE

This research project is assigned by the Waag Society, the organization who is going to design and develop the learning environment Games Atelier as described. The design principles and functional requirements which are formulated by means of the research project are meant to be supportive for the design and development process of Games Atelier.
Games Atelier is one of the first learning environments in its kind to be developed with and for secondary education in the Netherlands. Hopefully, Games Atelier offers a validated and practical learning environment in which students can playfully learn in the real world outside the classroom environment.

1.10 OVERVIEW OF THIS THESIS

Chapter 2 of this thesis will describe the organizational context in which this study is carried out. More information is given about Waag Society and the background of the research problem. The chapter describes the intended target users and the functionalities that provide the basic location-based and collaborative functionalities of the program Games Atelier.

In Chapter 3 literature that informs about several themes related to Educational Science and Technology will be explored. These themes are the net-generation, constructivism, game-based learning, location-based mobile games and mobile learning.

Chapter 4 gives insight in the design approach and research method. Furthermore, this chapter describes the 4E-model, which predicts the possibility of implementing an innovating interactive program, data-acquiring techniques, and data-collection moments, techniques for analysing the data, and threads to validity of the research methods.

Chapter 5 describes the outcome of the research activities during the analysis and design phase. First, the data collection activities will be distinguished, which are the user scenarios, naturalistic observation, technology and content workshops, focus group discussions and questionnaires. The analysis of the acquired data leads to the definition of user needs, usability and user experience goals and establishment of the requirements for the program. Literature study concerning constructivist learning theories, game-based learning and location-based mobile games informs about design principles for an effective learning environment and the characteristics of effective location-based mobile games. Finally, this chapter will

describe the outcome of the conceptual design activities during the design phase, resulting in a conceptual model, web structure models and three prototypes which illustrate the functionalities and graphic user interfaces of the program Games Atelier.

The third prototype, which represents the web-based application of the program Games Atelier, will be evaluated by a group of teachers and experts of Waag Society. Chapter 6 reports the results of this evaluation.

Finally, Chapter 7 answers the main research question. The design principles for an *effective web-based learning environment for playing and creating location-based mobile games* will be depicted, together with the most important conclusions of this research project.

2 EXPLORATION OF THE PROBLEM: ORGANIZATIONAL CONTEXT

The following chapter describes the organizational context of the research project. The program Games Atelier will be designed and developed by the foundation Waag Society in Amsterdam. First the history and mission of the organization are described, together with the organizational structure. Furthermore the background of the research problem is defined, including the intended target group and the technology that provides the basic location-based and collaborative functionalities of the program Games Atelier.

2.1 DEVELOPING NEW MEDIA AT WAAG SOCIETY

Waag Society was founded in 1994 by Caroline Nevejan and Marleen Stikker. First the foundation was called 'Society for old en new Media', de Waag. The foundation is named after the place where it is situated, which is de Waag at the Nieuwmarkt in Amsterdam. Marleen Stikker was mayor of The Digital City, one of the first public communities on the Internet. Partly founded out of this public community, the mission of Waag Society is to make new media available for groups of people that have little access to computers and Internet, and increasing their quality of living. Nowadays, Waag Society is actively involved in networked art, education, health care and Internet related issues like bandwidth and copyright (Waag Society, 2007). The media lab developed into an innovative think tank and there have been attempts to bring prototypes developed by Waag Society to the market. For this purpose, WaagLabs was founded in 2002, which introduced Board Messenger, special software for mentally challenged, successfully to the market in the United States.
Waag Society has a worldwide network with partners in countries like India, Canada and the UK. Within India there exists a close cooperation with sister organization Sarai. Together with partners from different universities and companies Waag Society is actively involved in research and development, but also experiments with new technologies, art and culture (Waag Society, 2007).
Waag Society is divided in four domains, which are Health Care, Culture, Society and Education, as can be seen in Figure 1.

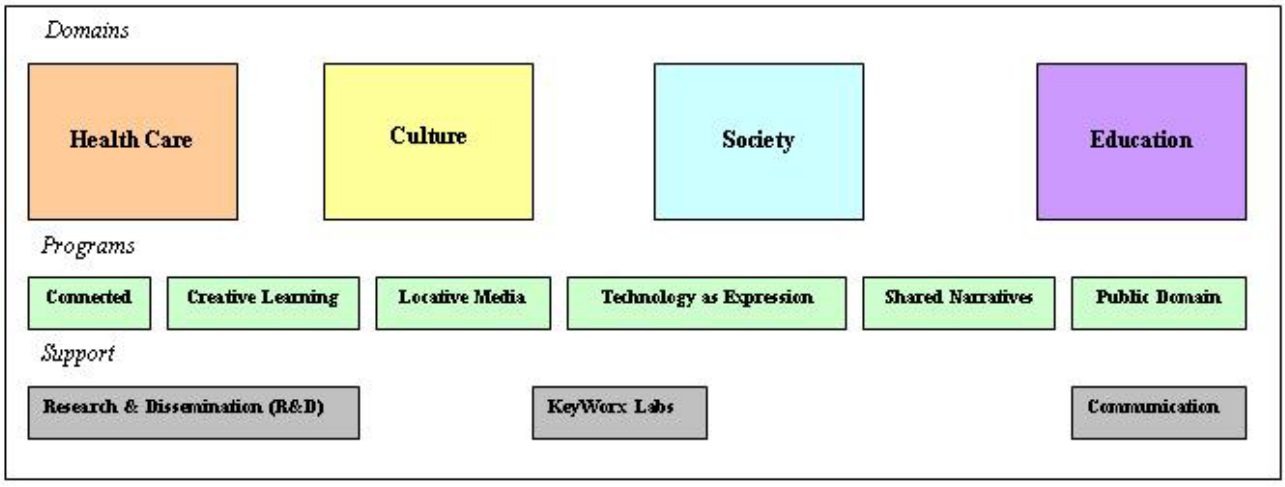

Figure 1: Organizational structure of Waag Society

Within the Health Care domain, Waag Society deploys new media in the Health Care section. An example of this is PDA's which take over administration tasks, so that more time can be spending on the patients care. Also, Waag Society develops communication systems for patients in the IC regaining consciousness and not being able to communicate in a natural manner.

Within the Culture domain, Waag Society experiments with networked art. Waag Society is a pioneer on this subject, connecting artist on different locations by means of the Internet. KeyWorx software is specially developed to support networking artists. KeyWorx now underlies all applications developed by Waag Society. The Culture domain involves research, lectures and exhibitions, and also has an artist-in-residence program.

Within the Society domain, Waag Society organises debates and conferences, and produces publications about social aspects of Internet, the public domain, privacy, copyright, freedom of information, the exclusion of underprivileged groups from communication media such as the Internet, and the use of the new media by non-governmental organizations (NGOs). The activities within this domain resulted in the alternative copyright licensing system Creative Commons and the close cooperation with Sarai, a sister organization in India.

The domain Education focuses on innovations in primary and secondary education. Waag Society treats students as media producers, involved in active learning about topics reflecting their personal interest. The pedagogy that fits Waag Society well is social constructivism. The Creative Learning Lab provides students with digital tools which facilitate active learning. The Platform for Education and Innovative Media is a forum where professional educators can exchange information about education and new media.

Waag Society is actively involved in different projects, initiated and coordinated by the program managers Frank Kresin and Henk van Zeijts. The programs are relevant for more domains at one time and provide guidelines for research, pilots and prototypes executed within projects. The projects are now categorized into six programs, which are Connected, Creative Learning, Locative Media, and Technology as Expression, Shared Narratives and Public Domain.

The activities Research & Dissemination (R&D), KeyWorx Labs and Communication support Waag Society as a whole.
The support activity Research & Dissemination investigates and defines Waag Society's research methodology (empathic and participatory methodologies) and best practice. The application and integration of these creative research processes within national or international wide research programs is also investigated. Furthermore, the activities focus on the social, ethical and political implications of technological development.

KeyWorx is an open source software platform that offers developers the means to create multimedia applications that are characterized by multi-channel interaction and multi-user behaviour. KeyWorx applications have a shared usability in enabling users to collaboratively create multimedia content.
The support activity KeyWorx Labs structures the development by using a roadmap and couples this to projects of the diver's programmes.

2.2 BACKGROUND OF THE PROBLEM

Games Atelier is a project executed by the programs Creative Learning and Locative Media of Waag Society. Creative Learning investigates and develops prototypes for innovative learning. The research questions that guide the programme within the different projects concern the topics gaming/ playful learning, mobile learning, media wisdom/ identity and collaborative learning.

Locative Media develops and investigates location-based media. Research questions within this program concern the topics psycho geography, social structures, time and history, gaming, and instruments, devices, interfaces & technology. Location-based media combines the locative technology of GPS with real-time data traffic and a portable device. People can be traced with a dynamic map of the area and voice and image recordings can be added to these traces. Frequentie 1550 is and Games Atelier will be developed by means of this software.

The digital environment Games Atelier combines features of Frequentie 1550 and N8Game. Frequentie 1550 and N8Game are both developed in earlier projects of Waag Society.
The pilot city game Frequentie 1550 was developed in 2005 with multi-user gameplaying functionalities and evaluated by students of the secondary school.
N8game uses Geotracing functionalities, meaning that users leave a trace on a digital map by means of GPS on their mobile phone. Digital content can be added to this trace and be saved on the Internet.

The project Games Atelier started in January 2007 and will finish at the end of 2008. In 2007, the platform will be developed and evaluated within Amsterdam and in 2008 the platform will be implemented as a validated learning method within the Netherlands.

2.2.1 Target users of the program Games Atelier

The primary target users of the program Games Atelier are students of secondary schools in the Netherlands and their teachers. The students are approximately between twelve and eighteen years old and visit the base and upper classes of all educational levels (VMBO, HAVO and VWO). The base classes are the first two years of VMBO classes and the first three years of HAVO and VWO classes.
The teachers are decision makers that in the first place select the learning methods which are to be applied in the classroom environment. Furthermore, the teachers prepare the project and coach the students while producing and playing the location-based mobile game.

2.2.2 Technologies used and accompanied features of these technologies

The general Internet based digital environment Games Atelier serves as a toolkit for teachers and students to create, play and share location-based mobile games.
The technology used will be Internet, GPS-technology and mobile phones (UMTS), combined with the GeoWorx platform.

The GeoWorx platform is a technological platform which combines KeyWorx and Geotracing functionalities. The tools provided by the GeoWorx platform are real time communication, locative and tracing functionalities, Content Management System (CMS) and Web 2.0 social networks. The platform exists of three different parts, which are the community, the web-based environment and the location-based mobile application.

The community as supported by the Web 2.0 social network enables the users to share the produced games with others. Within the web-based application platform, the users can collaboratively produce games, supported by the Content Management System.
The web-based application and mobile application both contain tracing functionalities, multi-user gameplay functionalities and real time communication. These functionalities enable both teams to cooperate from a distance, communicating and sharing digital media.

The mobile application is supported by location-based technology. The application combines the locative technology of GPS with real-time data traffic and a mobile device. Within this project the mobile device will be used to collect information from the environment by means of video, photo, text-based or voice-

recording, to receive instruction or assignments just in time, linked to the location where the learner is at, and collaboration between students, mobile and Internet-based.
By means of locative and tracing functionalities people can be traced with a dynamic map of the area and voice and image recordings can be added to these traces. The trace and records added to this trace is automatically saved on the Internet.

Because the trace and records added to this trace is automatically saved on the Internet, the users are able to view the results of their activities within the Internet environment.

2.3 SUMMARY

This chapter explored the organizational context and practical issues of the research problem.
The organization Waag Society defined the preconditions of the program Games Atelier. These preconditions result from experiences and technologies that were gained from previous projects of Waag Society. The preconditions concern the functionalities of the web-based and mobile applications used to construct Games Atelier, and the intended target group, being students and teachers from the secondary schools in the Netherlands.
The following chapter explores literature about research topics that are related to the stated research problem. These topics are the users of the program, constructivism, game-based learning, location-based mobile gaming and mobile learning.

3 LITERATURE REVIEW

Location-based mobile gaming is a relatively new way of using media in educational settings. Still, the research problem can be related to relevant research topics. Within this chapter state-of-the-art literature that relates to the following topics will be explored: the net-generation, constructivism, game-based learning, learning outside the classroom environment on an authentic location, location-based mobile games and mobile learning.
The students that are part of the intended target group are part of a generation that uses new media extensively in their free time, but at school they receive traditional methods that are made with an older generation in mind. The difference between the net-generation and the older generation is so large, that the students of the young generation cannot learn effectively according to the traditional method. The literature about this young generation, which is called the net-generation, is explored to understand the needs of the target group.
The program Games Atelier combines several aspects which are regarded as important aspects of the learning theory constructivism. These aspects are users who learn by means of collaboration, producing their own and meaningful artefacts which increase the active attitude of students, learning within an authentic context, individualized learning and learning by reflection. Literature is investigated in order to understand how a constructivist learning environment supports these processes.
Game-based learning is a pedagogy that makes use of games to learn students' knowledge and skills. Video games attract the attention of young students and motivate them to play constantly. Educational researchers examined the games to reveal the attractive and motivating aspects and formulated design principles for educational games. Because students produce games within the program Games Atelier, they should be supported to design these games according to the design principles of game-based learning.
Learning outside the classroom in an authentic location is characterized by solving ill-structured problems that are strongly related to the authentic location. The students solve the problem by analyzing the environment and searching for information to understand the real-world visualisations.
The location-based game is a new research area in the educational research field. Examples of location-based mobile games will be studied in order to inform and inspire the development of Games Atelier. Mobile technologies are a feasible way to support game-based learning in an authentic context. The research area is also quite new, but ideas are exchanged about the interesting features of the mobile applications to support collaborative and situated learning.

3.1 NET GENERATION

The target users of the program Games Atelier are students of secondary schools in the Netherlands, from approximately 12 till 18 years old. This can be related to what has recently been called "the net generation". Veen and Jacobs (2005) describe the so-called "neomillenial" learning styles the net-generation, which are students who are now between 14 and 20 years old. Veen & Jacobs investigated how to adjust education to the preferences and learning styles of this new generation. He describes the youngsters, the characteristics of the media they find attractive and design principles for new learning environments.
The media use of the net-generation is characterised by using television and radio, being complemented with the use of mobile phones, Internet and video games. Media dominates a large part of their life. Veen & Jacobs predict that students will soon use portable multimedia devices, such as laptops or Smart Phones that provide them access to Internet any time and any where. The net-generation has a preference for using screen-based tools, like computer, Internet and mobile phones. In comparison with older generation, this generation develops different skills and learning styles while using new media (Veen & Jacobs, 2005).
For this generation using ICT, like Internet and multimedia is self-evident. Internet is used as a social environment, more than a library of information sources. The net-generation is used to function in global virtual communities, communicating effectively with other people over the whole world.

These students are used to being challenged by problems in games and invent strategies to solve these problems. They learn outside the classroom environment in virtual environments where information is available anytime they need the information.
Veen and Jacobs conclude that technologies that are used outside school have strongly enhanced the skills of students. A standard element of the curriculum that is offered to the students at the secondary school is not tuned to the skills the students train outside school. This generation doesn't function properly in traditional education (Oblinger & Oblinger, cited in Veen & Jacobs, 2005).
Veen and Jacobs (2005) concludes that modern education should involve the real and virtual world. The curriculum should offer students freedom to experiment and make applications with ICT that are relevant within a context outside school.

3.2 CONSTRUCTIVIST LEARNING ENVIRONMENT

The program Game Atelier supports students in producing, playing and reflecting on educational location-based mobile games. The program combines several aspects which are regarded as important aspects of the learning theory constructivism. These aspects are learning by means of collaboration, producing their own and meaningful artefacts, learning within an authentic context and learning by reflection. The following section describes all learning activities according the constructivist learning theories. These learning activities will be supported by means of the program Games Atelier in the create-play-view cycles of the program.

Learning by creating, playing and viewing location-based mobile games
According to Jonassen, Hernandez-Serrano and Choi (2000) knowledge is a dynamic process, and subject to multiple revisions, elaborations, representations and interpretations. The knowledge is captured in objects, theories, models and discussions and shared with peer students. The longer the students actively investigate the topic, the more the students know. The models that they build to explain things are simple at first, but with experience, support, and reflection, they become increasingly complex (Jonassen, Hernandez-Serrano & Choi, 2000).
The program Games Atelier supports this dynamic process of knowledge building in make-play-view cycles. Students can make a location-based mobile game. For students to make the game, they investigate a problem that is related to the real world and represents his insight and the knowledge that solves the problem into a meaningful game scenario, including information and assignments. This game can be shared with peer students, who are invited to play the game. While they play the game they produce new media and elaborate on the educational contents that are included in the game and make multiple representations of this knowledge. The results of the playing activities are stored and presented in the web-based application, which supports the students to reflect on the game as a product, the game activities, and the knowledge generated while playing the game.

Figure 2 illustrates the learning activities and the support of these learning activities within the CLE Games Atelier. The location-based mobile game can be seen as a learning object that is produced, stored, played and reviewed within the learning environment. The game is structured by characteristic and motivating elements, like a clear final goal, gameplay, a storyline etc. The learning activities define and articulating the information need, searching for information and producing a product are central activities when creating, viewing and playing the game.

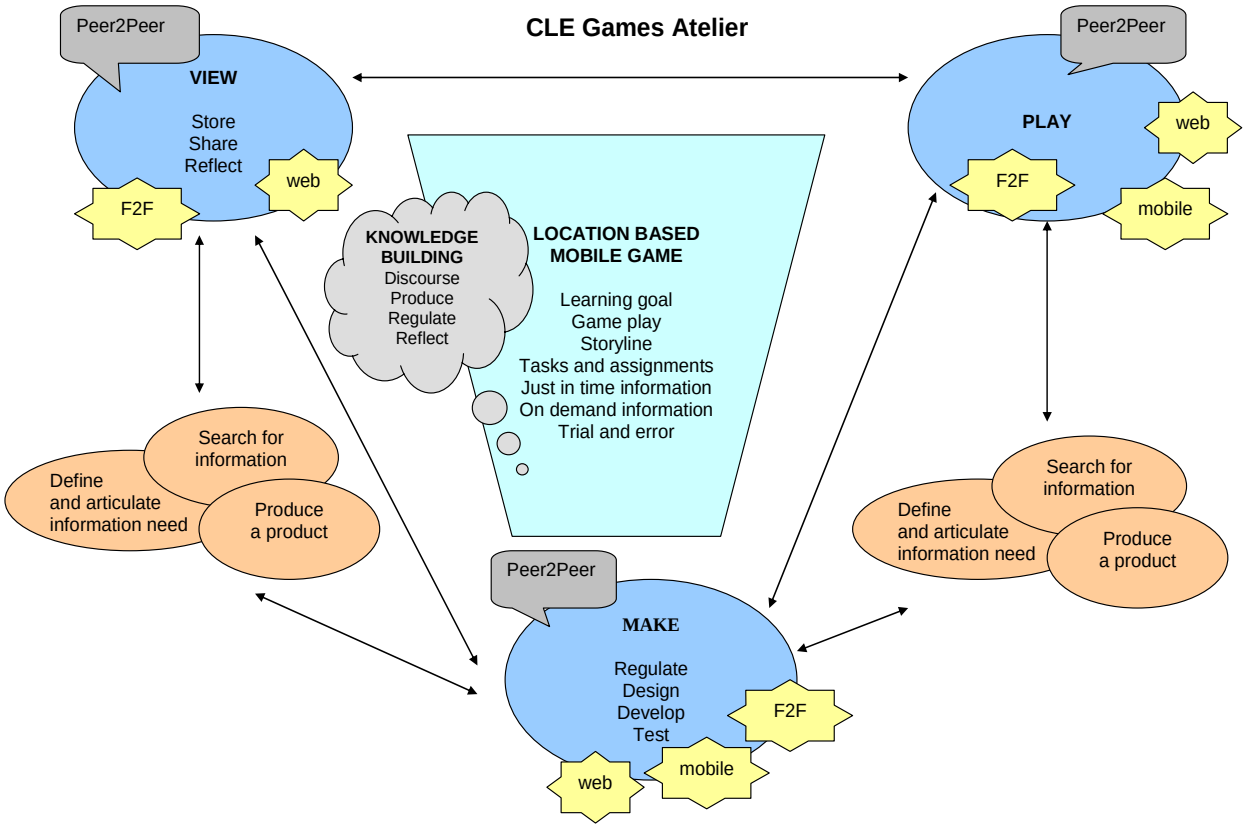

Figure 2: Constructivist Learning Environment Games Atelier

Active learning

In constructivist learning environments, students solve problems by actively producing knowledge themselves, in stead of reproducing knowledge that is delivered by a teacher or textbook (Jonassen, Hernandez-Serrano & Choi, 2000).

The learner-centred learning environment requires a different role of the teacher than the traditional teacher-centred learning environment. In stead of being an expert who transmits what he knows to the student, the teacher coaches the student while the students build their own knowledge products and knowledge structures. Coaching involves observing and helping individuals while they attempt to learn or perform a task (Brandt, Farmer, & Buckmaster, cited in Choi & Hannafin, 1995). The student should have the opportunity to discover his own solution to the problem and discover his own learning strategy, so the coaching is more implicitly, than explicitly, only when the students need the support.

The teacher supports the individual student during the learning activities and adjusts the support needed to the progress the students make. The ongoing dynamic assessment and adaptation of support enables the tutor to monitor progress, and then provide appropriate support and feedback (Naismith, Lonsdale, Vavoula & Sharples, 2006).

Intention-action-reflection cycles

Constructivists believe that learning is a process of meaning making, not one of knowledge transmission. According to Jonassen, Hernandez-Serrano and Choi (2000) meaning making is "a process of resolving the dissonance between what we know for sure or believe that we know and what we perceive, what we would like to know, or what we believe that others know" and that it involves wilful, intentional, active, conscious, constructive practice that include intention-action-reflection cycles.

The learning is oriented by an intention to solve the dissonance between what is perceived and what is understood. The students seek to understand the phenomena in a way that resolves that dissonance, what is

the learning activity. In order for the student to find a solution to the dissonance, the student should articulate and reflect on what he knows and what he needs to know and is a conscious process (Jonassen, Hernandez-Serrano & Choi, 2000). After explicating the intention, the student must define and clearly articulate the information need and purpose. This need and purpose steers the searching strategy for information that relates to the declared intention. The students collect information, interpret the information in response to the intention and determine the relevance of the information. The students need to critically assess the validity of the information and in order to enhance the validity; they should pursue a strategy of triangulation, meaning that they collect information from difference sources and compare these sources of information among each other (Jonassen, Hernandez-Serrano & Choi , 2000). According to Jonassen, Hernandez-Serrano and Choi, this process of intentionally searching for, interpret and assessing the information promotes meaning making and therefore learning.

The knowledge can be constructed socially and/ or technically, which means that the students can create new knowledge by solving a problem, supported by a simulation or by means of investigation, creating a product or through discussions (Choi, 1995).

Constructing knowledge socially

Following the constructivist learning theory, knowledge can socially be constructed through discourse and collaboration (Jonassen, Hernandez-Serrano & Choi, 2000). Pask (cited in Naismith, Lonsdale, Vavoula & Sharples, 2006) explains that effective learning can only exist when the student is able to converse with himself what he knows. The learning becomes most effective when the student can converse with each other, and share their descriptions of the world. Within group discussions, students can ask each other questions and respond to each other. By means of discussion personal views on a certain problem or topic, students provide and are exposed to multiple perspectives. Following Jonassen, Hernandez-Serrano and Choi (2000), these multiple perspectives promote critical examination of concepts, ideas, issues or dilemmas. By having to negotiate sense making with a larger community of students, the critical thinking skills of inquiry, reflection, sense making, argumentation and knowledge building (individually and within the community) are afforded (Jonassen, Hernandez-Serrano & Choi , 2000). These different angles can only exist when individual students actively participate. The students make conclusions on their own based on facts and arguments, and make sure that these arguments are in line with the facts. They examine information on their own and form their own opinion about the correctness of information (Verloop & Lowyck, 2003). Furthermore, collaborative learning creates a team spirit, which is a motivational condition for learning and generates a product which is superior to what an individual can produce, because different knowledge and skills of individual students are combined. In Games Atelier, possibilities for conversation with peers exist and are motivated while creating the game, playing the game and reflecting on the game.

Constructing knowledge technically

When the intention for learning is articulated and information is found that sufficiently relates to this intention, the students can represent this information by means of a personally constructed product. The emphasis is on the mental processes that occur during the construction of the artefact, not on the quality of the final product.

Constructing knowledge by representing the understanding in a meaningful product, encounters the student to use a diversity of cognitive learning skills. These skills are analysing the different concepts and their relation, selecting the most important information, making relations between different topics in the subject matter and between knowledge already known, organizing and connect different kinds of information in a new structure, concretise by describing examples, personal experiences and visualising concepts and critical thinking (Verloop & Lowyck, 2003). When students want to represent their understanding on a certain topic, they have to make choices about what topics to represent, construct relationships among the topics and choose in what form their understanding of the knowledge is best represented.

The student can use a multimedia of hypermedia tool to construct the product. The multimedia tool allows the student to represent the knowledge in divers' manners, which are text, audio, pictures, video and more. Furthermore, the student must develop arguments to justify the design used to represent what they have learned (Jonassen, Hernandez-Serrano & Choi, 2000).
The programs Game-maker and Create-a-scape are both examples of multimedia tools that allow students to construct games and location-based digital media.
Overmars (2005) developed the authoring tool Game Maker, in which users can develop their own 2D and 3D videogames. The program is object-oriented, meaning that users can choose form several objects and drag and drop these objects in their personal game field. This way they can collect and orchestrate their personal game. This makes this software easy to use, according to users.
Overmars states that creating games involves many different aspects and that all these aspects can be used in an educational context. These aspects include for example defining the gameplay, writing the story, creating the levels, defining the behaviour of the characters in the game. Creating games appeals to all ages and to both males and females. It involves a lot more than programming, bringing together aspects of liberal arts, mathematics, social sciences and computer science. Overmars decides that creating these aspects of the game will be highly motivating, especially when the game is used in other classes. Creating a game will be an excellent group project, where different students can use and train different skills and interests. The project Create-a-scape (Mortimer, 2006) involves a website which offers an authoring toolkit for teachers and students of the secondary school that enables the users to create mediascapes, which are digital media products (sound and images), which can be attached to a digital map by means of a mobile device and GPS. The mediascapes can be picked up and exchanged with other students who carry a mobile device. Mortimer (2006) defines this mediascapes as "location sensitive sounds and images that are placed in local landscapes that can then be experienced via a PDA hand-held computer and headphones". Mortimer emphasises the empowering and motivating effect on students creating mediascapes.
The contents production can be built upon their existing knowledge, interests and cultural backgrounds of the students and interact with the location. The completed resources may also make a welcome addition to the range of learning resources already available.
The project shows similarities with the concept of Games Atelier, because students create their own media by means of web-based or mobile technologies, they attach it to a location by means of GPS and another user can receive the media by means of the mobile device. This way the students create media which informs and interacts with the location. Following Mortimer (2006) developing this media is an active and creative endeavour that results in the creation of new and original learning experiences and resources.

Regulative activities
While engaged in knowledge-building through collaboration and producing a product, students may also develop regulative skills, like project management, organizational, presentation, and reflection skills. According to Papert (cited in Stager, 2005), a student regulating their own activity is necessary for constructing meaning and knowledge. The students 'learn to learn' and this involves taking charge of their own learning. Students need to take initiative and plan their own time, in order to understand the proper time to do a job.
Regulative skills involve orientation, which is preparation of the learning activities, planning, which is designing the learning process and plan of approach based on the information of the orientation activities, monitoring whether the learning activities and progress is according to the result they want to achieve, diagnose the result and adjust the plan of approach, learning goals and activity according to the diagnosis, monitoring and assessment activities.
Within Games Atelier the students regulate their learning process while creating the game, playing the game and viewing the games. While creating the game, the students orientate themselves on the learning activity, while using information about and examples of location-based mobile games that are supplied by the learning environment.

Reflection on the learning experience
Constructivist learning environment should support reflection on the performance and thinking processes of the student in order for the student to correct these processes (Jonassen, Hernandez-Serrano & Choi, 2000). In order to make learning effective, the students must reflect on learning goals during and after the learning activity (Gee, 2003). Reflecting is thinking through the learning experiences and division of tasks between the student, peer students and teacher in general (Verloop & Lowyck, 2003). When the learning environment is able to make the learning activities visible for the students afterwards, the program supports the students to reflect on strategies of learning and learning processes.

Assessment by the teacher
After the learning activities, the teacher measures important learning outcomes and assesses whether the students understood the subject matter, they can remember it, and whether the students can apply the knowledge and skills and they possess insight and overview. The learning results should be consistent with the learning goals as explicated at the beginning of the learning activities (Verloop & Lowyck, 2003).
In Games Atelier different kinds of learning activities need to be assessed, which involves creating and playing the game and need different kind of assessment. The students, who participate in playing the game, perform problem solving activities and need performance assessment. The students who participate in creating the game should be assessed by means of portfolio-based assessment.
Good performance assessments reflect the complexity of real worlds and measures many facets simultaneously (Choi & Hannafin, 1995). Performance assessment requires a collection of complementary sources such as observations of student performance, exhibits, presentations, interviews, student-generated projects, simulations, and role-playing (Dana & Tippins, cited in Choi & Hannafin, 1995). Performance assessment involves the presentation of a task, special project, or investigation associated with either a routine or problematic situation.
Portfolio-based assessment provides useful collections of student work-in-progress and final products, through which students can become active in their own assessments. A part of the assessment consists of participatory assessment by students. Portfolios allow students to become better planners and students, because students reflect on their own cognitive growth and understand better what activities are needed to learn and how much time is needed to finish these activities (Choi & Hannafin, 1995). Herz (cited in Veen & Jacobs, 2005) sees educational potential for the way gamers are assessed during and after playing a game. The game presents a 'performance portfolio' which reflects the main characteristics of the gamer and the competences that have been trained during the game. This assessment focuses not on assessment criteria, but gives insight in the performance and accomplished skills.

3.3 GAME-BASED LEARNING

Approximately 75% of all Dutch students between fourteen and twenty years old play regularly computer games (Veen & Jacobs, 2005). Following Salen and Zimmerman (2003) games are "systems in which players engage in an artificial conflict, defined by rules, that results in a quantifiable outcome". Juul (2003) states that the outcome of games is variable and assigned with different values. Therefore the player exerts effort to influence the outcome and feels emotionally attached to the outcome. Commercial video games are very attractive to students and keep them focused and concentrated for a very long time.
The enormous impact of commercial games has attracted significant interest from educators and researchers in the Educational Science and Technology research area (Kirriemuir & McFarlane, 2004). Researchers, teachers and designers of learning resources are beginning to ask how games might be used to support children's learning.

The key areas of research in the field of investigation of game-based learning are the motivational aspects of games, learning by doing and learning by collaboration. These research areas are relevant for the design of Games Atelier, because the program supports the students in designing motivational and educational

games. When the students produce games and play the game they learn through their performance and collaboration with peer students.

Diverse authors have analyzed the impact of games on education. Games offer a learning experience in which players learn by doing. To some researchers, games can promote higher order learning, such as increased meaningful dialogues among students (McDonald & Hannafin, cited in Kirriemuir & McFarlane, 2004). Other studies describe the effects of games on social skills (Pellegrini et al., cited in Kirriemuir & McFarlane, 2004). Authors synthesize the effects of games on education to enhance learning through visualization, experimentation, and creativity of play (Amory et al.; Betz, cited in Kirriemuir & McFarlane, 2004), and often include problems that develop critical thinking, defined by Huntington (cited in Kirriemuir & McFarlane, 2004) as the analysis and evaluation of information in order to determine logical steps that lead to concrete conclusions (Kirriemuir & McFarlane, 2004).
Following Kirriemuir and McFarlane (2004) the research evidence for the impact of the games on education is complex and thinly spread. Kirriemuir & McFarlane suggests, in order to better understanding games and gameplay, and how they contribute to learning, it may be necessary to distinguish more clearly the nature of gaming and the nature of learning and the learner.

The research area which examines the motivational aspects of games, investigates the assumption that good educational computer games motivate students to learn and make learning fun. In practice students often find playing educational games boring (Veen & Jacobs, 2005). On the other hand, commercial video games are very attractive to students and keep them focused and concentrated for a very long time. So what is the difference between educational games and commercial games made for entertainment? Is it possible to apply the characteristics of commercial games to educational games in order to make them more attractive and motivational? How can an engaging learning environment be designed, based on the motivational aspects of games?

An important characteristic of commercial video games is that they are intrinsically motivating. A learner is intrinsic motivated when their activities are steered by personal interest (Verloop & Lowyck, 2003). So, commercial games are adapted to the personal interest of students. Several researchers are interested in investigating the motivating aspects of games and apply these motivating aspects to create engaging learning environments (Schwabe & Goth, 2005; Rieber, Davis, Matzko & Grant, 2001).
In the taxonomic model of intrinsic motivations for learning, Malone and Lepper (1987) decide on challenge, user control, curiosity, fantasy and collaboration to be the characteristics of a highly engaging and motivating learning environment.
Following Jones (cited in Kirriemuir & McFarlane, 2004) the sense of user control is enhanced by means of a task with clear goals the learner can complete and which provides immediate feedback, and the ability to concentrate on the task through deep but effortless involvement (losing awareness of worry and frustration of everyday activity).
In order to achieve challenge for the player, Malone (1981) proposes that it is important not to make the learning task too easy or difficult because that will reduce the intrinsic motivation of the task. Rieber (1996) states that challenge in the game should remain optimal adapted to the abilities of the learner. Therefore challenge can be increased or decreased by the learner themselves to keep the challenge of the task optimal.
Games possess many or all the characteristics of an engaging and intrinsic motivating learning environment as described by Malone and Lepper (Juul, 2006; Rieber, 1996).
Prensky (cited in Schwabe & Goth, 2005) proposes that six structural elements characterize games, which are (1) rules, (2) goals and objectives, (3) outcome and feedback, (4) conflict, competition, challenge and opposition, (2) social interaction and (6) story or representation that exaggerate interesting aspects of reality. When Schwabe and Goth (2005) developed their location-based mobile game for the University of Zurich, these structural elements supplied by Malone and Lepper served as a basic grid for the design of

the game. These game elements will also provide the basic grid for the game scenarios of the location-based mobile games which will be developed within Games Atelier (see also section 5.3 of this thesis).

An important research project which investigates the motivational aspects of commercial games and the impact of these games on learning is the research project of Gee (2003). Following Gee difficult but fun games are designed to "trigger deep learning that is itself part and parcel of the fun". Based on his analysis of computer and video games, Gee listed principles of learning which are built into good games.
He categorizes the learning principles in three themes, which are empowering, problem-solving and understanding.
Learning principles for empowering the students are involvement of students in co-designing the game, customizing the game to different learning styles, identification with a certain role or task and manipulating powerful tools. Learning principles for problem-solving are ill-structured problems, challenging and pleasantly frustrating problems, repeated cycles for practicing skills, information supplied by the system 'just in time' and 'on demand', simplified versions of the game as a tutorial or first level, safe environments with authentic characteristics, and skills are practiced to accomplish a greater goal. The repeated cycles for practicing skills as offered by good games is similar to the constructivist learning environment that offers students the ability to manipulate and test various solutions to the problem (Jonassen, Hernandez-Serrano & Choi, 2000).
The learning principles for understanding show how the learned skills and principles fit into a larger system and the whole meaning, and knowledge making understandable by means of image and action.
The well-ordered and challenging problems and clear goals were declared to be important motivating aspects by as well Malone and Lepper (1987), Rieber (1996) and Prensky (cited in Schwabe & Goth, 2005).

One important research project in the key research area learning by collaboration is the Kid Design Studio project of Rieber (2001). Rieber investigates children playing and designing educational games. First, the young students design their own game and later other young students play the games as designed by their peers. The most important conclusion of this study is that games should support and influence the social relationship among players and peers. One goal of the research project is to support collaborative learning by means of the program Games Atelier and the importance of cooperation to intrinsic motivation is also stated by Malone and Lepper (1987).

Salen and Zimmerman published in 2003 the book "Rules of Play: Game Design Fundamentals". This book is often cited in studies about game design and educational games. In this book Salen and Zimmerman offer a model to look at all kinds of games and define core concepts as play, design and interactivity of games. Salen and Zimmerman are game designers and teachers at the MIT. The book offers a theoretical framework about games which is informative for developing the Games Atelier program, because motivating games are to be designed within this program. In order to do so, the ground rules of game genres and gameplay should be understood.

Another important book about the basic theory of video games is Half Real (Juul, 2003). In the book, video games are defined, also in relation to non-digital games, how players learn to use a game, how players imagine the world of a game, and why video games are fun. Author Jesper Juul is a game-developer, video game theorist, and assistant professor in video game theory and design at the Centre for Computer Game Research Copenhagen.
Csikszentmihalyi (1992) is the first author to describe 'flow' as the aspect of gaming that makes people want to play games, and as such many times cited by other researchers investigating what makes gaming fun. Flow is summarized by several researchers as "the state in which we are so involved in
something that nothing else matters" (Csikszentmihalyi, 1992). A 'flow state-of-mind' can be achieved by means of a clear goal, concentration, loosing self consciousness, loosing track of time, direct feedback in order to follow your own progress, the activities are challenging and not too difficult or too easy, personal

control, and intrinsic rewarding (Csikszentmihalyi, 1992). Kirriemuir & McFarlane (2004) argument that learning environments should investigate and use the deep structure of gameplay experience that contribute to 'flow'.

3.4 LEARNING OUTSIDE THE CLASSROOM ENVIRONMENT IN AN AUTHENTIC CONTEXT

In Games Atelier the students play and make games within an authentic context outside the classroom environment. When creating and playing location-based mobile games, students collaboratively explore the real-world environment to search for understanding of certain problems that are related to this environment. This can be problems related to biology, geography or any other subject matter in the curriculum of secondary education. The following section describes the characteristics of an effective lesson outside the classroom environment.

For constructive learning it is important that the learning environment is authentic and situated in a real-life situation. When the learning activities, which are used to understand the outside world, are embedded in a real-world context, and abstract concepts are related to and illustrated by authentic examples, the knowledge and skills become more meaningful for the students and the learning becomes more effective. Good educational video games have also the potential to make abstract learning concepts more concrete by means of images and activities (Gee, 2003).

Embedding learning activities in their authentic context makes it easier for students to learn how to use and apply new knowledge in activities outside schools. Since authentic tasks are often problem-based, students are better able to gauge what they are learning and how to use it (Collins; Collins, Brown, & Newman, cited in Choi, 1995). Application of new knowledge and skills to solve authentic problems is an important cognitive learning skill (Verloop & Lowyck, 2003).

Anchored instruction is a form of context-based learning and has its roots in constructive thinking. It is very similar to problem-based learning and makes use of the rich environment the students live in. The real-world environment contains all elements needed to solve a complex and realistic problem. Solving the problem within an authentic context, the student processes the knowledge in the most natural way (Verloop & Lowyck, 2003). Piaget proposed; humans cannot give information to, which they immediately understand and use. Instead, they must build up knowledge through experience. Students learn, based on first-hand experience, when a particular method or strategy is appropriate in authentic, rather than contrived, contexts.

Constructivist learning and game-based learning is often related to problem-based learning or project-based learning. In problem-based learning, students are engaged in solving realistic problems that provoke the curiosity of students and provide a focus for the learning activity. The learning environment is very open and uses experiences from the real world. The problems are ill structured and reflect the complexity of the authentic situation (Jonassen, Hernandez-Serrano & Choi, 2000 Verloop & Lowyck, 2003). Ill-structured problems are difficult to solve because the solutions and solution paths are not obvious. In order for the problem to be authentic, the performance must have some connections to the real world or some aspects of that world. The students must apply rather than recollect knowledge (Bergen, cited in Choi, 1995). The students work in project groups and analyse the problem extensively from different points of views.

3.5 LOCATION-BASED MOBILE GAMING

Game Atelier will become a learning environment in which students can create and play their own location-based mobile games. Location-based mobile games are a sub-genre in the pervasive gaming field, which combines the virtual domain of the computer and the physical and social aspects of the real world. In location-based mobile games the entire world where we live in is regarded as a game board. Buildings, a block, or a city becomes the game board and the human players themselves become the proactive and highly unpredictable playing pieces (Magerkurth, Cheok, Mandryk & Nilsen, 2005). Pervasive computing is using a seamless integration of technologies, which allows people to access and interact with

information any place, any time. Figure 3 illustrates the use of seamless integration of technologies. The technologies are often referred to as smart devices or information appliances, designed to perform a particular activity. Commercial products include mobile phones and Palm Pilots (Preece, Rogers & Sharp, 2002).

In this section some examples of location-based mobile games are described. Not all these games have educational goals, but these design projects can be inspiring and informative for developing the program Games Atelier. The location-based mobile games have some aspects in common. They are highly motivating for the user by means of immersion in the game and environment of the game. This motivating aspect is according to the aspects described in the section game-based learning. Also, the games are designed to support interaction between players, which enhances learning by means of collaboration and interaction with the context of the game. Because the games are situated in the real world where we live in, playing the game can support situated learning. This interaction with the authentic location is accomplished by means of context-aware mobile devices, which will be described in the next section mobile learning.

Figure 3: Location-based mobile technologies (pervasive learning, 2007)

The location-based mobile game 'The Songs of North' is developed by Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi (2004). This entertainment game is designed to demonstrate possible technical and game design solutions for pervasive games. The study is interesting for the development research of Games Atelier, because design principles for location-based mobile games can be extracted from this study. The game genre of 'The Songs of North' is a role-playing game with meaningful and motivating quests. Role-playing game is one of the possible genres to be developed with the toolbox provided by the program Games Atelier. Within the game 'The Songs of North', the players are motivated to move around the city, to communicate and cooperate together (Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi, 2004). These aspects will be important for Games Atelier as well.

In the case study of Raessens (2007), the pilot mobile and location-based educational game Frequentie 1550 is analyzed, investigating the ways in which mobile and location-based technologies can be used as micro-learning tools. Frequentie 1550, as being a role-playing game, can be used as a social and reflective learning tool, which blends entertainment and education. This can be very motivating to the students (Raessens, 2007).

Schwabe and Goth (2005) developed an educational location-based mobile game, called Mobile Game. Through the research project the researchers discuss design issues of a mobile game system with a focus on issues specific for mobile learning and designing the interface of a mobile learning game. Furthermore they present data on the effects of a mobile game on participant motivation and on the features causing those effects (Schwabe and Goth, 2005). They conclude that the motivational effect is caused by immersion in a mixed reality environment and investigate how this immersion in a mixed reality environment can be designed.
Mixed reality means that the participants' activities are partially represented in physical space and partially in digital space and both spaces stand in correlation to one another (Schwabe & Goth, 2005).

Facer, Joiner, Stanton, Reid, Hull & Kirk (2004) describe the design of Savannah, which is a powerful and engaging learning experience by using mobile technologies in physical interaction with space and other players in combination with principles of engagement and self-motivation, as described by Malone (1981). The research focuses on the design process, gameplay and supporting technologies.
Savannah is a role-playing game in which the rules of the game resemble the behaviour of lions. The rules should enhance the understanding of the students about the animals' behaviour. Facer, Joiner, Stanton, Reid, Hull & Kirk (2004) conclude that for education there is a need to ensure that the games rules reflect the rules of the environmental lessons being taught and that mobile games have a potential to motivate students to self-directed learning.

Benford is one of the most cited authors in the research area of location-based mobile gaming.
Benford et. al. (2003) developed the location-based mobile game 'Can You See Me Now?' and wrote an article for game designers on how to integrate uncertainties of the GPS within the game scenario. The GPS does not always allow showing the position on the digital map. Therefore you can make use of these uncertainties for developing an engaging experience.

Flintham is another much cited author in this research field. Flinthams' research relates to supporting public, mobile mixed-reality experiences, with a research interest in construction of software tools and infrastructures to support pervasive gaming and locative and new-media projects. Flintham et. al. (2003) developed two entertainment location-based mobile games 'Can You See Me Now?' and 'Bystander'. In their study, the researchers explore the different forms of collaboration that can take place between players on the city streets and online players.

3.6 MOBILE LEARNING

Mobile learning projects are blooming all over Europe, ranging from the use of Personal Digital Assistants (PDA's) and tablet computers in classroom environments, through mobile phones to support learning in schools and museums, and to context-aware technology for field trips and tourist visits (Naismith, Lonsdale, Vavoula & Sharples, 2006). Location-based mobile games are experiments to develop engaging and effective learning experiences (Facer, Joiner, Stanton, Reid, Hull & Kirk, 2004; Raessens, 2006; Schwabe & Goth, 2005). The mobile devices have interesting and unique capabilities which are potential to support several contemporary learning theories and enable engaging forms of learning. Educators and technical developers are interested to exploit these capabilities, but application of theory to the use of these technologies for educational purposes is lacking (Naismith, Lonsdale, Vavoula & Sharples, 2006). Although several authors have posed the question about the pedagogical potential of mobile devices,

research in this field is recent and more full-field research studies on the impact of wireless communication networks are required (Tatar et al., cited in Sánchez, Salinas & Sáenz, 2006).

Location-based games made and played within the program Games Atelier blends mobile learning, e-learning and game-based learning. Mobile learning is generally indicated as m-learning, relating m-learning to e-learning. Georgiev, Georgieva, and Smrikarov (2006) define m-learning as "a form of existing distance learning and e-learning that provides the ability to learn anywhere at anytime without permanent physical connections to cable networks which can be achieved by the use of PDA's, smart phones, cell phones, portable computers and tablet PC". Additionally, these devices must have the "ability to connect to other computer devices, to present educational information and to realize bilateral information exchange between the students and the teacher". O' Malley (cited in Kukulska-Hulme & Traxler, 2005) define mobile learning as "taking place when the learner is not at a fixed, predetermined location, or when the learner 'takes advantage of the learning opportunities offered by mobile technologies". Mobile learning can be spontaneous, informal, contextual, portable, ubiquitous and pervasive. It has a lot in common with other types of e-learning on desktop-computers, but with the advantages and drawbacks of more varied and changing locations, more immediate interaction, and smaller, often wireless devices (Kukulska-Hulme & Traxler, 2005).
The support of mobile devices can be richer than PC's, because it can be used immediately when the learner feels like learning or the support, for instance by means of note taking or making pictures, is helpful when the student is not behind a computer. Mobile devices should be viewed as useful, lightweight portable adjuncts to PC's, because it is easy to exchange media between the PC and mobile device (Trinder, 2005).
For certain activities, like writing documents or exploring the Internet, the PC is better usable. E-learning and m-learning can complement each other. Games Atelier is also using the computer and mobile devices to complement each other and optimize the learning experience. Mobile phones are being used to deliver educational contents on the right place and the right time and to support collaboration between students. Computers are being used to make the educational contents that are to be delivered on the mobile phone, and to supplement the game being played, because by means of computers the players can search for information sources on the Internet.

Context-aware mobile phones can support students by offering appropriate assistance when required. The teachers or other students who participate in the activity can monitor the individual students and give feedback or support when necessary (Naismith, Lonsdale, Vavoula & Sharples, 2006).
For supporting collaboration between users when being on location, mobile devices may provide the environment in which conversational learning takes place. Mobile technology can extend the range of activities and the reach of a discussion into other worlds through games, and to other parts of this world by mobile phone or e-mail. The technology provides a shared conversational learning space, which can be used not only for single students but for groups of students (Naismith, Lonsdale, Vavoula & Sharples, 2006).
In Games Atelier mobile phones are used when playing the mobile location-based game to receive content on location, share this content between users and to support collaboration between users when they are far away from each other. The technology provides the environment in which 'conversational learning' takes place (Pask, cited in Naismith, Lonsdale, Vavoula & Sharples, 2006). It can extend the range of activities and the reach of a discussion into other worlds through games, and to other parts of this world by mobile phone or e-mail (Naismith, Lonsdale, Vavoula & Sharples, 2006).

A good example of a context-aware mobile application is the interactive mobile multimedia tour in the museum Tate Modern in London. Tate Modern used mobile technology as a pilot in 2002 (Proctor & Burton, 2003). PDA's in combination with a wireless network showed background information about the exhibits on the screen highlighted special details to focus the attention of the spectator. An expert was similarly talking about the pictures. Interaction with visitors occurs by answering questions or by

developing a soundtrack for the paintings. The visitors were given the right information when they entered the room. The visitors could request to send additional information of the paintings they had seen to their home e-mail address and through the network the museum they could send messages to the PDA's. Based on the evaluation of this pilot, key areas for further research are the facility for visitors to communicate directly with the gallery, for peer-to-peer communication, to access online databases while in the gallery and to e-mail themselves information through the Tate website, and improvement of processing speed, tour interface, and location-sensitive context delivery.
This study can be informative for developing Games Atelier, because the context-aware interaction can be leading for developing media which enhances the location in Games Atelier. The research on communication tools and the mobile interface are interesting topics to include in Games Atelier. Evaluations of the interactive multi-media tour in Tate Modern indicate that regarding the content itself, the most effective design approaches were those that incorporated audio, particularly audio-visual coherence and interactive messages. Visitors did not respond well to long messages, particularly those that were primarily text-based (Naismith, Lonsdale, Vavoula & Sharples, 2006).

3.7 SUMMARY

This chapter reviewed the literature about topics that are related to the design of Games Atelier, which are the net-generation, constructivism, game-based learning, learning outside the classroom environment in an authentic location, location-based mobile games and mobile learning. Reviewing the literature helps exploring the research area and helps defining the project statement.

The program Games Atelier combines several aspects which are regarded to be important aspects of the learning theory constructivism. These aspects are active students who learn collaboratively, produce their own and meaningful artefacts, learn within an authentic context and reflect on these learning activities.
Games Atelier supports as well the tasks of the students as well as the tasks of the teachers. Within Games Atelier, the teacher coaches the students in their active learning process. Coaching involves observing and helping individuals while they attempt to learn or perform a task (Brandt, Farmer, & Buckmaster, cited in Choi, 1995).
The net-generation, as described by Veen and Jacobs (2005) indicate that students of the younger generation integrate Internet and multimedia devices in their personal life. They train skills and gain knowledge by using these new media, like Internet or videogames. The students train skills outside the classroom environment in their free time, which results in the fact that the curriculum of the school is not tuned in on the students characteristics. The young generation of students is used to playing games at home. Because the games contain motivating elements, like speed, interactivity and direct feedback, the students demand this also from the experiences they have on school. To enhance the effectiveness of education, the practice must adjust more to these expectations. Veen and Jacobs conclude that modern education should offer students the opportunity to experiment with ICT. The students should make products that have a relevant application in a real-world context. Games Atelier offers students the opportunity to create location-based games that are integrated within the real-world context.

The constructivist theorists believe that meaningful knowledge building can only take place when the student processes the knowledge socially and/ or technically. Socially processing compasses discoursing with peer students or with the teachers, i.e. collaborative learning. Collaboration involves students negotiating different points of views and learning from each others knowledge and skills. Analysing a problem from different angles is recommended by problem-based and anchored instruction and also emphasized by the teachers during the user analysis. The students process the knowledge technically when they build an artefact. The processes are more important than the quality of the product. Multimedia tools can support the students in building artefacts using multiple objects and media. Multiple perspectives promote critical examination of concepts, ideas, issues or dilemmas. Reflection is essential for students to learn. They should gain insight in the choices they made themselves during the learning activity. The

teachers appreciated the Geotracing functionality as a valuable reflection technology that stores all information and media as collected in the field.

The key areas of research in the field of investigation of game-based learning are the motivational aspects of games, learning by doing and learning by collaboration. These research areas are relevant for the design of Games Atelier, because the program supports the students in designing motivational and educational games. When the students produce games and play the game they learn through their performance and collaboration with peer students. The motivational aspects of games can inform the design principles for an engaging and intrinsic motivating learning environment. In their taxonomic model of intrinsic motivations for learning, Malone and Lepper (1987) decide on challenge, user control, curiosity, fantasy and collaboration to be the characteristics of a highly engaging and motivating learning environment, which all are characteristics of good motivational games. Location-based mobile games make use of these intrinsic motivational aspects of video games and are further examined in Chapter 5.

Location-based mobile games are a sub-genre in the pervasive gaming field, which combines the virtual domain of the computer and the physical and social aspects of the real world. In location-based mobile games the entire world where we live in is regarded as a game board (Magerkurth, Cheok, Mandryk & Nilsen, 2005).
The literature about designing location-based mobile games informs the construction and design of these games. Some examples of these research projects are described in this section. The research area is still very new and there is little research done to prove the pedagogical effectiveness of these games.
Location-based mobile games have potential to support collaborative learning and learning in an authentic context. Using context-aware technologies, the player can receive assignments and information that enhance the real-world location. Because the games are situated in the real world, playing the game supports learning outside the classroom environment in an authentic environment. The games are designed to support interaction between players, which enhances learning by means of collaboration.
Context-aware technologies combine mobile technologies and GPS signals to receive learning objects that are connected to that specific real-world location. The GPS only operates outside buildings. Context-aware technologies support m-learning, which is defined as “a form of existing distance learning and e-learning that provides the ability to learn anywhere at anytime without permanent physical connections to cable networks which can be achieved by the use of PDA’s, smart phones, cell phones, portable computers and tablet PC” (Georgiev, Georgieva, and Smrikarov, 2006). For certain activities, like writing documents or exploring the Internet, the PC is better usable. E-learning and m-learning can complement each other.
The program Games Atelier combines the computer and mobile devices to complement each other and optimize the learning experience. Context-aware devices deliver educational contents on the right place and the right time and to support collaboration between students. Computers are used to make the educational contents that will be delivered on the mobile phone, and to supplement the game being played, because by means of computers the players can search for information sources on the Internet.
The mobile and web-based technology provides the environment in which ‘conversational learning’ takes place (Pask, cited in Naismith, Lonsdale, Vavoula & Sharples, 2006). It can extend the range of activities and the reach of a discussion into other worlds through games, and to other parts of this world by mobile phone or e-mail. The technology provides a shared conversational learning space, which can be used not only for single students but for groups of students (Naismith, Lonsdale, Vavoula & Sharples, 2006).

The literature as examined in this chapter provides insight in the main characteristics of mobile and game-based learning and information about how users can be supported in creating, playing and viewing the educational location-based mobile game. These topics will be investigated more elaborately in section 5.2. In the next chapter, the design approach and research method as followed during this research project are discussed. The program Games Atelier is designed according to the user-centred design approach and in order to formulate validated design principles, the developmental research method is followed.

4 DESIGN APPROACH AND RESEARCH METHOD

This chapter gives insight in the design approach and research method that are followed in this research project to design the program Games Atelier. The user-centred interaction design approach and the developmental research method are chosen for this project, because both approaches design and development of interactive products and are suitable for the design of an innovative and complex product, what Games Atelier really is because only few of comparable programs have been designed and none are used in the Netherlands. From the start of the design project, prototypes are developed that reflect the needs and requirements of the target group. At the beginning, these prototypes are very simple, but following iterative cycles, the prototypes evolve in more sophisticated versions that more and more reflect the proper requirements of the target group. According to Tripp and Bichelmeyer (as cited in Nieveen, 1999), in these situation "little formal research is needed to begin a project, and much information can be gathered from research conducted as students use the prototype".
The user-centred design approach involves users from the start of the project and focuses on user needs rather than technical concerns. Focusing on the needs of teachers and students is important in order for the teachers to really use the program in practice. The developmental research method prescribes to embed the design rational for the product in recent literature in order to formulate validated design principles. According to the user analysis validation of the program is very important for teachers who use the program.
Both the design approach and the research method chosen show similarities. According to both methods, the development of the program follows iterative cycles of analysis, development and evaluation. The target users and context of the target users are analysed before the development. The program is evaluated and adjusted in iterative cycles, until the product satisfies the users' needs.

First the user-centred design process of interaction design will be described. The user-centred design process includes five phases, which are the analysis, design, development, implementation and evaluation phase. All phases will be explained, but the main focus of this research project is the analysis and design phase. Secondly the developmental research method will be described. Important activities of this research method are preliminary investigation of tasks, problems and context, and searching for connections of that analysis with knowledge from literature. This can be done by means of a literature review, consultations of experts, and analysis of available examples. The results of these activities are described in the fifth chapter.

Furthermore, this chapter describes the 4E-model, which predicts the possibility of implementing an innovating interactive program, data-acquiring techniques, data-collection moments, analysis of the data and threads to validity of the research methods.

4.1 THE USER-CENTRED DESIGN PROCESS OF INTERACTION DESIGN

Interactive products (such as web-based applications and educational games) are spaces for human communication and interaction, which supports people in their activities in effective and aesthetically pleasing ways (Winograd, cited in Preece, Rogers & Sharp, 2002). The interactive product employs the capabilities of a computer directly to a task that the user wishes to perform. Games Atelier is an interactive product which supports the activities of teachers and students from the secondary school. Therefore, a key concern for designing this interactive system is to understand the kind of activities people are doing when interacting with the system (Preece, Rogers & Sharp, 2002). In order to design a system that is effective and aesthetically pleasing for the target users and to optimize the users' interaction with the system, it is important to understand the wishes and capabilities of the teachers and students. These wishes and capabilities are translated to the usability and user experience goals, which inspire the design of the program. Usability goals involve optimizing the interactions people have with interactive products to

enable them to carry out their activities. User experience goals explicate the way the interaction with the system feels like to the user (Preece, Rogers & Sharp, 2002).
Besides identifying usability and user experience goals, other important characteristics of interaction design is the focus on users and iteration of the design (Preece, Rogers & Sharp, 2002).

4.1.1 User-centred approach

Focus on user's means that the program is designed following a user-centred approach and the users' concerns are leading for the design and development, rather than the technical concerns (Preece, Rogers & Sharp, 2002). The programs' use and target domain are investigated, the needs of the target users are identified and requirements for the program established by the designer. The usability and user experience goals are part of the formulated needs and requirements of the program.

To investigate the users' concerns, representative users from the real target group, which are the students and teachers from the secondary school, are consulted and involved from the start of the design process. User involvement leads to more accurate information about the tasks that will be supported by the program, more intensive discussions about the requirements of the system, better opportunities to negotiate and justify design ideas, increase of user commitment and ownership of the final deliverable, stimulation of the professional development of the participants and changes in the work environment of the participants (Moonen; Schneidermann, as cited in Nieveen, 1999).

4.1.2 Iteration of the design

To investigate the programs' use and to decide on the best design guidelines, alternative prototypes are developed according to the established requirements. Representatives of the target users interact with these prototypes and evaluate the usability and acceptability. After these try-outs, designers discuss the experiences, preferences and suggestions for improvement with the target users. This activity is called prototyping, which involves "producing a limited version of the product with the purpose of answering specific questions about the designs' feasibility or appropriateness" (Preece, Rogers & Sharp, 2002).
Interacting with prototypes gives both the users as well as the developer of the prototype insight in the potentials of the system and its desired characteristics.
Especially in development projects that aim at innovative and complex products, with few experiences to draw on, a prototyping approach appears to be appropriate. According to Tripp and Bichelmeyer (as cited in Nieveen, 1999), in these situation "little formal research is needed to begin a project, and much information can be gathered from research conducted as students use the prototype".
The iteration of the design process allows the program to be refined based on feedback of the users interacting with limited representations of the program. As users and designers engage with the domain and start to discuss requirements, needs, hopes and aspirations, then different insights into what is needed, what will help, and what is feasible will emerge (Preece, Rogers & Sharp, 2002).

There are different kinds of prototypes that are suitable for different stages of development and for extracting different kinds of information. Smith (as cited in Nieveen, 1999) distinguished the evolutionary and throw-away prototypes. The evolutionary prototype is adjusted after every evaluation with the users, and evolves into the final product.
The prototypes being developed during this research project are throw-away prototypes, supporting the investigation of the users' needs and acceptability of the design. The prototypes were designed, and used to collect the needs and requirements by means of evaluation of this prototype. The needs and requirements are taken into account in a next prototype. The product is thrown away after every evaluation.

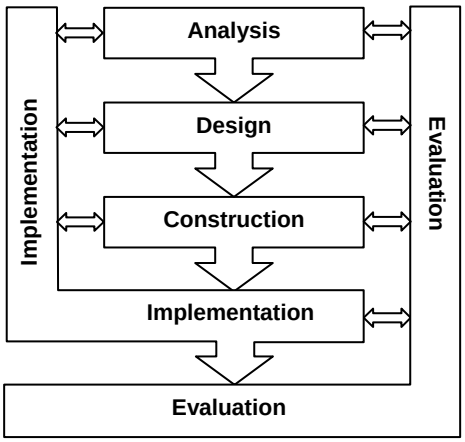

Figure 4: General educational design model (Visscher-Voerman, Gustafson & Plomp, 1999)

Figure 4 shows the general educational design model, developed by Visscher-Voerman, Gustafson and Plomp (1999), which is an appropriate illustration of the interactive design approach of this project. The model visualizes the iterative and user-centred characteristics. The model is user-centred, because the design focuses on the needs of the target user group and not on the possibilities of the technology. The teachers and students are involved from the start of the design process, and the prototypes of Games Atelier will be evaluated by the users during the analysis, design, construction and implementation phase.

Interaction design projects are divided into five phases: the analysis, design, construction, implementation and evaluation phase (Preece, Rogers & Sharp, 2002). During this research project the focus will be on the analysis and design phase of the interactive system. According to the iterative characteristics of the interaction design approach, prototypes will repeatedly be evaluated and adjusted during all these phases, evaluating the acceptability of the design. This evaluation during the design process is called formative evaluation.

4.1.3 Analysis phase

During the analysis phase the designer analyses the end users, stakeholders and problem space. This investigation phase is called the requirement activity, because the needs of the teachers and students are translated into requirements. Requirements are statements about what Games Atelier should do or how it should perform according to this research project (Preece, Rogers & Sharp, 2002).
The requirements are fundamental for determining the acceptability and usability checklist, which will be consulted for the formative evaluation of Games Atelier (Preece, Rogers & Sharp, 2002).

4.1.4 Design phase

Analyzing the needs and requirements of the interactive products' target users inspires the design of Games Atelier. During the conceptual design phase, the requirements are translated into the conceptual model, which captures what the product will do and how it will behave (Preece, Rogers & Sharp, 2002). Also, the 'look and feel' and design of the interface, the structure of the program, the interaction style and the use of media are decided on by the designer. Based on the conceptual model, a prototype is developed and tested among the users. This prototype is developed by means of PowerPoint. According to the results of this formative evaluation, the product is adjusted.

4.1.5 Construction, implementation and evaluation phase

During the construction phase, one final design is chosen among the evaluated prototypes and translated into the physical and interactive program. This interactive program will be implemented and summarily evaluated during the implementation phase and evaluation phase. The users of the implemented product will be analyzed by means of quantitative and qualitative investigation tools, such as observations or filling in questionnaires, also based on the early constructed acceptability and usability checklist (Preece, Rogers & Sharp, 2002). The construction, implementation and evaluation phase is not in the scope of this research project.

4.2 DEVELOPMENTAL RESEARCH METHOD

Besides designing and developing the program according to the user-centred design process, the design process is supported by the formative research approach, which is a type of development research.
Designing and developing the program Games Atelier is an explorative design study, because oriented to solve practical goals of the organization Waag Society. It takes place before the developmental process and aims to clarify a problem-in-context and generate specific design ideas.
The formative research approach is chosen to ensure that the product is developed based on validated design principles and quality of the program will be optimized. By means of theoretical embedding the design rationale into recent knowledge, the design rationale will be validated and more transparent to other developers (Van den Akker, Branch, Gustafson, Nieveen & Plomp, 1999).
Besides developing prototypes and establishing requirements that inform the specific design of Games Atelier, more general design principles will be formulated, referring to characteristics of the program, which can be informed for other similar design projects (Reeves, 2000; Richey & Nelson as cited in van den Akker, 1999).

Formulating design principles reflects scientific goals and is called reconstructive research.
The formative research both aims at providing ideas to optimize the quality of the intervention to be developed and generating and testing design principles. Formative research takes place during the whole design and development process of the intervention (Van den Akker, Branch, Gustafson, Nieveen & Plomp, 1999).

The process of developmental research is cyclic or spiral: analysis, design, evaluation and revision activities are iterated until a satisfying balance between ideals and realization has been achieved (Van den Akker, Branch, Gustafson, Nieveen & Plomp, 1999). These aims are similar to the aims of the user-centred design process as described above. The aim is not to elaborate and implement a completed program, but to develop prototypes that increasingly meet the requirements of the target users.

Van den Akker, Branch, Gustafson, Nieveen and Plomp (1999) describe additional activities which distinguishes development research from development practice. These activities are preliminary investigation of tasks, problems and context, and searching for connections of that analysis with knowledge from literature. This can be done by means of a literature review, consultations of experts, and analysis of available examples.

Another activity distinguishing developmental research from developing products is theoretical embedding the design rationale into recent knowledge. This should make the design rationale validated and more transparent to other developers. The design principles can be tested by the users in a natural environment, in order to generate empirical evidence of the practicality and effectiveness to target users. Also in developmental research much attention is paid to systematic documentation, analysis and reflection on the entire design, development, and evaluation and implementation process and on its

outcomes in order to contribute on the expansion and specification of the methodology of design and development (Van den Akker, Branch, Gustafson, Nieveen & Plomp, 1999).

The emphasis of the activities during the development research depends on the aims and type of research. The formative research approach includes all sort activities, with emphasis on theoretical embedding and empirical testing of the intervention. The goal of the test is to enhance the quality of the prototype.

Development research approaches are often conducted in the area of media and technology. It is a suitable approach for complex, innovative tasks for which only a few validated principles are available to structure and support the design and development activities. The image and impact of the intervention to be developed is often still unclear, so the research focuses on realizing limited but promising examples of those interventions (Van den Akker, Branch, Gustafson, Nieveen & Plomp, 1999). This is certainly the case for Games Atelier. The design of the program is based on mobile learning and game-based learning, which are new topics in the educational science and technology research area.

4.3 4E MODEL

The program Games Atelier is partially designed according to the 4E-model (Collis & Moonen, 2001). The 4E model (Figure 5) illustrates the relation between the factors Ease of use, Environment, Engagement and Effectiveness of an educational product. The 4E model guides the investigation during the user and context analysis, the development of the design principles and the evaluation of the prototype.
According to Collis and Moonen (2001) the likelihood that a target user will use a technological innovation for a learning-related purpose is a function of four groups of factors, which are the Environment (the institutional context), Educational effectiveness (perceived or expected), Ease of use and Engagement (the personal response to technology and to change).
In the 4E-model, the Environmental factor determines the level of the success threshold. This means, the stronger the institutional support and environmental climate for implementing the program will be, the lower the 3E vector-sum of Educational effectiveness, Ease of Use and Engagements needs to be to predict successful implementation of the product.
It is not easy to determine or predict the Environmental factor for the program Games Atelier. The institutional support depends on the administration of all individual secondary schools, but the decision makers for using the program will be the teachers. This probably weakens the Environmental factor, so the Ease of use, Educational effectiveness and Engagement should be relatively high. But the program is offered to the teacher for free and this can strengthen the Environmental factor, so the other factors can be lower.
The 4E model leads the evaluation of the prototype, and therefore it can be guiding for the design the program. The factors of which the 4E model exists are also leading for the variables where the user and context investigation focus on. Because the environment is not part of the program to be designed and cannot be determined by the users, the formative research mainly focuses on optimizing the educational Effectiveness, Ease of use and Engagement of the users.

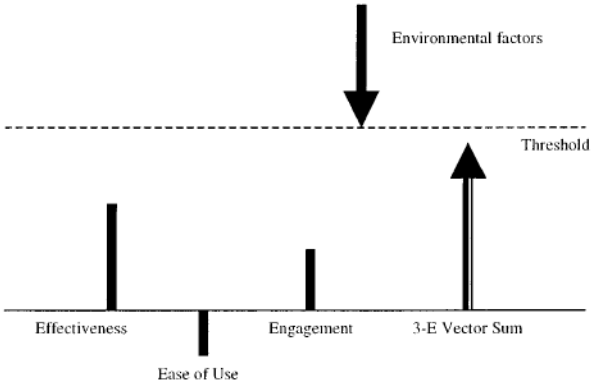

Figure 5: 4E model (Collis & Moonen, 2001)

4.4 DATA GATHERING TECHNIQUES

The purpose of data gathering is to collect sufficient, relevant, and appropriate data so that a set of stable requirements can be produced. To investigate the users' concerns, representative users from the real target group are consulted and involved during the design process.
The researcher needs to find out about the tasks that users currently perform and their associated goals, the context in which the tasks are performed, and the rationale for why things are the way they are (Preece, Rogers & Sharp, 2002). In order to explore the problem, the user needs and requirements, the data collection methods used are user scenarios, workshops and focus group discussions, questionnaires, observations. These are rich qualitative research methods used to interact with the target user groups to gradually clarify the problem at stake and the characteristics of the potential solution.
Efficiency of procedures is crucial, especially for early stages of formative evaluation, with the intervention still poorly crystallized (Van den Akker, Branch, Gustafson, Nieveen & Plomp, 1999). The program Games Atelier is a new and innovative program. User needs and requirements are broadly investigated by means of qualitative investigation techniques. Samples of respondents and situations for data collections will usually be relatively small and purposive compared to sampling procedures for other research purposes.
Sweeney, Maguire and Shackel (1993) states that questionnaires are 'powerful instruments to investigate the attitude and opinions of the target group'. This instrument is chosen to acquire data from the students. The youngsters are difficult to distillate information from by means of a focus group discussion when they are in a large group of more than five persons.
Based on the analysis of the data, user requirements will be established, which lead to the design guidelines of the application and the development of a prototype.

4.5 DATA COLLECTION MOMENTS

There will be two phases during the research project for data to be collected by means of a variety of data acquiring techniques, which are the analysis phase and the design phase. The analysis phase has a purpose to analyse the target users of the program and the context of the program, in order to investigate the users' needs, user experience goals and usability goals. Eventually, the user analysis leads to a list of requirements, which are statements about what Games Atelier should do and how it should perform according to this research project (Preece, Rogers & Sharp, 2002).
During these requirement activities, three prototypes are developed. The first prototype is a location-based mobile game. This prototype combines paper-based elements with Geotracing software and smart phones. This prototype helps the designer to understand the tasks involved in creating a location-based mobile game. These tasks will be supported by the program Games Atelier. Furthermore, the prototype is tested by the intended target group, which gives them insight in the location-based mobile experience.

The second prototype is three moodboards which capture three different themes and spheres that are representative for different game genres. The moodboards are collages of visual elements. They are constructed to support and structure a discussion with students of the secondary school about their preference for the 'look and feel' of Games Ateliers' user interface, their association with creating and playing games, and what theme most motivates and attracts them.
The users interact with the prototypes, which helps to sharpen the requirements. The requirement analysis activity is the main part of the research project. The techniques to gather data from the users and context are divers, in order to get different perspectives and construct triangulation (Preece, Rogers & Sharp, 2002).

In the second phase of the project, the design phase, a final prototype is developed, based on the literature analysis and the requirement analysis activities. This prototype represents the web-based application of Games Atelier. This prototype captures the requirements that are established according to the user and context analysis, and the literature review. This prototype will eventually be evaluated by the teachers in a formative evaluation moment.

4.6 ANALYSIS OF THE DATA

During the analysis phase the data is collected by means of user scenarios, survey questionnaires, observations and focus group discussions. Except for the questionnaires, these are qualitative methods. The data collection results in documents that describe the research activities in a detailed manner. The documents are analyzed by means of coding (Krathwohl, 1998). Tags, a descriptive word or phrase, were added to meaningful words, sentences and topics and these tags were organized in a logical flow. The researcher should look for repeating events, routines and concepts. The researcher decides on the most meaningful phrases, based on the most important variables which are investigated. The decision on the included elements is a subjective decision, and it constructs the foundation of the research and design of the program. These analyses and tags will lead to the list of needs and requirements (Krathwohl, 1998).

4.7 POTENTIAL THREATS TO VALIDITY

The potential risk of analyzing qualitative data by means of coding is rival explanation. Coding must be done carefully to maintain the data validity (Krathwohl, 1998). The coding is subjective and fundamental for the research process and results. In order to be as careful as possible, the researcher should ask experts and colleagues to review the analysis. Also, the researcher can study literature to find out which variables and tags are most common in comparable studies.
Interviews and questionnaires can be affected by response sets, particularly with attitude, personality and interest scales. Respondents might give false answers slanted towards their sense of what is desirable, to preserve their self-images, or to avoid feelings of discomfort, or respondents can be "yeah or nay-sayers" (Krathwohl, 1998). Researchers need to be alert on response sets, and to avoid yeah or nay saying, researchers can best construct the questions in a way that respondents can't answer yes or no.

To avoid an overdose of uncertainty in the data, triangulation is applied. Triangulation is the use of data from different sources across persons, situations, and methods, to ensure that the data is not overtly influenced by one point of view (Krathwohl, 1998). To construct validity, the researcher relates data from different methods to other measures, showing that the measure relates to how the construct would display itself, and that the measure samples it domain appropriately. The most common type of triangulation is data triangulation, using multiples sources of data across time, space and persons (Denzin, cited in Krathwohl, 1998).

4.8 SUMMARY

The fourth chapter explained the user-centred design approach and developmental research method as followed during this research project. The user-centred design approach, combined with the developmental research method should be appropriate for several reasons. The development of Games Atelier is to be an innovative and complex project, because there are few comparable programs in the world and it is an innovative domain, especially for the educational research domain. The user-centred design approach, as well as the development research is recommended for these kinds of innovative and complex projects. The user centred design and developmental research approaches show many similarities. For example, both approaches use prototypes, which are formatively evaluated and adjusted in iterative cycles. The formative research approach is characterized by developing a qualitative product according to a problem-in-context, but also to generate generalizable design principles. This would be the aim for this research project. Also, the conceptual design for Games Atelier is to be embedded in state-of-the-art literature.

The activities generated within this research project is the context and user analysis, resulting in a needs analysis and requirements, which lead into usability and acceptability checklists for the Games Atelier product. Furthermore, several prototypes are conducted, from the early start on, which are evaluated by the intended end users of the product. The cyclic research and design process results in a conceptual model, a prototype and screen dumps, informing the designers for developing the physical product.
In order to explore the problem, the user needs and requirements, the data collection methods used are user scenarios, workshops and focus group discussions, questionnaires, observations and literature study. These are rich qualitative research methods used to interact with the target user groups to gradually clarify the problem at stake and the characteristics of the potential solution.
These data collection methods are described more elaborately in the next chapter, together with the results and analysis.

5 RESULTS OF THE ANALYSIS AND DESIGN PHASE

The following chapter describes the outcome of the research activities during the analysis and design phase. Most of the research questions will be answered. In the first section the teachers, students and the context in which the program will be used is investigated in search for answers to the question: *What are the user needs, user experience goals, usability goals and user, usability, context and functional requirements of the target users for creating, playing and viewing location-based mobile games?*
The second section describes how to create an effective location-based mobile game in the program Games Atelier according to the state-of-the-art literature in combination with the user-analysis, answering the question: *what are the characteristics of effective educational location-based mobile games?*
The third and final section of Chapter 5 describes the outcome of the conceptual design activities, investigating how the needs and requirements can be translated into functionalities and graphic user interfaces of the program Games Atelier.

5.1 INVESTIGATING NEEDS, USER EXPERIENCE GOALS AND USABILITY GOALS

This section describes the analysis phase and the research activities which were carried out to answer the following research questions:
What are the users' needs, user experience goal and, usability goals of the target users for creating, playing and viewing location-based mobile games? Which user, usability, context and functional requirements can be established based on these user needs and goals?
The analysis phase includes gathering information about the user needs, user experience goals and usability goals, interpreting this information and establishing requirements, based on the formulated user needs and goals.
As discussed in the previous chapter, the program is designed according to the user-centred interaction design approach. This approach aims to design the program based on users' concerns, rather than technical concerns. Therefore, a key interest for designing this interactive system is to understand the kind of activities people are doing when interacting with the system (Preece, Rogers & Sharp, 2002). The first part of the research question, exploring the user needs, user experience goals and usability goals is investigated during the analysis phase in order to understand the activities which need to be supported by the system.
Teachers and students were involved from the beginning of the analysis phase. User involvement leads to more accurate information about the tasks that will be supported by the program, more intensive discussions about the requirements of the system, better opportunities to negotiate and justify design ideas and increase of user commitment and ownership of the final deliverable (Moonen; Shneidermann, as cited in Nieveen, 1999).
First, the data collection techniques will be described, secondly the results of the analysis phase, which is a description of the user needs, user experience goals and usability goals and finally the requirements, which are based on these needs and goals.

5.1.1 Data collection activities

This section distinguishes the research activities that were executed during the analysis phase of the project. An overview of the data collection techniques, the researched variables, respondents and created prototypes is given in Table 1.
The analysis phase is divided in three phases. First, the user context was explored by means of user scenarios, written by the teachers, and an observation at a secondary school. Secondly, the abilities and needs of the target group when playing the location-based game was investigated.
Two throw-away prototypes were designed, used to collect the needs and requirements by means of evaluation. During three technology workshops the users tested the first prototype, a location-based mobile game. The teachers participated in focus group discussions and students filled in a questionnaire to evaluate the experience. Later on the teachers took part in two content workshops, exploring the programs'

potential to support learning outside the classroom environment and game-based learning. A participation workshop was organized where the students designed a game scenario and graphic user interface for the web-based application. Furthermore, they evaluated three moodboards, representing three different game designs.

Section 5.1.1 describes the construction, samples of respondents and most important variables of the data collection activities in detail.

Table 1: Overview of the data collection activities

technique	variables	respondents	prototype
User scenarios	characteristics, context, tasks, goals	4 teachers	---
Naturalistic observation	context, daily activity, characteristics, capabilities and skills concerning use of computers and multimedia	secondary school	---
Technology workshop (TWS) 1: structured focus group discussion	characteristics, capabilities and skills concerning use of location-based mobile technology, playing the game and desirable features for program	5 project leaders	location-based mobile game
Technology workshop (TWS) 2: structured focus group discussion	characteristics, capabilities and skills concerning use of location-based mobile technology, playing the game, and pedagogies CSCL, game-based learning and learning outside the classroom as supported by the technology	12 teachers	location-based mobile game
Technology workshop (TWS) 3: questionnaire	needs, user experience goals and usability goals concerning location-based mobile games and mobile learning.	26 students of 2nd base class	---
Contents workshop (CWS) 1: structured focus group discussion	creating a lesson in the authentic context and enhanced reality by means of location-based technologies	12 teachers	---
Contents workshop (CWS) 2: structured focus group discussion	game-based learning and creating location-based mobile games	12 teachers	---
Contents workshop (CWS) 3: questionnaire	'look and feel', user experience goals and capability to design games	26 students of 2nd base class	3 moodboards

5.1.1.1 User Scenarios

At the start of the design process, four teachers wrote an user scenario. Carroll (2000) defines scenarios as an "informal narrative description. It describes human activities or tasks in a story that allows exploration and discussion of contexts, needs and requirements" (Carroll, as cited in Schwabe & Goth, 2005). The construction of scenarios is often the first step in establishing requirements and the focus is on user tasks. The user scenarios focused on the tasks supported by the program Games Atelier. The scenarios were used to find out about the tasks that users currently perform their associated goals and the context in which the tasks are performed. The users do not experience using a program at a detailed level of human computer interaction, like pressing buttons or using menus. A heuristic for writing scenarios focused on the client's needs and concerns is to initially couch them at the basic task level, the level at which people experience their own activity (Carroll and Rosson, cited in Carroll, 2000).

Data collection samples
The user scenarios are written by four teachers who teach at three different schools in Amsterdam. All teachers teach ICT in combination with a different subject at VMBO level. For privacy reasons, the user scenarios are indicated by means of US teacher A, B, C and D.

Construction of the user scenario
According to Potts (cited in Carroll, 2000) user scenario have characteristic elements, which are a setting, actors, the goals and objectives the actors try to achieve and a plot, which is a sequence of events that happens to the actor or actions that changes the circumstances of the setting. These elements are used to guide the user scenarios as written by the users and experts and support the analysis of the user needs and context. The description of the setting is confirm the context of the program and supports the analysis of this context. The description of the actors, their objectives and the goals they try to achieve are confirmed the users' characteristics and abilities. The description of the plot supports the analysis of the tasks the users try to achieve.

Most important variables
The most important variables that were acquired by means of the scenarios are the characteristics of the users, information about the context in which the program will be used, the tasks the users are to perform while using the program, and the goals the users want to achieve when using the program.
The user scenarios as written by the respondents can be found in the appendices (see also Appendix A: Four user scenarios by the teachers).

5.1.1.2 Observation at the secondary school OSB

By means of observation in the naturalistic setting the characteristics of the users, task the users try to achieve, how the users achieve these tasks currently and the context of the students and teachers were investigated. Because the program Games Atelier will be used in the secondary school, the school OSB in Amsterdam was visited and observed for one day. Following Preece, Rogers and Sharp (2002) observation involves "spending some time with the target group as they go about their day-to-day tasks, observing work as it happens in the natural setting". An important variable focused on during this investigation was the use of ICT by teacher and students during class and the environment of the school to inform the environmental requirements and the user needs. The observation resulted in field notes. Taking field notes is the most inconspicuous technique to record observations.

Data collection samples and construction of the observation
The observed target groups were the first, second and third base classes of the secondary school OSB in Amsterdam. Furthermore, the school was observed as a whole, by visiting different classes and asking ad hoc questions to teachers.

Most important variables
The most important variables investigated were the physical, social and technical circumstances of the target group using the program, the daily activity of the target group, the characteristics and the abilities and skills concerning use of computers and multimedia at school.

5.1.1.3 Workshops

Six workshops have been organized with the project leaders, teachers and students. The first three workshops were technology workshops and focused on playing the location-based mobile game. The main goal of these workshops was for the users to experience the location-based mobile technology.
The final three workshops were two context workshops with the teachers and one participatory workshop with the students. These workshops focused on creating the location-based mobile game, as supported by the web-based application.

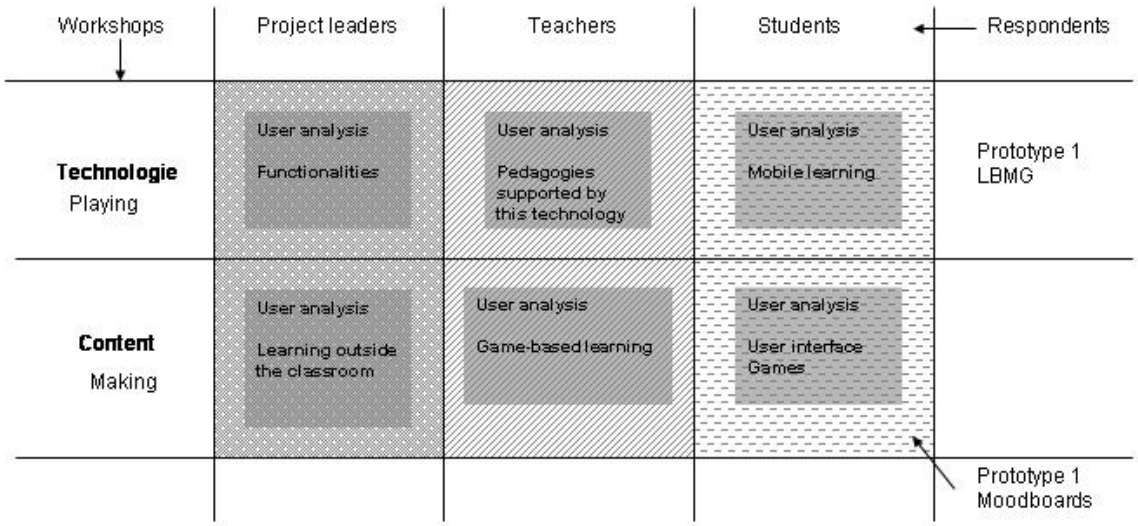

Figure 6: Research topics analysed during the workshops [3]

5.1.1.3.1 Technology workshop: three sessions

A prototyped location-based mobile game was developed for the students and teachers to interact with game elements and gameplay, smart phones, GPS and Geotracing within the historical city of Amsterdam. The users were observed while playing the game, which resulted in field notes. The experience has been evaluated by means of focus group discussions with the teachers. During the first technology workshop desirable functionalities were discussed with the project leaders. During the second technology the teachers discussed the pedagogies CSCL [4], learning outside the classroom environment in an authentic context and game-based learning. The students evaluated the location-based mobile experience by filling in a questionnaire.

The game is tested by the teachers and the students. Interacting with prototypes gives users as well as the developers of the prototype insight in the potentials of the system and its desired characteristics (Preece, Rogers & Sharp, 2002). Developing a prototyped location-based mobile game has several purposes. It is a chance as developer to gain experience with creating location-based mobile games. This provides insight in the tasks that need to be supported by the program and investigating the characteristics of effective educational location-based mobile games. Furthermore, the game is played by the target group and evaluated. This informs the requirements of effective location-based mobile games. And it gives the students and teachers the chance to gain experience with the technology used within the program. The

[3] LBMG is an abbreviation for location-based mobile game
[4] Computer Supported Collaboratively Learning

participants of the game are also involved in workshops where the design of the program will be discussed. Knowledge about the technology will be necessary to have insight in the possibilities.

Prototype 1: Location-based mobile game experience

The first prototype is a location-based mobile game experience and is located in the centre of Amsterdam. The game contains structural elements for games as described by Prensky (cited in Schwabe & Goth, 2005), which are rules, goals and objectives, outcome and feedback, gameplay that contributes to the excitement, and social interaction.

The technology used is GPS, smart phones and Geotracing software, existing of a mobile and web-based application. The GPS and Geotracing software enable the route of players in the field to be captured, or 'traced' on the digital map of the Geotracing website. These traces can be viewed live on the website and is stored on the Geotracing site, so it can also be viewed after playing the game. The smart phones are used to record photos and voice recording, which are sent directly to the Geotracing site, using the mobile Geotracing software. This media is attached to the digital map at the exact location where the media is sent. The smart phones are also used to receive and send SMS text messages.

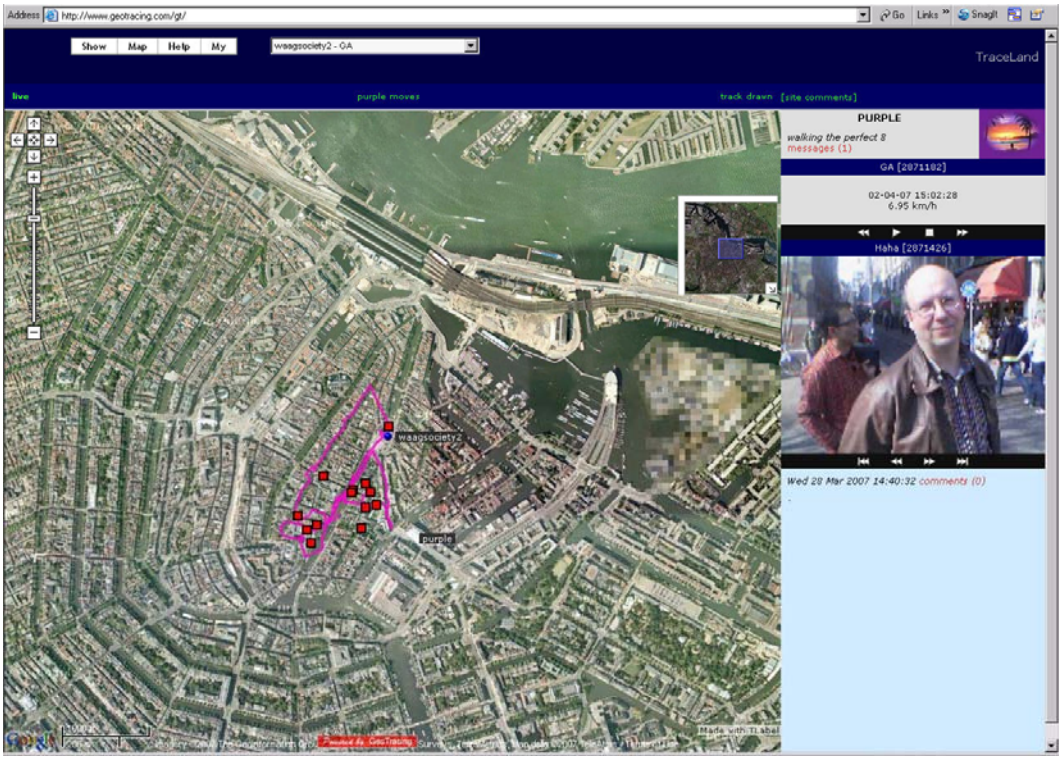

Figure 7: reviewing the game activities on website geotracing.com[5]

Two groups play against each other and both groups are divided in a home team and a mobile team. The final goal is to collect as many points as possible and the group which collects the most wins. Points can be earned by finishing assignments.

[5] At the left side of the webpage one finds the digital map with the 'trace' and the media attached to the location. The media is indicated by icons. The right side of the page shows the media as captured on location and sent to the website.

The home team and mobile team both receive different assignments. The mobile team receives a paper-based map with a certain route they have to trace. The trace can be viewed on the digital map at the Geotracing site, and the home team has to guess the form of the route. The group earns 50 points when they guess the right form. The mobile team has to return to the home team within thirty minutes.

The home team also receives a paper-based map. Icons indicate where the home team sends the assignments to the mobile team. The home team has to come up with a theme and send two assignments according to this theme by means of text messages to the mobile team. The formats of the assignments are determined by the researchers, but the topic of the assignments is open. The formats are 'send 5 photos about (…)'and 'ask 5 persons for their favourite (…) and send the voice records'. The home team has to think of topics that are related to the theme. When the mobile team guesses the theme, they earn 50 points more. For every media send to the Geotracing site, the team earns 20 points.
Furthermore, the home team sends an assignment to the mobile team that is related to the name of the street where they are at.
In order for the home team to sabotage the competitors, the home team can send one bomb to the mobile team during the game. This bomb is the command to stop all action for two minutes.

The gameplay involved in this location-based mobile game is the form of the traces, the time limit and the bombs. The assignments are designed in order to motivate the home teams and mobile teams to cooperate together and to compete with the other team. Because it is important for all players to participate actively, roles are divided among the players.

Within the home team, one person sends the text messages to the mobile team, which are the assignments, but also feedback on whether the media send by the home team is received at the Geotracing site, whether the answer is correct and the remaining time. This is important to motivate the mobile team to continue. Another person coordinates the groups' process of developing assignments and decides when to send the assignments and the bomb to the mobile teams. The last person guards the game process. How much points are received by the teams and how is the other team doing?
Within the mobile team one person operates the smart phone for sending media, one person determines the route by means of the map and one other person receives and sends text messages.

A document with the following elements support the players: Instruction on how to use the smart phone and Geotracing software, phone numbers, an escape procedure, different assignments for the home team and mobile team, the game rules described and a worksheet for the home team to fill in the answers of both home team and mobile team.

First technology workshop (TWS1)

During the second technology workshop the project leaders played the prototyped location-based mobile game (prototype 1) and discussed their experience and desired functionalities.

Data collection samples
Five project leaders participated in this workshop. These project leaders teach the subject matter ICT at VMBO level at three different schools in Amsterdam. They are closely involved in developing Games Atelier. Therefore they possess expert knowledge about the project, teaching and ICT.

Activity: playing the game and focus group discussion

The project leaders received first a short presentation and demonstration of the technology. After the demonstration, they played the prototyped location-based mobile game (prototype 1). The five teachers were divided in two mobile teams.

When the project leaders finished the game, they reviewed the results of the game activities as captured on the Geotracing website on a big screen. The project leaders discussed their experience and their ideas about how this technology can support school activities in a focus group discussion. According to Preece, Rogers and Sharp (2002) a focus group discussion can be very revealing to discuss issues and requirements.

The focus group discussion was recorded by means of a voice recorder and transcript.

Most important variables
The most important variables to focus on during the first technology workshop were the characteristics and abilities of the teachers to use the location-based mobile technology. Furthermore, the teachers discussed the desirable features of the program to support playing location-based mobile games.

Second technology workshop (TWS2)

During the second technology workshop the teachers played the prototyped location-based mobile game (prototype 1).

Data collection samples
The second workshop is held with a group of twelve teachers, representing all levels of the secondary school, which are base classes VMBO, HAVO and VWO, and upper classes VMBO, HAVO and VWO.

Activity: Playing the game
After a presentation and demonstration of the technology, the groups were divided in two teams that played against each other. Both teams were divided in one mobile and one home team. The home team stayed inside behind the computer and the mobile team played the game in the field. The mobile teams were observed while playing the location-based mobile game and the data was recorded by taking field notes. When the teachers finished the game their experiences were discussed within a focus group discussion.

Activity: Discussion of pedagogical approaches supported by the technology
After this discussion the teachers were divided in three smaller groups to discuss three different pedagogical approaches. On group discussed CSCL, another group discussed game-based learning and the last group discussed learning outside the classroom environment in an authentic location. The pedagogical approaches were determined and assigned to the groups by the researchers. The results of these group discussions were presented and discussed more elaborately in a focus group discussion.

The data acquired during the focus group discussions were recorded by means of note taking.

Most important variables
The most important variables that were examined during this second technology workshop were the characteristics and capability of the teachers to use location-based mobile technology. Furthermore, the tasks of the teachers were investigated and how these tasks can be supported by means of the location-based mobile technology, focussing on the pedagogies computer supported collaborative learning, learning outside the classroom environment in an authentic context and game-based learning.
The pedagogies learning outside the classroom environment in an authentic context and game-based learning will be described more elaborately in the section 5.2.2 (see also authentic learning environment)

Third technology workshop (TWS3)

During the third technology workshop the students played a location-based mobile game (prototype 1).

Data collection samples
The third technology workshop is held with 26 students participating. The students all visit the second class of the secondary school OSB in Amsterdam.

Activity: playing the game
The prototyped location-based mobile game could not be tested during TWS3. There were more smart phones with GPS necessary to offer the game to this large amount of respondents. Therefore, an alternative game was developed. The group was divided in nine small mobile teams, who shared two smart phones together. The route was divided in small parts and each team was send to a different starting point. The starting point of one mobile team was the finish for the other team. At these points, the smart phones were handed over to the other mobile teams. When the teams received the mobile phones, they received assignments by means in the form of text messages on the phones. The students were assigned to make some pictures and interview people on the street. All media was sent back to the Geotracing site and the routes of the students were traced. The route and media attached to the route could be viewed on the website when the students finished the game.
The game combined collaborative and competitive elements, because three mobile teams worked together against six other mobile teams. The final goal was to retrieve points by sending all the media and to return back as soon as possible. Who returned first was the winning team.

Activity: Filling in the questionnaire
The questionnaire is a mixture of open and closed questions. The location-based mobile experience is evaluated by means of a questionnaire, because it was not effective for this target group to discuss the results by means of a focus group discussion. Sweeney, Maguire and Shackel (1993) states that questionnaires are 'powerful instruments to investigate the attitude and opinions of the target group'. After the experience, the students were very excited and could not focus on the discussion. Therefore, the students were asked to fill in the questionnaire a few days after the experience to capture their opinion.

They evaluated their experience while playing the location-based mobile game, their personal interests and characteristics, and experience with mobile technology in general.
First, the students were asked for their age and gender, whether they possess a mobile phone, which features are integrated in this phone and which features they use most. These questions are asked to measure the experience the students have with mobile technology.
Furthermore, the students were asked whether they use the mobile phone to support school activities and which activities these are. This question informs about the experience of the students with mobile learning. The students were asked whether they experienced lessons outside the classroom environment before and what lessons they followed outside the classroom environment. They were asked whether these lessons become more attractive when they are supported by GPS and the mobile phone. This question measures whether the students are more motivated by means of the location-based technologies. They are also asked which elements of the location-based mobile experience they enjoyed the most and which subjects' matters in their opinion are most suitable for Games Atelier. The questionnaire can be found in the appendices (see also Appendix B: Questionnaire TWS3)

The most important variables
The most important variables to be investigated by means of the observation and the questionnaire were the needs, the user experience goals and usability goals of the students concerning playing and viewing location-based mobile games and mobile learning.

5.1.1.3.2 Content workshops with teachers: creating a location-based mobile game

In a later stadium of the research project two content workshops were organized with the same group of teachers as the second technology workshop. The technology workshops examined the abilities of teachers and students to play location-based mobile games. The focus of the content workshops shifted to investigating the capabilities and tasks that relate to creating the location-based mobile game, as supported by the web-based application. The teachers who participated in the technology workshops were invited to discuss two pedagogies that are closely related to location-based mobile learning, which are learning outside the classroom environment and game-based learning. These pedagogies will be described more elaborately in section 5.2.2 (see also authentic learning environment) and section 5.3 (see also producing location-based mobile games).

First content workshop (CWS1): learning outside the classroom environment in the authentic context

The goal of the first content workshop was to determine how Games Atelier could support the teaching practice outside the classroom environment on an authentic location.

Data collection samples
Twelve teachers, representing all classes and levels of the secondary school, which are base and upper classes of VMBO, HAVO and VWO. The teachers teach at three different schools in Amsterdam.

Activity: developing scenario for lesson outside the classroom environment in the authentic context
First the teachers received an introduction to clarify the main purpose of the workshop. After this introduction, the teachers formed groups and received a form that structured the assignment and discussion. Together the teachers developed scenarios for a lesson outside the classroom environment in an authentic context, using digital media to enhance the reality. The group of teachers was asked to come up with a theme for a lesson outside the classroom environment and what learning goals the students can achieve during this lesson. They should explicate what level of education they teach.
To describe learning outside the classroom environment in an authentic location, the teachers should think about what kind of information can be found on location about this subject, how this information best be experienced by the students, what assignments do the students have to solve on location and by means of which media must the students capture their answer.
To describe the manner in which the teachers would like to enrich the reality, the teachers should describe what kind of information/ media can be added to the location to enrich the experience, to support your learning goals, where can this information/ media be found? The teachers were also asked to describe how the learning goals can be tested or reflected on, what they find the most important to reflect on and what kind of end product the students will produce.

The data was recorded by means of note taking.

Most important variables
Most important variables to focus on during this content workshop were suitable assignments for learning in the authentic context. The assignments were determined by the teachers, as well as the topic of the digital media used to enrich the authentic location. The teachers were asked to explicate an educational theme, learning goals, what information can be found on location, assignments to be solved on location,

and what information should be delivered to enrich the environment. Because most teachers teach different subject matter and students with different ages and educational level, they were asked to discuss the difference between these level and ages.

Second content workshop (CWS2): Game-based learning

The second content workshop focused on game-based learning. In order to stimulate the teachers to think in advanced about games and game-based learning, they are asked to fill in a diary with some assignments.

Data collection samples
Twelve teachers, representing all classes and levels of the secondary school, which are base and upper classes of VMBO, HAVO and VWO. The teachers teach at three different schools in Amsterdam.

Activity: developing a location-based mobile game
During this second content workshop the teachers developed a concept for a location-based mobile game. This concept elaborated on the scenarios the teachers developed during the first content workshop and therefore the teachers formed the same groups as in the first workshop. Developing the concept was supported by means of a structured form which the teachers filled in individually and was analyzed after the workshop. The form is a mixture of closed and open questions (see also Appendix C: Form used for CWS2).

The teachers were asked to use the learning goals and educational theme they developed during the first content workshop and make choices to transform this lesson outside the classroom environment into a location-based mobile game. The form offered them options for game genres, gameplay and game elements. The choices had to be explained on the form. The options for game genres were the adventure game, role playing game, research assignment, simulation game and strategy game. The teachers could choose between different game elements. Some game elements are general elements of games (storyline, challenge, achieving one main goal) others are more specific for certain game genres. For example allocating different characters, which are typical for role playing games, or simulation/reality which is a characteristic of simulation games.
Furthermore, the teachers were asked to indicate what their plan of approach and needs would be to make, play and reflect on this game.

Activity: focus group discussion
After developing the scenarios the teachers participated in a structured focus group discussion. During this discussion, certain topics were discussed, which are the different roles of students and teacher while creating and playing the game, the learning effects of creating and playing the game, using games to teach knowledge and skills for different subjects matter and educational levels of students. The information gathered by means of the focus group discussion and the scenarios of the games should inform the user analysis and design of the program. The discussion was recorded by means of voice recording and transcript.

The focus group discussion is structured by means of eight questions. The first five questions are about the appliance of the different educational game genres to support students of different educational levels. Which game genre is suitable to support which target group of student? Can certain target groups be assigned to be more suitable to support certain target groups? Which gameplay is suitable to support which subject matter or educational contents? Which skills might be taught or trained by means of which game genre? What are the learning results of creating and playing games?
The other three questions concern the division of roles between students while creating and playing the game. The division of roles for the individual students is important for active involvement of all students

during the group processes. The teachers are also asked what their role might be in organizing, creating and playing the game.

Most important variables
The most important variables to be investigated were game-based learning, focusing on different subjects, themes and educational levels. The teachers were asked to clarify which subject matter or themes can be supported by the educational games genres, the division of roles between students creating the game and playing the game, and the organization and material needed for creating and playing the game.

5.1.1.3.3 Participatory design workshop with students (CWS 3): creating their own game

In order to investigate the user experience goals of the students, a workshop was organized with the twenty-six students who also participated in the third technology workshop (TWS3). The workshop mainly focused on their capability to design games and game elements (storyline, gameplay) and their preferences for the graphical design of the web-based application. Spending time with the students helped to enter their world and understand how they perceive things. This can be important for the success of the product (Preece, Rogers & Sharp, 2002).

Data collection samples
The workshop is held with 26 students participating. The students all visit the second class of the secondary school OSB in Amsterdam.

Construction of the participatory design workshop
The students were divided in small groups of three to five students. Using paper and pencils they were asked to design a location-based mobile game scenario. They should decide on a game genre, a final goal and certain rules. Furthermore, the students were asked to design an avatar and the playground of the game, as it is presented on the website of Games Atelier. McMahan (cited in Veen & Jacobs, 2005) describes avatars as being graphical representations of the player. The avatar is a character that moves within the game environment. The player determines the characteristics and capabilities, clothes, aids and qualities of the avatars. The player sees the game environment through the eyes of the game, but additionally sees the avatar on the computer screen represented.
The results were presented by the students, which was recorded by means of a video recorder and transcripted.

In order to investigate the user experience goals, the characteristics of the students and to evaluate their experience concerning Games Atelier in more detail, a questionnaire was filled by the students. The questionnaire can be found in the appendices (see also Appendix D: Questionnaire CWS3).

Construction of the questionnaire
To investigate the personal interest, the students were asked for their favourite video game, website, TV-programme, magazine and book. The students were asked which atmosphere they like best for the home page of Games Atelier. To identify the characteristics, the students are asked how often you play videogames per week and whether they prefer to play alone of with friends.
To identify their personal experience and motivation for educational game, the students were asked for their opinion and experience with educational games
The students were asked to analyze websites according to questions about functionalities, look and feel and ease of use. Their opinion about these websites can determine whether these websites contain features or a look and feel can be used as an example for the design of Games Atelier. The websites chosen were Hyves, Youtube and Game Maker. The commercial websites Hyves and Youtube contain features to upload and share media (pictures, videos) and CMC tools, like forums, social communities, e-mail and instant messenger. Game Maker is applied on secondary schools and is a toolkit that enables the students

to make 2D video games. Game Maker is a program that is easy to use for students and popular in secondary schools. The functionalities are similar for creating/ constructing games in the learning environment.
The students were asked whether they know the websites, which functionalities they use often, which functionalities they dislike and whether they find the website easy-confusing and nice-boring.
The students were asked for their opinion about creating their own game. Furthermore, they were asked what activities they find important when creating their own game in Games Atelier.

Most important variables
The most important variables to be investigated are the 'look and feel' of the program, the user experience goals of the learner, capabilities to design games and game elements.

5.1.2 Analysis: Needs, user experience goals and usability goals

The data as collected by means of the previous described activities is analysed by means of coding. Tags, a descriptive word or phrase, were added to meaningful words, sentences and topics and these tags were organized in a logical flow (Krathwohl, 1998).
Analysis requires some kind of framework. The main goal of the analysis phase is to identify the needs, usability goals and user experience goals of the teachers and students for Games Atelier to support effective learning. To achieve this goal of identifying the needs, the characteristics and capabilities of both the teachers and students and the tasks they both want to achieve are analysed. Furthermore, the usability goals and the user experience goals are analyzed during the analysis phase. The user experience goals and usability goals inspire the design of the program. The most important issues that characterize the needs, usability goals and user experience goals of the target users are tagged and organized in order to give meaning to these variables. Table 2 gives an overview of the characteristics and capabilities of both the teachers and the students.

5.1.2.1 User Needs

The needs can be divided in characteristics and capabilities, and task that the users want to achieve. First the characteristics and capabilities of the teachers will be described, together with data from the user analysis that indicate these characteristics and capabilities. Secondly the needs of the students will be described.

The characteristics and capabilities of the teachers

1) Learning process is more important than learning product
One teacher indicates during the focus group discussion of the second content workshop, that the process of creating and playing the game is more important than the product of the project. The other teachers agree. This idea is confirm the constructivist theory that knowledge constructs in the head while building artefacts and socially interacting with peers and teachers.

2) Teacher coaches the students
When asked by the researcher about the role of the teacher in the class, during the focus group discussion of the second content workshop, one of the teachers indicates that the teacher is the inspirer, coach and expert in the classroom environment. Another teacher argues, based on this comment, that the teacher needs clear insight in the individual learning process of the students and the learning results (CWS2).

Table 2: Characteristics and capabilities of the teachers and students

Characteristics and capabilities of teachers	Characteristics and capabilities of the students
Learning process is more important than learning product	Students are better motivated when they do something that fits their personal interest
Teacher coaches the students	The mobile phone fits the personal interest of the students
The teachers have little time to prepare a project	Video games fit the personal interest of the student
Clear additional value to the existing educational practice	Sharing and uploading personal media fits the interest of the students
	Opinion about educational games
	The capability of students to make good games depends on interest and educational level
	The capability of students to play a certain game genre depends on the educational level
	Students are easily distracted
	Students respond well to visual hints and pictures
	Students are competitive. Competitiveness is more important for upper classes

3) The teachers have little time to prepare a project
One of the teachers argues during the focus group discussion of the second technology workshop; the method alone needs a lot of effort and time to use in the class. According to this teacher, they don't have much time to spend on extra activities that are not included to the curriculum. The teachers always have to make choices and there is a lot offered to them. Therefore teacher wants to be convinced of the educational value of the method (TWS2). The argument that the teacher has little time to prepare the project is during the second content workshop (CWS2) repeated by another teacher. A discussion took place with an agreement that the teacher needs a tutorial that teaches how the program works in minimal steps.

4) Clear additional value to the existing educational practice
The additional value of the educational method Games Atelier should be clear to teachers.

When the additional value is discussed within the group *(TWS2)*, the teachers think the following elements to have much didactical value:

- Real-world examples that visualize the educational problems
- The method used is closely related to the personal interest of the students.
- The Geotracing software makes it easy to collect and view the results directly.
- The educational information is offered in phases.

The characteristics and capabilities of the students

1) Students are better motivated when they do something that fits their personal interest
The user analysis confirms the assumption made at the beginning of the study, that students are motivated when the activity fits their personal interest.
A teacher spoken to during the observation at the secondary school did a project with students who visit 4-VMBO. The assigned the students to make a TV program. At the start of the program, the teacher had the idea to make a news program. The students were not motivated by this idea of the teacher, but thought of the idea to remake Jackass, a popular program, broadcasted on MTV. The end result was very successful. The teacher concluded that the students are most motivated to make a product about a topic that is close to their personal interest (Observation OSB).

2) The mobile phone fits the personal interest of the students
One teacher that joins the discussion during the first technology workshops argues that mobile technology as used within Games Atelier fits the personal interest of the students. The teachers describe that the students are all day engaged with the mobile phone, making pictures, videos and using Bluetooth (TWS1). This teacher teaches VMBO base classes in Amsterdam.

According to the questionnaire the students filled in after the third technology workshop (TWS3), most of the students (96% of the respondents) own a mobile phone. The students, who have a mobile phone, indicate that these phones have features that support voice calling, sending text messages (SMS) and image messages (MMS), WAP, which are a mobile Internet browser, a photo and video camera, a voice recorder, mp3 player and diary. No student possesses a mobile phone with GPS. Figure 8 gives an overview of the functionalities of the students' mobile phones.

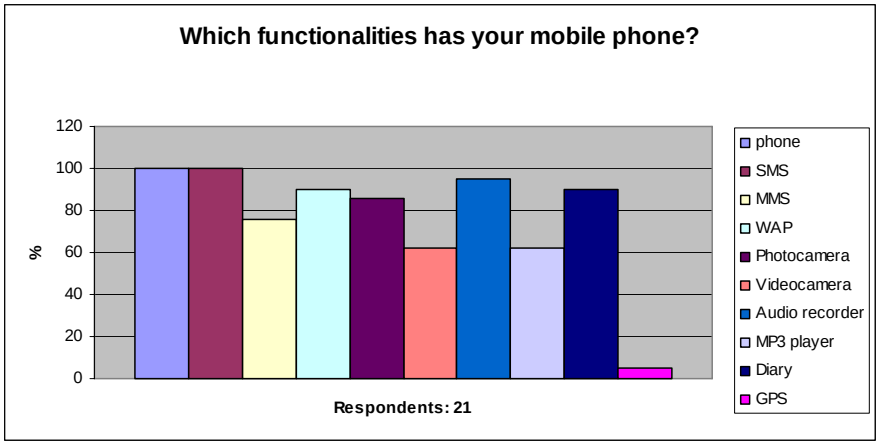

Figure 8: Overview of the functionalities on the respondents' mobile phones

The most frequent used features are the phone, SMS text messages and the photo camera (questionnaire TWS3). The questionnaire indicates that these students prefer sound above text features. Probably sounds are more attractive and easier to use than text messages. Figure 9 illustrates the most favourite mobile features of the respondents.

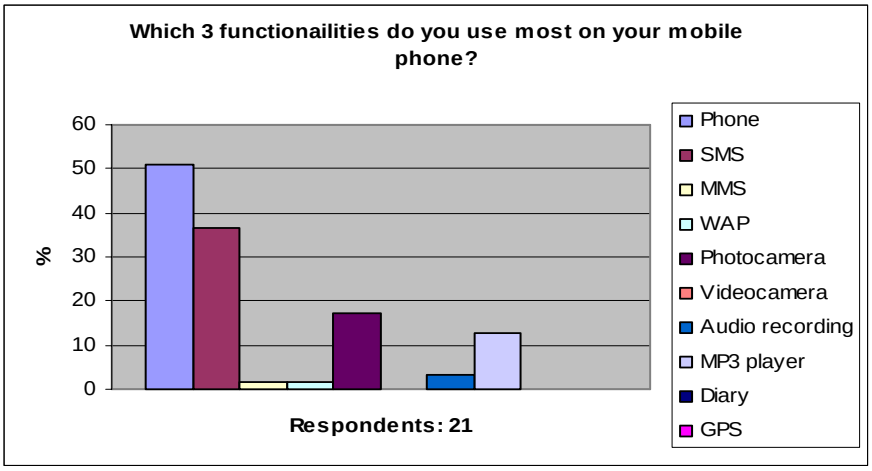

Figure 9: Mobile functionalities that are most used by the respondents

3) Video games fit the personal interest of the student

According to the respondents to the questionnaire, and illustrated in Figure 10, the students play very often videogames (questionnaire CWS3). Nine out of nineteen students responded that they play more than ten times a week, containing six boys. The other students play one to three times a week. Only one student indicated that he or she never plays video games.

Figure 10: the frequency of the respondents playing video games[6]

When the students were asked for their favourite video game, all the students chose one. This fact is noticeable, because the students were also asked for their favourite magazines, TV program and websites, but little more than half the respondents filled in these questions. Table 3 gives an overview of the favourite websites. Videogames are apparently more popular. When asked for their favourite websites, four out of fifteen students chose website that provide games they can play on the Internet.

[6] The histogram is divided in girls (left) and boys (right)

Table 3: Answers to the question: which website do you like best?

BOYS	why?	GIRLS	why?
spelen.nl (2X)	nice games	funnygames.nl (2x)	you can play nice games
my own site	I made it myself	pp2g.com (3x)	make your own page/ like watching people
Voetbalzone.nl	news about soccer	youtube.com (2x)	like watching movies/ you can see everything you want
youtube.com	I'm a member	albinoblacksheep.com	humor
		chello.nl	you can learn educational games

4) Sharing and uploading personal media fits the interest of the students
When asked for their favourite website in the questionnaire (CWS3), three of the fifteen students chose Youtube to be their favourite website. Youtube is a website where users can upload and share their videos. All students know the website Youtube and more than the half of the students are subscribed to the website. The website contains features that support uploading and sharing videos and to support a community, the website contains CMC tools, like forums, e-mail and instant messenger.
Fifteen out of nineteen students indicate that they use the website to watch videos. Other popular features are to watch videos of friends (7) and to upload the videos themselves (6). No student makes use of the community at the website or the CMC tools that support the community (see Figure 11).

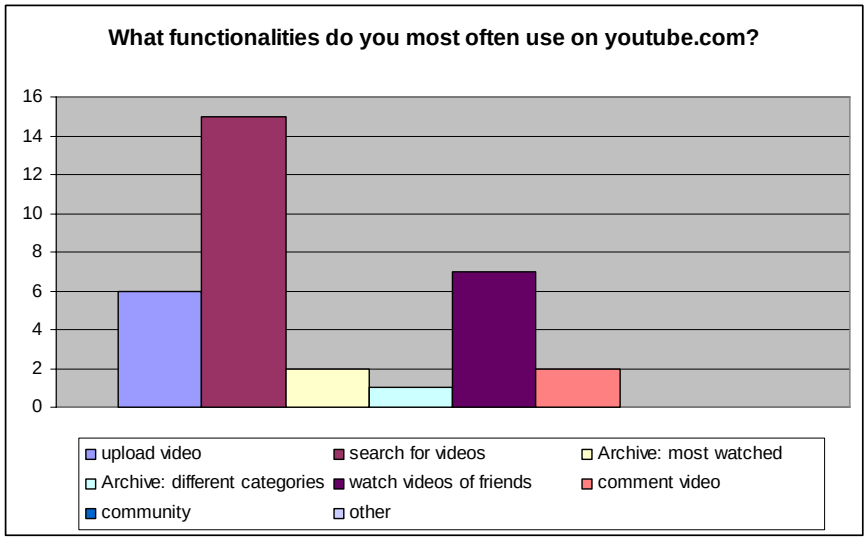

Figure 11: The functionalities of youtube.com used most by the respondents

5) Opinion about educational games
When asked what aspects the students like about educational games, the most appreciated characteristic is the fact that they learn something when they play the educational game and that it is different than other lessons at school. These answers were given by students that answered yes to the question whether they played educational games, but that were only six out of eighteen respondents. Apparently, students don't play many educational games at school (questionnaire CWS3). The answers are illustrated in Figure 12.

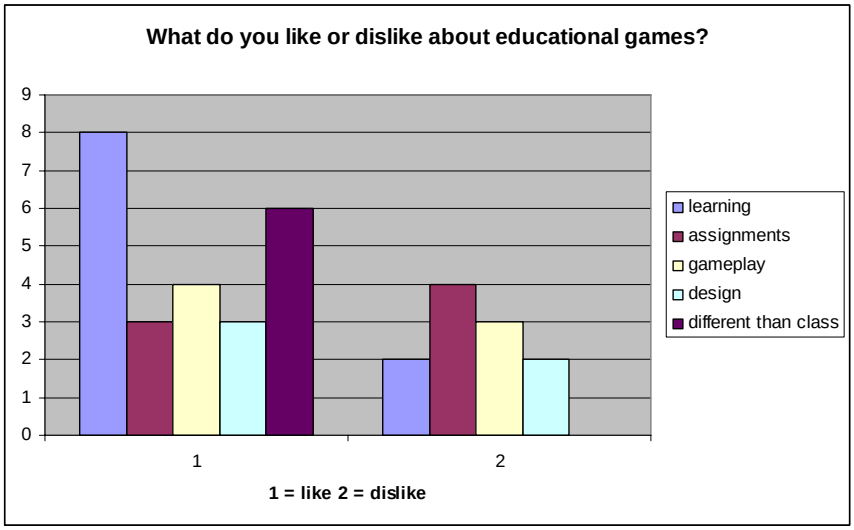

Figure 12: Overview of the aspects that the respondents like and dislike about educational games

6) The capability of students to make good games depends on interest and educational level.
One teacher indicates during the focus group discussion of the second content workshop (CWS2), that students who join the base class of VMBO are not capable of creating a complicated game. This teacher teaches base classes VMBO himself and he thinks that young students are not able to think in abstract concepts. Another teacher reacts to this statement and argues that personal interest in games is more influential of whether they can make a game or not. This is not totally dependent on the level of education. Some students will be challenged when they can make an adventure game when they are interested in these games. In reaction to that, another teacher comments that she is amazed by what students can do when they are supported by ICT programs. This discussion found place after the teachers themselves experienced creating games in the second content workshop. It illustrates the need for a general program that offers many choices for the students to experiment. The teachers have their own expectations about the educational capabilities of the students, and should be able to steer this process.

During the participatory design workshop (CWS3), the students were asked to design a game within the groups. The students were free to design any game they want. Two of the six groups designed an educational game, these were all girls. There is a clear difference in educational level and design. The lower level design games that include adventure, fantasy, fighting and defeating enemies. The students of a higher educational level designed games that were more realistic, with educational and functional elements. The differentiation in level should be taken into account when students share and play each others game. In order to be effective, the students should enjoy the game elements and the design of the games to become engaged and immersed in the game.

7) The capability of students to play a certain game genre depends on the educational level
When creating the concept for the game during the second content workshop (using individual forms), a teacher that teaches both the base classes and upper classes makes a division between the educational levels in choosing the game genre. The teacher indicates that the strategy game is suitable for base classes to be introduced to a certain topic. The upper classes are more suitable to play the simulation game and research assignment. Another teacher that teaches base classes chooses the simulation game to be played by students of a base class. Apparently, assigning game genres to be played by different educational levels depend on the point of view of the teacher. There is no general guideline, but it depends on the insight of the teachers.

One teacher explains on the form that is filled in during the second content workshop that the educational contents, assignments and assessment must differ for the different educational levels. The HAVO/VWO students will need less explanation and can be tested on insight. The VMBO students will need more explanation, more coaching and should be asked for facts (CWS2).

8) Students are easily distracted
Especially when students learn outside the classroom environment, the students get distracted very easily. Within the first technology workshop a teacher states that younger students, especially the students of the VMBO level get distracter very easily. When these students walk on the streets, they receive so much impressions, it can't be asked of them that they focus on learning (TWS1). Another teacher makes the same statement during the second technology workshop (TWS2).

9) Students respond well to visual hints and pictures
During the focus group discussion of the first content workshop, one teacher indicates that support by means of pictures or visual hints supports the student very well (CWS1). The other teachers don't respond, but this remark is confirmed by Veen and Jacobs (2005) who state that students have short attention periods and are used to strong stimulating visual information (Veen & Jacobs, 2005).

10) Students are competitive. Competitiveness is more important for upper classes
According to the teachers, students are competitive. They find playing against peers more fun than playing with peers.
For higher classes competitiveness is more important than for lower classes (TWS1; TWS3).
This statement is confirmed by one teacher who applies during the second content workshop gameplay that motivates competition between teams to games played by upper classes. This gameplay is for example a confrontation between teams when they are in each others neighbourhood, retrieve each others traces in order to hunt each other, and block each other way in order to prevent the competitor to continue (CWS2).

The tasks and goals the teachers and students try to achieve

The following section describes the tasks and goals the teachers and students try to achieve during their daily activities. The tasks the teachers and students try to achieve are combined, because the learning process is a combined endeavour of the students and the teachers. Table 4 gives an overview.

1) Achieving learning goals should be the main concerns while playing the games
During the workshops, the teachers thought of educational contents and goals to be reached by playing or creating a game. Important educational goals mentioned were knowledge and awareness about the subject on location, developing research skills and skills to solve problems, collaboration, and presenting and reflecting on results, giving and receiving feedback. More specifically, for geography students in the base classes should learn how to read a map. At the beginning of a series of lessons, the students should be motivated to learn about a certain topic (US teacher C; CWS2).

Table 4: Overview of the tasks and goals of teachers and students

	Tasks and goals of teachers and students
1	Achieving learning goals should be the main concerns while playing the games
2	Structure and assistance when creating and playing the game
3	Students should work independently
4	Collaborative learning while playing and creating the game
5	The students should learn actively: division of roles when playing and creating the game
6	Learning activities according to the didactical approaches learning by doing and learning by exploring
7	Open assignments to stimulate creativity, effective learning and active learning
8	Reflection
9	Reuse of the media
10	Assessment
11	When the game is made by the students, it should be tested before others play the game
12	Needs for creating the game
13	Needs for playing the game

The final goal, gameplay and assignments of the game depend on the educational goals and the theme of the project. When creating a game, the students should understand and carefully think about how the assignments can support learning (TWS2). This can be an enormous challenge.
According to the teachers, the educational goals should be the main focus and should be indicated by the teachers themselves. Achieving learning goals is most important according to the teachers. The game elements are entertaining, but the information that is exchanged between the students should be of educational value (TWS1; TWS2).

2) Structure and assistance when creating and playing the game
When creating playing the game were discussed within different focus group discussions, he teachers indicated as well the program as the game should be clearly structured (TWS1; TWS2).
When the prototyped game was played by the students during the third technology workshop, this became very clear. The students were very loud and it was difficult to capture their attention. In order to capture the interest of the students, especially when being outside the classroom environment and groups working together, the game should be very well structured and organized and every individual student should have a role (TWS3).

For creating the game, it is important to keep the process simple. The need for structure and assistance is emphasized by the teachers (CWS2). The games that are made are soon too expanded and complicated. Besides it is complicated to make a game (you should know the educational contents, you should understand the effect of the game choices), the educational game should be effective and adjusted to the target group. This complicated task should be clearly guided by the program.

3) Students should work independently
The teachers want students to work independently, without much steering of the teacher. Some teachers aren't used to letting the students work independently. They are more used to teaching in front of the classroom environment (CWS2).

4) Collaborative learning while playing and creating the game
During the workshops with the teacher, several teachers indicate that collaboration between the players is important, because the individual students learn from each other. By means of collaboration, the students make use of each others individual knowledge and qualities (CWS1; CWS2).
During the second content workshop, it is clearly indicated by the teachers that the games should be made by a group of students that is heterogeneous from nature (CWS2). This means that students with divers qualities and interest should complement each other when creating the game. Creating the game is a group's project and the students need different skills and knowledge, for example writing the storyline, designing the playground, inventing strategies or assignments. The heterogeneous talents enhance the quality of the game, but also the learning process.

Collaborative play and playing the game together with the whole class establishes team building (TWS1; CWS2). In order to support collaborative learning, the students of the different teams should be dependent of each other. Together they should reach the final goal (TWS2).

5) The students should learn actively: division of roles when playing and creating the game
Active participatory of all individual students is required for collaboratively learning. There should be a clear division of tasks between the students while playing and creating the game.
The teachers who choose for competition between teams when they made a concept for the location-based mobile game, they emphasize that the roles should be divided between the individual students and that during the game the students should use each others individual knowledge and skills (CWS2).
During the focus group discussion, it is indicated by the teachers that the games should be made by a group of students that is heterogeneous from nature. This means that students with divers qualities and interest should complement each other creating the game. With creating the game, the students need different skills and knowledge, for example writing the storyline, designing the playground, inventing strategies or assignments. The heterogeneous talents enhance the quality of the game, but also the learning process (CWS2).
During the location-based mobile experience, the roles were divided between the students one individual student was responsible for making pictures, another student for reading the map and the other student for receiving and sending media on the mobile phone (TWS3).

6) Learning activities according to the didactical approaches learning by doing and learning by exploring
When developing scenarios for the lesson outside the classroom environment during the first content workshop, all teachers chose to organize a research project on location. All teachers developed an open research goal for the students to investigate a certain topic on location.

The investigation during the research project on location (CWS1) involved making pictures and video's on location, interviewing people in the neighbourhood. For one project, the home team supports the mobile team behind the computer, looking for additional information on the Internet or other information sources. But mostly, the mobile team is alone, investigating the location, collecting and storing all kinds of media and analyzing this media at school.

During the focus group discussion of the second content workshop(CWS2), one teacher defines that students should first experience learning activities and by evaluating what went wrong and what went well, the students are more motivated to learn the appropriate knowledge and skills. Therefore it is necessary to first experience the activity and later gets insight in the process. This is confirming the game-based learning theory. The students experiences real examples and the abstract educational concepts becomes more meaningful to the students. Another teacher has the opinion that students should first learn theoretically and construct prior knowledge, which they will use when playing outside the classroom.

Perhaps, this depends on the subject. The latter teacher teaches the subject mathematics, the first teacher teaches Biology.

According to one teacher during the first technology workshop it will be most interesting for teachers to assign students to make pictures of bridges in the neighbourhood, find out how these bridges are constructed and show this information in a final product. Than the students explore the real world, explore information and produce an end product of what they have learned (TWS1).
The teachers (TWS1) discuss the potential use of the program for research in the field. The students can collect data on a particular location and attach this information to the digital map. After a period of time, the students can return to this location and collect data again, because the program stores the coordinates. The students can compare the data when they are back at school. This is called research through time and can be useful for biology applications.
The students can play a certain game repeatedly every year and compare the information that is collected through the years.
The same application for the program is suggested by a different teacher during the first content workshop (CWS1). The location can be investigated by interviewing the people who live on that location, analyze the area (building, vegetation) and capture the area by making pictures. The data is stored and further analyzed when the students get back at school. The same location can be investigated a period of time later.
Evaluating the prototyped location-based mobile game, one teacher indicated that the location where the game is played should invite the students to learn. There should be rich educational information to be found in the environment. Another teacher indicates that the assignment that the student receive when learning on location should be clearly related to the location (TWS2).

7) Open assignments to stimulate creativity, effective learning and active learning
The teachers indicate that an open assignment should enhance the educational effectiveness. The assignment itself can be specific, but the way the students solve the problem should be open (TWS1). The teacher wants to be able to play a game without extensive preparation. This can be achieved by means of an open problem that is ill-structured.
Furthermore, other teachers indicate that an open assignment or research goal stimulates the creativity of the students to find a solution the problem in their own way (CWS1).

One teacher at the secondary school OSB explains that the assignments the students receive are quite open, because the students work independent and may decide what they want to do and how they want to achieve this. The conditions for the assignments are strict and determined by the teacher and between these boundaries the students have a lot of freedom (Observation OSB).

8) Reflection
In all focus group discussions with teachers it is indicated that the students should reflect on their learning results of playing the game.
One teacher indicate that the results of playing the game should become meaningful to the students and that this can be achieved when the results are reflected on (TWS2). These results should be compared among each other (CWS1; US teacher C). For reflection on the game results, the students need an overview of the results, and an opportunity for the students to give each other feedback. They can both give feedback on the game as a product and the process of playing the game. The results must be presented by the students. One teacher indicates that the students should be supplied with reflection questions (CWS2).

9) Reuse of the media
The teachers need to reuse the media that is collected in the field. The teachers who developed a scenario for a lesson outside the classroom environment indicate that the media should become meaningful to the

students when they can reproduce an end product. The suggestions for the end products are a digital map with several layers, a website or graphics and tables. The digital map and the graphics and tables are cognitive tools that help the students analyze the data (CWS1).

10) Assessment
It is desirable for the teacher to assess the learning result of all students. Therefore all processes should be recorded, which are stored on the computer. The teacher needs clear insight in the individual learning process of the students and the learning results (CWS2).
The teacher needs to assess the game and playing the game according to different aspects, like knowledge, collaboration, and creativity. This assessment should be accessible for students. They should be able to print the assessment and results. The teacher assesses the game and playing the game by the students. This assessment should be attached to the game automatically (US teacher B).
The teacher can assess the results of playing the game by means of a test, but this depends on the level of the class. By means of a test the teacher can evaluate whether the project reaches the learning goals appropriately (TWS2).

11) When the game is made by the students, it should be tested before others play the game
One teacher stated during the first content workshop that the assignments should be tested by the students who make the game, but there should also be criteria and examples for the students to appropriately steer this process of articulating the assignments (CWS1).
A teacher observed that the assignments that were constructed within the prototyped game were sometimes too complicated. This is caused by the fact that the assignments are not tested. The makers of the game should take time to test the assignments before the game is played by others *(*TWS2).
Within the questionnaire (CWS3) students indicate that testing the game is a preferable activity when creating the game.

12) Needs for creating the game
According to the teachers, when creating the game the program should supply the students with a task structure, map of the location, example games and the teacher should supply information sources about the topic. When creating the game, the students should visit the location.
Another teacher also indicates that for creating the game, a clear plan of approach should be available.

13) Needs for playing the game
For playing the game, the students need the mobile phones with GPS, a stopwatch, a coach on location (CWS2).

5.1.2.2 User experience goals and usability goals

The previous section described the user needs, which were identified after several research activities with the intended target group. The following section describes the user experience and usability goals, which were discovered when analysing the data collected during all the research activities.
Understanding the user experience goals of the users is explicating the quality of the user experience, the way the interaction with the system feels like to the user. Satisfying user experience goals is important in order to achieve affective learning experiences, like arousing positive emotions and motivate students to teach (Preece, Rogers & Sharp, 2002).
Satisfying usability goals is generally regarded as ensuring that interactive products are easy to learn, easy to use, effective to use from the users' perspective. It involves optimising the interactions people have with interactive products to enable them to carry out their activities at work or school (Preece, Rogers & Sharp, 2002). The usability goals can be divided in the goals effective to use, efficient to use, be safe to use, easy to use, have a good utility, easy to learn and easy to remember how to learn.

Effective to use refers to how good a system is doing what it is supposed to do. Efficient to use is concerns the way a system supports users in carrying out their tasks. The user can carry out many tasks through a minimal number of steps. Safety involves protecting the user from dangerous conditions and undesirable situations. The utility bear on the extent to which the system provides the right kind of functionality so that the users can do what they need or want to do. Does the system provide an appropriate set of functions that enable users to carry out all their tasks in the way they want to do them? Easy to learn is important, when users don't want to spend long to learn how a program works and easy to remember how the program works is important when the users use the program on an irregularly basis.

Recognizing and understanding the trade-offs between usability and user experience goals are essential, which is illustrated in Table 5. It enables the designer to become aware of the consequences of pursuing different combinations of them in relation to fulfilling different users' needs. Not all of the usability goals and user experience goals apply to every interactive product being developed. Some combinations will also be incompatible. What is important depends on the use context, the task at hand, and who the intended users are (Preece, Rogers & Sharp, 2002).

Table 5: the user experience goals and usability goals for Games Atelier

User experience goals	Usability goals
Motivating to learn	Effective to use
Enjoyable, entertaining and fun	Efficient to use
Stimulating creativity	Easy to learn
Helpful	Easy to remember how to use
Rewarding	Good utility
	Safe to use

User experience goals

Depicting the user experience means explicating the quality of the user experience, the way the interaction with the system feels like to the user (Preece, Rogers & Sharp, 2002). This involves explaining the nature of the user experience in subjective terms and relates closely to the characteristics of the users.
User experience goals differ from the more objective usability goals in that they are concerned with how users experience an interactive product from their perspective, rather than assessing how useful or productive a system is from its own perspective.

As well as focusing primarily on improving efficiency and productivity at work, interaction design is increasingly concerning itself with creating systems that are satisfying, enjoyable, fun and entertaining, helpful, motivating, aesthetically pleasing, supportive of creativity, and rewarding.

The entertainment and computer games industry has researched the characteristics of interactive products that should provide enjoyment, fun, etc. Understanding which video games the users enjoy and which elements the users enjoy when playing video's should support understanding how to accomplish the user experience goals which are important for the students.

According to the user analysis it can be concluded that the interaction should feel motivating to learn, enjoyable, entertaining and fun, helpful and rewarding to the user. Furthermore, the program should encourage the creativity of the students.

1) User experience goal: motivating to learn

Games Atelier is a learning environment which promotes students to learn independently and actively, both when students make the game and when students play the game. The initiative for the learning activities lies with the students and not with the teacher (Veen & Jacobs, 2005). In order for the student to learn effectively, the student should be intrinsically motivated, meaning personally interested in the learning activity (Verloop & Lowyck, 2003).
During the user analysis it was investigated which activities the students find motivating and engaging. When the students are engaged, they will loose track of time and learn unconsciously. Because the students are distracted very easily, it is very important that the program is motivating to the students (TWS1).

Evaluating the location-based mobile experience, the students were asked whether these lessons become more attractive when they are supported by GPS or the mobile phone. *Statement 1 asked whether the lessons become more attractive when GPS is used* and *statement 2 when mobile phones are used.* Most students responded with neutral to both the support of mobile phones and GPS, but the tendency is positive for both the functionalities (Figure 13). It can be concluded that the use of GPS and mobile phones enhances the motivation of students to follow courses outside the classroom environment. The teachers evaluated the location-based mobile experience to be fun and highly motivating (TWS2).

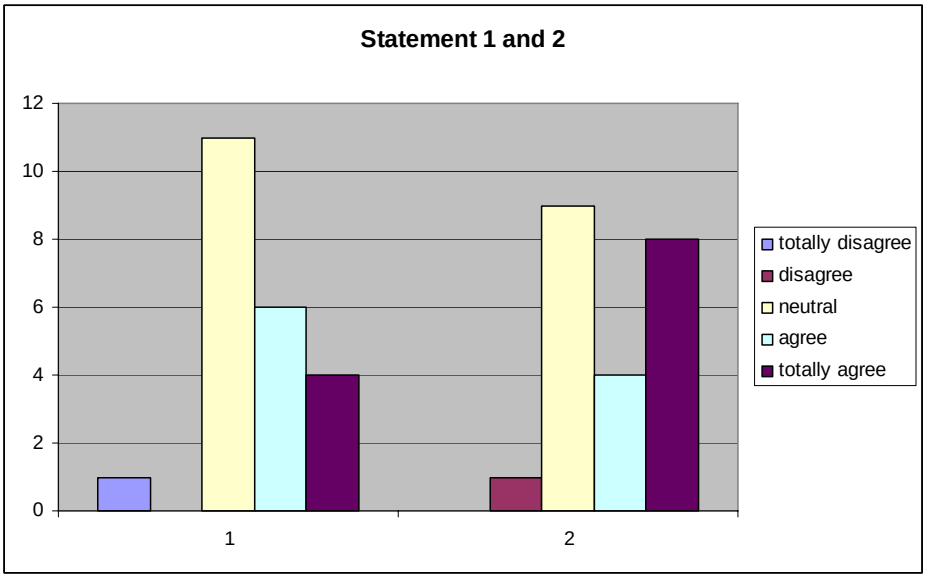

Figure 13: Make GPS and mobile technology lessons outside the classroom more attractive?

The students were asked which elements of the location-based mobile experience they enjoyed the most (Figure 14). Receiving and doing assignments on location and viewing the media they produced during the game on the website Geotracing was most popular. Besides these elements the students enjoyed playing against other teams (competition) and reviewing their trace on the website Geotracing after playing the game best. It can be concluded that the students both appreciated the game activities, but also the possibility to review all the activities and the media as produced in the field on the website.
No student chose reading the map as being an enjoyable element of the game. This may be caused by the fact that the roles were divided during the game and that only a few student did read the map to find the right direction (TWS3).

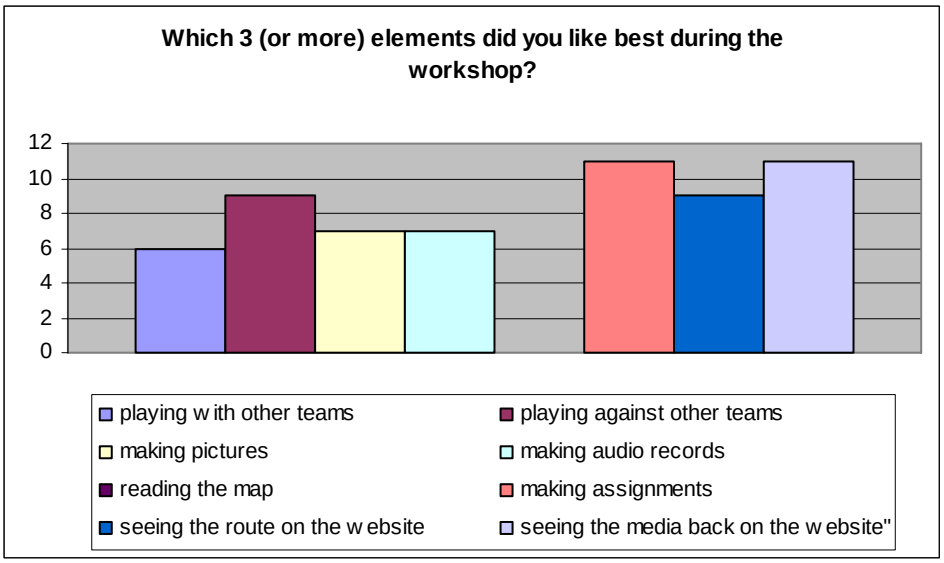

Figure 14: The elements the respondents liked best while playing the location-based mobile game

This thesis describes how students can design an intrinsically motivating game according to the literature (see also section 5.3).

2) User experience goal: enjoyable, entertaining and fun

For the students to be interested in the learning activities, the educator should make use of the elements that are interesting to the students.
The user analysis indicates that the students are personally interested in sharing media (Youtube), playing video games, and using the mobile phone for social interaction with friends and producing media (pictures and video's). The questionnaire filled in by the students after the third content workshop (CWS3) indicates that almost all students play video games in their leisure time (see also Figure 10). Literature review indicates that video games contain all characteristics of learning activities that are intrinsic motivating to students (Rieber, Davis, Matzko & Grant, 2001).

When students were asked to design an avatar during the participatory workshop (CWS3), it became clear that designing the avatar is very popular under the students. Most students started directly designing the avatar. Many of the avatars were gangsters. Apparently the gangsters are a popular theme among the students, both for boys and girls, and are they inspired by characters they see on TV and in video games. These gangsters possessed attributes to fight with, like pistols, swards and knives.
The style of the design differentiates between boys and girls. The boys draw aggressive looking figures. The girls use round forms and the avatars look very friendly. Identity is very important, especially clothing and hairdo. Because these respondents all live in Amsterdam, the avatars might be influenced by their own surroundings. The characteristics of the avatars are influenced by the media and the city.

The playground as designed by the students is according to the Geotracing website. It shows a digital map, which are augmented with icons and other game elements. Many students chose to design a labyrinth and located in an (American) city.

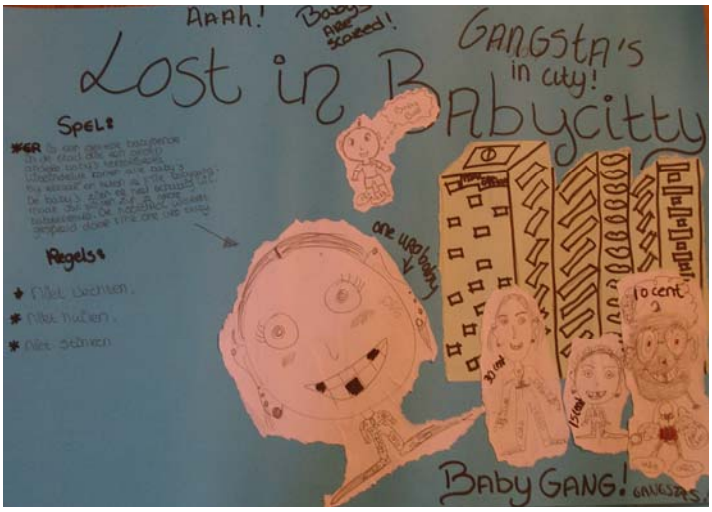

Figure 15: playground designed by group of students during participatory workshop

According to the questionnaire (CWS3) simulation games are most popular, but it should be specified that seven girls chose the simulation game Sims to be their favourite game. Table 6 gives an overview of the most popular video games according the respondents. Two boys chose GTA, which is a race simulation game. Apparently Sims is very popular with girls. Two students chose third person shooter games to be their favourite and two students chose role playing games. Other favourite games genres mentioned, but only by one person each, were an adventure game, fantasy game and sport game (questionnaire, CWS3).

Table 6: The most popular video games according the respondents of CWS3

Game genre	**Girls**	**Boys**
Simulation game	Sims (7X)	GTA (2X)
Sport game		Sport
Adventure game	Harry Potter	
Third person shooter	o Tomb Raider o Miami Vice	
Fantasy game		Final Fantasy
MMORPG		o Earth special forces o Runescape
Arcade	Burger rush	

3) User experience goal: stimulating creativity

Creation promotes knowledge building

Constructivist theorists promote knowledge building by means of producing artefacts (Jonassen, Hernandez-Serrano & Choi, 2000). Within Games Atelier, the students are enabled to make location-based mobile games themselves. According to the teachers, the learning effects will be very high when the students make the game, because the students should fully understand the subject matter and use cognitive learning activities, like analyzing, relating and reproducing knowledge (CWS2).

Learning will be most effective an enjoyable when the students make something that is close to their personal interest (Schlager, 2005). Teachers promote the creativity by offering a clear learning goal and structured environment, but between these strict boundaries the students are free to make something that relates to their personal interest.

Creativity stimulated by means of open assignments
Stimulating creativity can also be a goal when students play the game. Teachers indicate that the students will receive an open assignment on location. They should use their creativity to solve the problem (CWS2). When the assignments are open, the students can decide how to solve it and which media to use to capture the knowledge. This media can be photos, videos or text.

Creation is a motivating experience
According to Mortimer (2006), developing media in an authentic location is an "active and creative endeavour that results in the creation of new and original learning experiences and resources". This conclusion is based on the experiences with the pervasive program Create-a-scape, where students are supported in creating mediascapes. A mediascape is digital media that can be attached to and received on a real-world location by means of a mobile device. Mortimer emphasizes the empowering and motivating effect on students creating mediascapes. The content production can be built upon their existing knowledge, interests and cultural backgrounds of the students and interact with the location. The completed resources may also make a welcome addition to the range of learning resources already available.

Within the user analysis and as illustrated in Figure 16, the students indicate that designing the playground, avatars and other game visuals would be the most important and enjoyable activity when creating the game with the program Games Atelier. Writing the storyline, creating the assignments that support learning, designing the rules, creating videos and pictures that support the assignments and players who assess the game are all even appreciated (5 times) (CWS3).

Figure 16: The most enjoyable elements for students while creating a game

4) User experience goals: helpful

The program should be helpful. It should support the students to the maximum, because they should work as independent as possible; the system should provide all information they need and give clear instructions.

5) User experience goals: rewarding

Rewards are important within the learning environment Games Atelier, because rewards are believed to motivate students and help the knowledge and skills to become meaningful to them (Jonassen, Hernandez-Serrano & Choi, 2000). The students will be rewarded for their learning activities at different moments within the learning environment.

Rewards after creating the game
When the students made a location-based mobile game, the game will be shared within the program and peer students are invited to play the game. After playing the game, the students who made the game receive feedback on the product by the peers who played the game. According to Mortimer (2006), students who made products within Create-a-scape found this feedback from peers most rewarding. Overmars (2005), who developed Game Maker concludes that creating the game is highly motivating, especially when the game is used in other classes.

Rewards after playing the game
When playing the game, the students perform by choosing game strategies, solving problems and producing media. During the game, the students can be rewarded by means of points or direct feedback. After playing the game, the students are able to review the media they collected and trace on the website of Games Atelier. After the location-based mobile experience, the students indicated that receiving and accomplishing assignments on location, and collecting and reviewing the media and trace on the website to be the most exciting elements of playing the game (see also Figure 14).

Usability goals

Usability is generally regarded as insuring that interactive products are easy to learn, effective to use, and enjoyable from the users' perspective. It involves optimizing the interactions people have with interactive products to enable them to carry out their activities at school (Preece, Rogers & Sharp, 2002).

1) Usability goal: Effective to use

This refers to how good a system is doing what it is supposed to do. Is the system capable of allowing people to learn well, carry out their work efficiently, and access the information they need?

Flexible support for different users
Because the program should support the learning process of a divers target group, the program should be flexible. The users of Games Atelier differentiate in educational level (base and upper classes of VMBO, HAVO and VWO), age, interest and experience. These users all have different learning styles, prior knowledge, skills and capabilities. An assignments should be challenging to be intrinsically motivating (Csikszentmihalyi, 1992). Therefore, the problem should be neither too easy nor too complicated. It is important; the student receives the assignment, which is according to his personal educational level.

Flexibility when playing the game
While playing the game, the students can be monitored in the field by the teacher. The teacher may offer assistance when needed and adjust the assignment when the student finds them too difficult. The teacher

or peers will react directly on the learning process, steering or enhance the level of challenges during the game.

Flexible support offered by the program
When creating the games, the program Games Atelier is able to assist the student in designing assignments for students of different levels that are challenging and exciting (US teacher A).
Furthermore, when creating the game for the first time, the program controls the process. Later, when the user is more experienced in creating the game, the users can have more freedom and flexibility (CWS2).
The structure as offered by the program will be followed straight, but it should be possible for experienced students to use the program more freely, deciding their own work process, when designing the game (TWS2).

The programme structures the process and assists the student with every step
The teachers want the students to work independently (CWS2). This requires much support of the program, when needed. The programmed structures the process and assists the student with every step. One teacher indicated that a learning method is attractive to her when the students follow the method and know everything they need to know when they are finished *(observation at OSB)*.

2) Usability goal: Efficient to use

Efficiency refers to the way a system supports users in carrying out their tasks. The user can carry out many tasks through a minimal number of steps. Once the users have learned how to use a system to carry out their tasks, will they sustain a high level of productivity (Preece, Rogers & Sharp, 2002)?

Because students use Internet and video games in their free time, they are used to a certain speed, pace and efficiency that is often not offered by traditional learning materials, like books (Kirriemuir & McFarlane, 2004). The students are in control of the programs, creating choices about strategies and information they need at that time. The students need a program that is efficient to use, otherwise they will get bored and frustrated. This can be accomplished by using a non-linear structure, supported by means of hyperlinks.
The teachers indicate during the user analysis that teachers have little time and want to use methods that need little preparation. Therefore, efficiency of use is important for teachers too.

3) Usability goal: Easy to learn

How easy is a system to use? People don't want to spend a long time learning how a system works. The users want to get started straight away and get competent at carrying out tasks without too much effort. To a certain extent, people are prepared to spend longer learning more complex systems that provide a wider range of functionality (word processor). Online tutorials can help (Preece, Rogers & Sharp, 2002).

The teachers want a program that is easy to learn. They want to begin a project with little preparation, because they can do a project with Games Atelier once in a while. When the program is simple and you can start with the project it is more enjoyable for the teacher to do such a project (Observation at OSB, TWS2, CWS2).
Also a student indicated that ease of use enhances the motivation to use a program. This student enjoys the program Game Maker, because it is easy to make games with the program. Games Atelier is an instrument to make the location-based mobile game (observation at OSB). The main goal is to learn in an authentic context and not to learn ICT-skills. The program should offer maximal support and therefore the program should be easy to use, offer a simple user interface and be efficient (TWS2).

Tutorial to start the project
The teachers who initiates and coach the project, needs a clear tutorial in order to prepare and launch the project. This tutorial describes the preparation and process of the project in clear steps. This tutorial should not be elaborated, but just a few steps for a quick start (CWS2).

4) Usability goal: Easy to remember how to use

When users have learned how a system works, the system should be easy to remember how to use, especially important when the systems will be used infrequently. The users should be able to remind how the system works or be reminded how to use it, after not using the program for a couple of months. The users should be supported by the user interface in reminding how to carry out tasks (Preece, Rogers & Sharp, 2002). The program Games Atelier will complement the standard methods being used within the curriculum. The teachers can play or make a game just once in a while, on an irregular basis (CWS2). The users should be remembered how to use the program.

5) Usability goal: Good utility

The utility refers to the extent to which the system provides the right kind of functionality so that the users can do what they need or want to do (Preece, Rogers & Sharp, 2002). Does the system provide an appropriate set of functions that enable users to carry out all their tasks in the way they want to do them? Within the user analysis the needs are investigated and the preference for certain features. This information is the basis for designing the prototype of the program. When this prototype is formative evaluated, the utility will be tested.

6) Usability goal: Safe to use

Safety involves protecting the user from dangerous conditions and undesirable situations. In relation to the first ergonomic aspect, it refers to the external conditions where people work. It refers to helping any user in any kind of situation avoid the dangers of carrying out unwanted actions accidentally. It also refers to the fears of users making mistakes and the consequences for their behaviour. Make the chance that the users press wrong key buttons mistakenly small and offer various means of recovery should they make mistakes. Does the system prevent the users from making serious errors and, if they do make an error, does it permit them to recover easily (Preece, Rogers & Sharp, 2002)?

Support the students to keep the eyes on the real world and not on the mobile screen
The students of the mobile team should be safe when playing the game in the field (TWS2). The safety of playing on location can be enhanced by means of the interaction design, media chosen, the assistance offered by the program and by the game designed. This depends on the environment; playing a game in the city is more dangerous than playing a game in the forest.
When designing interaction and choosing media for the application, the designer should keep in mind that the main focus of the user should be on the location. Using audio in stead of visual media or text messages (video/ pictures) supports the students to keep their eyes on the real world. When finding their way, the home team can steer the mobile team, supported by the phone, in stead of the mobile interface that indicates the route and forces the students to keep their eyes on the mobile screen. One teacher indicates that the students of the mobile team should be assisted by a teacher in the field (US teacher B). He also prefers to use touch screen when playing the game. Schwabe and Goth (2005) also recommends using touch screens and offer multiple choice questions to be answered in the field, because these can be answered quickly, when comparing this with answer open questions by sending text messages.

Offer an escape procedure
The system should offer an escape procedure to support the students when technology fails (US teacher B). This escape-procedure was designed for the prototyped location-based game, which existed of a paper-based sheet with phone number, instructions how to use the application and a paper-based map.

The game offers a safe learning environment where students can rehearse skills in repeated cycles.
Literature emphasizes that game environments should offer a safe and protected learning environment where students rehearse skills in cycles of trial and error, are allowed to make mistakes and get the chance to analyze the mistakes and do it again (Freitas, 2006; Stager, 2005; Gee, 2004; Veen & Jacobs, 2005).
During the second content workshop, the only gameplay element that was not chosen by any teacher is the 'race where students who make a mistake are forbidden to continue'. This is confirming the theory that a game environment should be a safe environment were students are allowed to make mistakes.

5.1.3 Requirements

A set of stable requirements is produced from the identified needs, usability and user experience goals that form a sound basis to move forward into thinking about design. According to Preece, Rogers and Sharp (2002) requirements are statements about an intended product that specifies what it should do or how it should perform. You should make the requirements as specific, unambiguous and clear as possible.
Different requirements can be distinguished, which are the user, usability and functional requirements (Preece, Rogers & Sharp, 2002). The requirements will be clarified and described within the following section.
Table 7 gives an overview of the requirements and their relation to the user needs, user experience goals and usability goals as identified during the user and context analysis.

Table 7: User needs, user experience goals and usability goals in relation with the requirements

User needs	**Requirements**
Characteristics teachers	User requirements for teachers
Characteristics students	User requirements for students
Tasks and goals	Functional requirements
User experience goals	---
Usability goals	Usability requirements

5.1.3.1 User requirements

User requirements capture the characteristics of the teachers and students. Users' abilities and skills are an important aspect of the user requirements (Preece, Rogers & Sharp, 2002). Table 8 describes the user requirements for teachers and Table 9 describes the user requirements for students.
In addition, the user may be novice, expert, casual or frequent user. This influences the way the product is designed. The collection of attributes for a 'typical' user is called a user profile. Any one device may have a number of different user profiles.

Table 8: The user requirements for teachers

User requirements for teachers (URfT)
1. The program makes the learning process of the students visible for the teacher
2. The program supports the teacher in coaching the students
3. The additional and educational value of the educational method as offered by Games Atelier is clarified to the teachers

Attitude towards computers and user profile of teachers
Both observations on the school OSB and during the technology workshops indicated that the teachers have no problems using mobile phones and the computer. These technologies are becoming more integrated within the school and for use in leisure time. Probably, the teachers are not interested in these technologies will not be motivated to use Games Atelier as a program at the first place.
The teachers are expert users of the WIMP interface, but are novice users of the virtual game and the community sites. The teacher needs step-by-step explanation and clear information, in order for them to coach the students and feel secure about their role in the class (Preece, Rogers & Sharp, 2002).

Table 9: The user requirements for students

User requirements for students (URfS)
1. The program enables the students to create games and play games that fits their personal interest
2. The program prevents the students from getting easily distracted
3. The program displays visual hints and pictures

Attitude towards computers user profile of students
During the observations of the technology workshops with students (TWS3) and at the school, the attitude towards computers was measured.
The students are expert users of personal computers and mobile devices.
At school the students have access to pc's and the Internet. The students use the programs of Microsoft Office to support assignments. The PC is integrated in the classes. Students use the websites Google (Google, 2007) and wikipedia (wikipedia, 2007) to explore information at Internet *(observation at OSB)*.
The teacher explains that the students learn in the first class the basic ICT skills and those they need to apply these skills during their attendance at the secondary school.
The students are expert users of the WIMP interface, mobile devices, and community sites. An expert will require a flexible interaction with more wide-ranging power of control (Preece, Rogers & Sharp, 2002).
You cannot assume that all users are experts, so the program is provided with a help-function, which will provide help when necessary.

5.1.3.2 Usability requirements (UR)

Usability requirements capture the usability goals and associated measures for a particular product. To meet the usability goals we must identify the appropriate requirements (Preece, Rogers & Sharp, 2002). In Table 10 the usability requirements for Games Atelier can be found.

Table 10: The usability requirements for Games Atelier

Category	**Usability requirement (UR)**
1. Effective to use	a. The web-based system adapts support to the individual level of teachers and students, based on their educational level, interest and experience with the system. b. The web-based system offers support to the teacher and students when needed. c. The web-based system structures the process and assists the student with every step.

2. Efficient to use	a. When using the system, the students and teacher reach the support they need within minimal steps b. The system exists of a non-linear structure
3. Easy to learn	a. The students and teachers can learn the system while performing b. The web-based system provides a help-function and a tutorial c. The web-based system provides the teacher with a tutorial to start the project
4. Easy to remember how to use	The system is structured and designed in a consequent way
5. Good utility	The system provides the right kind of functionality according to teacher and students
6. Safe to use	a. The system supports the students to keep the eyes on the real world and not on the mobile screen. b. The system offers an escape procedure c. Within the game environment the students can rehearse skills in repeated cycles

5.1.3.3 Functional requirements (FR)

Functional requirements describe what the system should do. Understanding the functional requirements for interaction design is very important (Preece, Rogers & Sharp, 2002). Table 11 describes the functional requirements of Games Atelier.

Table 11: The functional requirements for Games Atelier

Create & Play	**Functional requirement (FR)**
FR 1	Achieving learning goals is the main concerns while playing the games. These learning goals should be integrated within the location-based mobile game. The program supports this inclusion of learning goals. a. The educational goals and the educational theme of the project determine the final goal, gameplay and assignments of the location-based mobile game. b. When creating the game, the educational goals and theme is determined by the teachers. c. The students should understand how to make meaningful assignments to accomplish learning goals.
FR 2	The system offers much assistance when creating and playing the game.
FR 3	When the game is made by the students, it can be tested before others play the game.
FR 4	a. The system supports collaborative learning while playing the game and while creating the game. b. The system supports the division of roles between students when playing and creating the game.
FR 5	The system supports learning activities according to the didactical approaches learning by doing and learning by exploring. These learning activities are: a. Solve open and ill-structured research assignments that are related to the environment.

	b. The location of the game contains much information which is used to solve the problem. c. Research activities are: making pictures, video's and voice records on location. d. The students are able to see the coordinates on the digital map on the computer screen.
FR 6	The system supports location-based mobile games being played by home team and mobile teams and only mobile teams in the field.
FR 7	The web-based system supports the teacher in preparing the project.
View	**Functional requirement (FR)**
FR 8	The web-based system supports the student in reflecting on their learning activities.
FR 9	The web-based system supports the students in giving each other feedback.
FR 10	The web-based system supports the reuse of media that is collected when creating and playing the game.
FR 11	The web-based system supports the reuse of games that are made in Games Atelier.
FR 12	The web-based system supports the teacher to assess the learning results of the students.

5.1.4 Summary

By means of the research activities writing user scenarios, observing the secondary school, technology workshops, content workshops and a participatory workshop, the user needs, usability goals and user experience goals were investigated and therefore an answer was explored to the question*: what are the user needs, user experience goals, usability goals and user, usability, context and functional requirements of the target users according to creating, playing and viewing location-based mobile games?*
Needs and requirements are formulated systematically and can be found in this section. They will be used as a basis to design the conceptual model and third prototype, as described and formulated in section 5.4.
The user analysis pointed out that the teachers need clear insight in the educational value of the program Games Atelier. They indicated some values, like the educational contents being presented in small sections while playing the game and real-world examples used to illustrate the abstract concepts. The user analysis also indicated that it is important for the students to understand how to make a game that support learning and to understand how the game can integrate intrinsic motivating elements. These subjects will be discussed in the section 5.2.

5.2 PRODUCING AND PLAYING EDUCATIONAL LOCATION-BASED MOBILE GAMES

Within the learning environment Games Atelier creating, playing and viewing the location-based mobile game are the central activities. The location-based mobile games can be seen as lessons outside in the real-world environment. Characteristics of an effective lesson outside the classroom environment have already been discussed in chapter 3. For example, the problem should be ill-structured and the assignments should be related to the real-world environment. This section elaborates on these characteristics and investigates what assignments the students of both the home and mobile team should receive, how they cooperate together while playing the game, what information the students will receive to enhance the environment and support the students while solving the problem and where they search for information.
It is from importance that students understand how to make a location-based game themselves and how to write meaningful assignments to accomplish learning goals as stated in one of the functional requirements (FR1c). The developers must understand how the game can teach peer students about a certain topic which is related to the real-world environment. Students and teachers must write these assignments and develop the information and digital media that supports the players when solving problems on location.
Furthermore, the developers of the game must understand how a game is constructed and what game elements make the player feel engaged and motivated. These topics have already been explored in Chapter 3 and 5. This section describes all game genres of the games that can be developed in the program and the related elements, like storyline, gameplay and direct feedback.
For developing the game, the students will be supported by means of the project environment and game template. The project environment supplies the students with information about how to develop assignments, supportive information and cognitive tools that teach the players about educational contents and how to create a game that is intrinsically motivating. This information is based on this section. The developed assignments, information and digital media can be uploaded by means of the game template in the web-based environment. The game template contains the intrinsic motivational game elements as described in section 5.2.2. The developers of the game can choose the game elements from the template. The program Games Atelier constructs the location-based mobile game, based on the uploaded data and the choices made.

The following section combines the knowledge extracted from the user and context analysis with state-of-the-art literature about constructivist learning theories and the pedagogies learning outside the classroom environment, game-based learning and mobile learning in order to describe the design principles for an effective location-based mobile game. The research questions: *What are the characteristics of effective educational location-based mobile games?* And: *How can the users be supported in creating, playing and viewing the educational location-based mobile game?* Will be investigated.

5.2.1 Assignments, information and digital media the students receive while playing the game

The following section describes the assignments, information sources and cognitive tools the home and mobile team receive while playing the location-based mobile game and how the program Games Atelier support these activities.

In general, a problem-based or constructivist learning environment challenges and supports the thinking of the students (Verloop & Lowyck, 2003). Within the constructivist learning environment Games Atelier students of a mobile and home team collaborate together from a distance to solve educational problems in the authentic environment. The mobile team is supported by mobile devices and the home team is supported by the personal computer. The personal computer and mobile devices complement each other, while both the teams receive problems that are based on the authentic location. The mobile team is at that specific location, exploring the information in the real environment. The home team sits behind the PC

and is able to search for information on the Internet. The Internet cannot be accessed by means of the mobile devices.

The students of the mobile team are challenged by complex and realistic problems which they receive on location through the location-based technologies. To solve these problems, they explore the rich real-world environment. The mobile devices offer digital information that is needed to solve the problem just-in-time (enhanced reality), together with cognitive and regulative tools that support the problem-solving processes. The students of the home team are also challenged by a complex and realistic problem. They receive this problem in the web-based game environment and it needs to be solved by exploring information on the Internet. The system supports the students by providing extra information resources and cognitive and regulative tools. The students of the mobile team provide the students of the home team with contextual information on demand. The students of the home team provide the mobile student with additional information from the Internet on demand.
The program Games Atelier provides the students with advice and guidance to help students make maximum use of their own cognitive resources and knowledge. The guidance and advice are implicit rather than explicit, and non-directive rather than directive, being provided when needed by students (Choi, 1995). Games Atelier provides the students furthermore with information and tools that cannot be found on the location or Internet. The developers of the game should therefore understand the information and tools that are needed to solve the ill-defined problems on location. This involves investigating the location when creating the game. Figure 17 illustrates the learning activities and information shared between the mobile and home team while playing the location-based mobile game. The left side represents the students of the mobile team being supported by the mobile application. The right side of the model represents the students of the home team being supported by the web-based application.

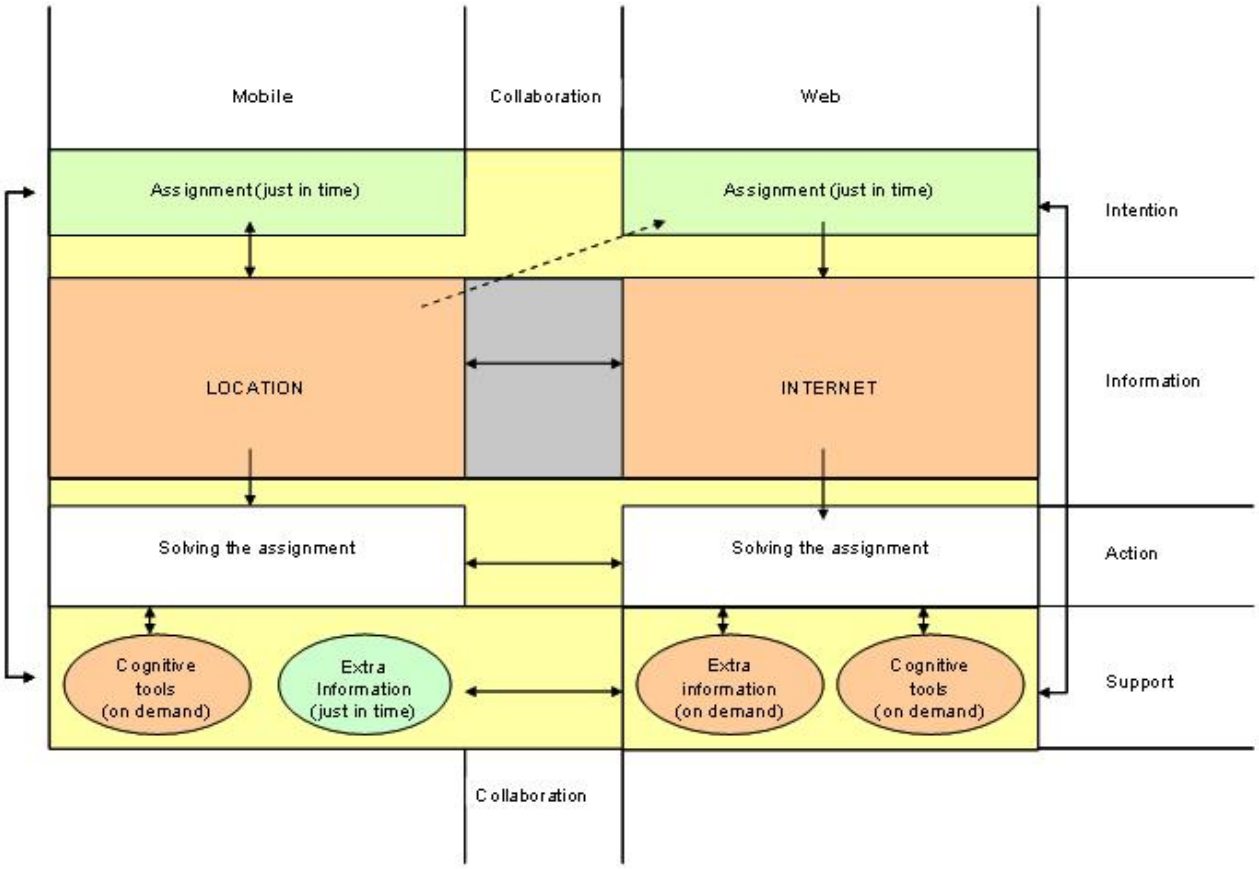

Figure 17: learning activities and information shared while playing the location-based mobile game

Problem context
Within location-based mobile games, the real-world environment serves as the problem context. The students construct the deepest meaning about abstract concepts when they are clearly tied to action in the world. The meanings of concepts are made clear through the experiences the students have in the real-world and the activities they carry out (Gee, 2003). Therefore the game includes the location in the game rules and activities.

Assignments
The system provides the students of the mobile and home team with meaningful problems that are tied to real-world, reflect authentic tasks and are illustrated by means of authentic examples. The visualization of the learning content by means of real examples is thought to be of great value by the teachers who participated in the user studies (CWS1). The problems motivate the students to articulate the intention to construct knowledge and solve the problem. The students receive the problems just-in-time and just-in-place, meaning that the problem is automatically connected to the right location and illustrated by means of authentic examples. The problem may steer the student where to look and how to perceive the authentic location they are at. The problem depends on the learning goals and the game genre. It can be an open and ill-structured problem that is embedded in a role-playing game, a research assignment, simulation game or production game. The problem can be closed and structured, and embedded in an adventure game where the students acquire knowledge through closed questions on location. The game genres will be discussed more elaborately in section 5.3.2.

Exploring information on the authentic location and the Internet
When the students have a conscious intention to solve the problem, they articulate the need and purpose for information. The strategy for searching information relates to that declared intention. To solve the problem, the students make use of relevant information that is provided in the learning environment. This information is provided just-in-time and on demand, by the real-world environment, Internet, and information that is pre-selected and provided by the program.
Making use of multiple information sources supports the student to analyse the problem from different angles. Learning is supported, because students can elaborate on or analyse different sources of information, combine the sources of information, integrate or relate the different sources to previous knowledge, anchor new knowledge to previous experience, and evaluate it (Jonassen, Hernandez-Serrano & Choi, 2000).

While being in the real world environment that relates to the problem that needs to be solved, the student of the mobile team explores this environment for relevant information. The information is collected by means of visual analysis and direct observation of the environment. Because the game is played on a larger playground, the students move between different locations. In order for the students of the mobile team to solve problems on location, they might require information from the Internet. In order to receive the right information, the mobile team can use the mobile phone to contact the home team and articulate the information need to the students of the home team who have access to the Internet on the PC. The students typically get useful information when they ask the right questions, and this can happen only if they develop the necessary higher order thinking processes such as articulating, analysing, reflecting, testing, monitoring, and evaluating what they know and what they don't know (Jonassen, Hernandez-Serrano & Choi, 2000).

Because the students of the home team are also confronted with complex and realistic problems they need to solve, they also explore information to solve the problem. The students of the home team have different tasks while playing the game than the mobile team. The problems are delivered just-in-time and just-in-place and are clearly related to the location where the mobile team is at.

This just-in-time pedagogy promotes students to be supported while performing a task or solving a problem. Because the information is supplied when the students need the information in the right context, the learning becomes more effective. When students receive information, they are actively involved in meaningful learning because they are responsible for performance and the learning required achieving it (Jonassen, Hernandez-Serrano & Choi, 2000). These features provide a variety of information to students when they are most motivated to learn, leading them to more meaningful learning and better performance.
Because the students of the home team are not personally present in the real-world environment, they need to ask for information that is supplied by the mobile team. They can do this by means of the mobile phone for voice calling or video conferencing. Because the students of the home team ask for the information on location, they need to articulate precisely what information they need. In order to do so, the students reflect on their prior knowledge and other information available, and construct knowledge actively.
In order to solve the problem, the students of the home team explore the Internet for information and for the students to collect the right information; he should construct a searching strategy that is based on the need for information. The home player should articulate need for information by typing a query in the search engine. The students of the home team can provide the students of the mobile team with information from the Internet on demand. In order to receive the right information, the mobile team member should articulate the needed information, which promotes meaningful learning.

Collecting data from the environment
When the process of finding information, analysing and relating this information to prior knowledge and multiple sources has led to a resolve of the problem, the student must represent the information is such a way that it reflects the personal insight. The student can be steered by the program in choosing the representation of the knowledge (this depends on the assignments), or the student can be free to choose the medium he likes and is confirm his personal learning style. The students can collect data or produce media, which is send to the program and collected in the web environment. The program has various modes of presenting and capturing information (such as text, graphics, visual images, audio, motion video, etc.) that enable students to capture information with the most effective mode depending on the situation.
According to the teachers during the first content workshop the students can solve for example a research problem by making pictures and video's on location, interviewing people in the neighbourhood. (TCW1).

Enhanced reality
Within the location-based experience, the rich real-world environment provides the mobile team with information to solve the problem. Often, this information is not sufficient and the developers of the game must provide the student who plays the game with complementary information that is relevant to solve the problem. The mobile device provides the mobile team with information, which cannot be obtained through observation. This information is captured in different forms of media (pictures, videos, illustrations or text) and designed to be viewed from precise physical locations (Sánchez, Salinas & Sáenz, 2006; Flintham et. al., 2003). Therefore, the developers of the mobile game must visit the location when they produce this information. Ryan termed this approach 'Enhanced Reality', because the real experience is enhanced by providing information just-in-time, adapted to the individual needs of the user.
An example of media that enhances reality is the 3D model of de Waag and the old city wall of Amsterdam (Figure 18). The 3D model is supplied by the mobile device and used when the students stand in front of de Waag. The 3D model presents de Waag in its original condition in the sixteenth century. The building is rigorous rebuild during its four hundred year existence. The student is asked to make a comparison between the original building and the actual state, and to declare the rebuilding. In order to do so, the student should visually analyse the Weighing House in the real world and the virtual model that is supplied by the mobile device. Furthermore, the model contains a digital map which is overlaid with the virtual city wall. The city wall doesn't exist any more, but remains can be found in the city. The students are asked to find these remains, guided by the digital map and the virtual city wall, and make photos of the remains of the city wall in the real world. The virtual models support the students to visualize the history and build on the consciousness of hidden history in the city.

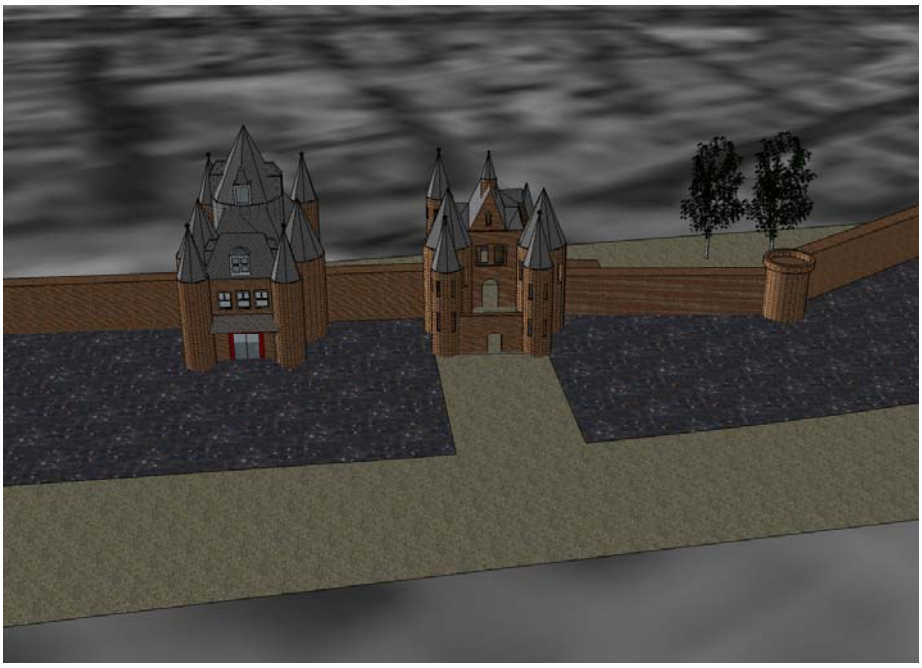

Figure 18: 3D model of the Weighing House and the old city wall of Amsterdam

During the first content workshop, the teachers were asked to brainstorm in separate groups of three persons about which information can enrich the reality and support the students while being engaged in a location-based experience (CWS1). One teacher thought of a simulation video, illustrating the effect of fire to the lunges, while the students are involved in a project about security in the public space. Another teacher imagined determination tables to be helpful when offered to the mobile team during field research, in order to recognize the vegetation. Both the teachers thought of this example individually.

The students of the home teams are also provided by the program with complementary information sources and cognitive tools to support the problem-solving. The students of the home team receive synchronically the just-in-time information which is supplied to the mobile team on location. One cognitive tool that supports the performance of the home team is the digital map that presents the live trace of the mobile teams in the field and represents the context as the game board on the user interface. This feature enables the students of the home team to monitor the activities of the mobile team. Geotracing software illustrates the route of the mobile team on the digital map, as captured by means of GPS. When the students of the mobile team send media to the program, the software attaches the media to the exact location on the digital map. This enables the students of the home team to visualize the context of the mobile team. While discussing the results of the brainstorm session (CWS1) one teacher, who teaches Biology, proposed to attach different kinds of data that is collected in the field to different layers of digital maps. This way, the location-based information can be compared with each other and combined. The teacher suggested to make a certain GIS map (Geo Information Systems) which allow users to combine different kinds of information of multiple layered maps (Edugis, 2007). These multiple layered digital maps that contain different sorts of information, can also be offered to the students while playing the game.

The digital map contains information about gameplay, like the zones illustrated on the digital map, or icons that illustrate hints that can be captured by the students of the mobile team. The developers of the

location-based mobile game in Games Atelier decide which information is presented on the digital map. The projected information is highly influenced by the rules of the game and the gameplay.
The developers of the location-based mobile game use the game template as provided in the web-based environment. This game template provides the developers of the game with possible choices for designing the game. The game template and the possible options which the developers of the game can choose from will be described in the following sections.

5.2.2 Producing educational location-based mobile games as supported by Games Atelier

It is already identified in Chapter 3 and section 5.1 that intrinsic motivation is from severe importance for flexible and learner-centred learning environments. Literature has been studied and the target users have been analysed to determine which characteristics of games can arouse this intrinsic motivation by the students. These elements will be integrated in the location-based mobile games that will be created and played supported by Games Atelier. When students and teachers create the games, they will be supported by means of a template. This template provides the users with all the possible options for game elements, which the users can choose by means of menus. The game template will be explained and illustrated in the later section 5.3. First, the following section will describe the structure of the intrinsic motivating games and all possible options as provided by the game template.

5.2.2.1 Educational game genres

Within the program Games Atelier students can produce educational games according to five different genres. The five game genres are adventure game, research assignment, role playing game, production game and simulation game. The genres are chosen by the Waag Society and the project leaders who are involved in the development process of Games Atelier. The main characteristics of the game genres will be described shortly in this section. Table 12 gives an overview of the game genres and the most characteristically game elements that are related to these game genres.

Table 12: Game genres and related game elements

Game genre	Game elements
Adventure game	linear structure; one main character; obstacles and opponents; hints and clues
Research assignment	linear structure; one main character; field research in a real world environment
Role playing game	non-linear structure; avatar; guild; solving problems or assignments; negotiation and collaboration
Production game	non-linear structure; produce or build a product by means of raw materials or money; negotiation and collaboration
Simulation game	non-linear structure; virtual environment with important elements of real situation; manipulate variables

Adventure game
The adventure game involves a linear storyline which and one main character. While playing the game, the character discovers obstacles and opponents. The obstacles the main character discovers are for example puzzles, riddles or assignments, which he must solve to continue and make progress in the game and eventually reach the final goal. The player is provided with hints and clues that help him to solve the obstacles (Veen & Jacobs, 2005).
The problems solved within the adventure games are closed and the students have little control over what happens in the game, because the structure is linear. The students are highly directed and steered. An

example of an adventure game is the Buin Zoo game (Sánchez, Salinas & Sáenz, 2006). Within this game, which is a guided tour, students use the mobile application when visiting the zoo. This mobile application provides a guided visit by representing different places of the zoo and the position of cages. The software asks questions and conveys information to assist students in their answers.

During the participatory design workshop, the students were asked to develop a scenario for a location-based mobile game (CWS3). The game genre adventure is most popular among the respondents. Three out of six groups designed a game that integrated elements of adventure games, for example solving an obstacle or challenge to go to the next level and a linear storyline. The obstacles were fighting and defeating an enemy, together with other players. Most games contained a clear final goal or mission and ended when the players reach a final level. There is only one game where students can win points when they succeed in solving assignments.

Research assignment
The research game contains similar elements as the adventure game genre, but it involves field research in a real world environment and collecting information in order to reach the final goal (Hordijk, 2007).

When developing scenarios for learning outside the classroom environment during the first content workshop, all teachers chose to organize a research project on location. They developed an open research assignment, for the students to investigate a certain topic on location. Some teachers indicated that the assignment or research goal must be specific, but establishing the investigation by the students can be open. This stimulates the creativity (TCW1).

Role playing game
Within a role playing game, the player chooses designs or customizes an avatar. Avatars are graphical representations of the player and students can relate to the characters they become. The player determines the characteristics and capabilities, clothes, aids and qualities of the avatars. This can be an animal, a person from history, space invaders, and researchers, anything that is relevant. The avatar is a character that moves within the game environment. The player sees the game environment through the eyes of the game, but additionally sees the avatar on the computer screen represented (McMahan, cited in Veen & Jacobs, 2005).
While playing the game the players cooperate together in a guild, which is a collection of players who come together to share knowledge, resources, and manpower (Seely Brown, 2007). Several players play together to solve a problem and assignments, but every player has an own identity, characteristics and task. The players are dependent of each other and negotiate together, determine a certain strategy, fight together or build a city (Hordijk, 2007).
The character finds objects and information which he can use to achieve a later goal. Solving problems or assignments makes the position or health of the character stronger by collecting objects, power or energy. In contrast with the adventure game, the storyline is non-linear and the players have a lot of freedom during the game (Veen & Jacobs, 2005).

Production game
The final goal of the production game is to produce or build a product by means of raw materials or money. At the start of the game, the players receive a small amount of money or raw materials, but this is not enough to build the product. More raw material or money has to be earned during the game by solving assignments. Collaboration is required, because the assignments can only be solved together with other players. Also, the raw material or money can be exchanged for information. This requires for the players to negotiate. The money or raw materials must be brought to a central place, for example a bank, in order to keep it safe. This can be a player in the field or the home team (Hordijk, 2007). The structure of the game is non-linear; students are free to explore the location for information. The games offer many

learning opportunities, while the students negotiates, should build a strategy and be constantly alert for danger (Dede, cited in Veen & Jacobs, 2005)

Simulation game
Garris, Ahlers and Driskell (2002) analysed the difference between simulations and games and noted that a simulation represents a real-world system and a game provides a reality into itself that does not directly represent some real-world event. The distinction can be blurred, because simulations can incorporate elements of games such as fantasy or scoring that may not be present in the real-world referent. In participatory simulations, the students themselves act out key parts in an immersive recreation of a dynamic system (Kirriemuir & McFarlane, 2004). By making the students part of the simulation itself, they are engaged in the learning process, and immediately see the effect their actions can have on the system as a whole. They do not just watch the simulation, they are the simulation.
Within a simulation game, the player needs to survive in a virtual environment. Important elements of a real situation are combined. The player can manipulate certain variables or take certain decisions which influence the outcome or scenario of the game. The simulation game teaches the player how variables or parameters influence each other or how certain strategies or tactics bring fortune. Simulation games are simplified forms of real systems. Players can make decisions with certain consequences and evaluate these decisions afterwards. Simulation games are an effective method in research, education and decision making (Veen & Jacobs, 2005). The structure of the game is non-linear; students are free to explore the location for information. An example of a simulation game is illustrated by Jonassen (2000). The students engage in a virtual problem environment, representing a firm and the student receive the assignment to manage the firm so that it becomes profitable. The problem context is illustrated by means of several resources (text based/ sounds etc), like interviews with employees, articles and annual reports. Students work their solutions out on a complex and multifaceted spreadsheet. Students manipulate the factors such as production rates, employees hired, or employees fired. These values are integrated into aggregate planning formulas to allow students to test the effects of any manipulation. They continue to manipulate the variables until they have achieved what they believe to be the maximum levels.

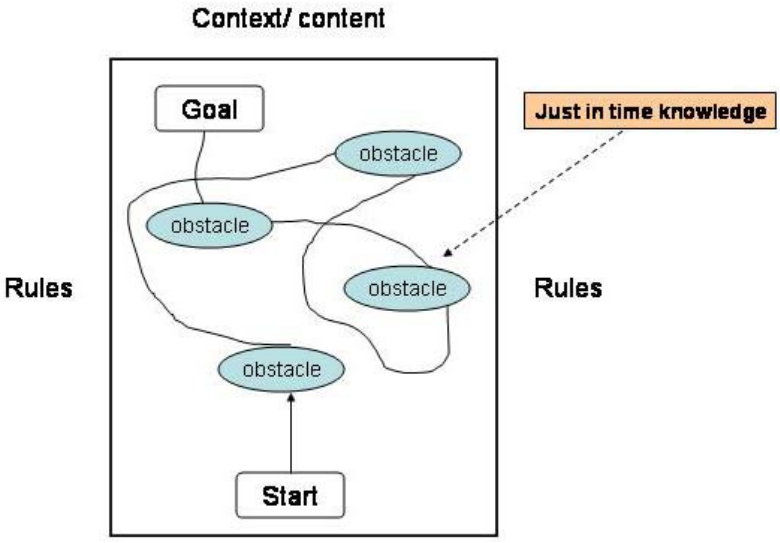

Figure 19: Location-based mobile game

In practice, games combine elements of different game genres. The location-based mobile game Environmental Detectives (Klopfer, Squire, & Jenkins, 2002) combines elements of simulation game, research assignment and role playing game. The students, who play the game, imagine they are a researcher who investigates an environmental problem. The students can import data into the mobile

application and the software calculates variables in responds to the data. This is an element of simulation games.
Within the program Games Atelier the students will be offered guidance to develop a game genre they choose. When they are more experienced users of the program, they will have more freedom to combine game elements of multiple games.

5.2.2.2 Elements of intrinsically motivating games

An intrinsically motivating game exists of certain characteristics and elements that are described in the literature. Intrinsic motivation is important because the students should be willing to engage in the learning activities in order to learn effectively. Intrinsic motivational elements relate to the personal interest of students and motivate the students to learn at their own initiative. Aspects that trigger this motivation according to the literature will be specified in the following section.

Prensky (cited in Schwabe & Goth, 2005) proposes six structural elements that characterise games, which are rules, goals, outcome and feedback, conflict and challenge, interaction and a storyline. These structural elements will be described more elaborately, in combination with the intrinsic motivating characteristics as described in the literature and should be included in and supported by the program Games Atelier in order to produce and play location-based mobile games that are intrinsic motivating. Table 13 gives an overview of these game elements.

Table 13: The elements of a location-based mobile game as designed in Games Atelier

Game elements of intrinsic motivating location-based mobile game
Rules
Gameplay
Storyline
Clear final goal and subtasks that contribute to reaching this final goal
Challenging and pleasantly frustrating problems
Non-linear structure
Levels
Direct feedback
Speed
Competition

Rules
Every game has rules that organize the game. Rules describe what the students should do when playing the game and specify limitations *and* affordances of the player when playing the game. Neumann & Morgenstern emphasize the distinction between the rules of a game, which are obligatory and the strategies the player plays with, which are not obligatory and pre-defined by the game (Juul, 2007).
Savannah is a role-playing game in which the rules of the game resemble the behaviour of lions. The rules should enhance the understanding of the students about the animals' behaviour. Facer, Joiner, Stanton, Reid, Hull and Kirk (2004) conclude that for education there is a need to ensure that the games rules reflect the rules of the environmental lessons being taught.

The Mscape project divides the rules of the games in a hierarchy of rule systems: there are the rules of the game itself, the local rules and the wider rules of the culture and society in which the game will be played. (Mscape, 2007). The rules of the games will be indicated and supported by the students who make the game. The local rules specify the size of the playground, the duration of the game etc. The wider rules of the location are stated by the government and society and should be investigated by the teacher.

Gameplay
All games include gameplay. Gameplay determines how the player interacts with the game-world and how that game-world reacts to the choices the player makes (Juul, 2007). Gameplay is closely related to rules, but they are not the same. Rules describe the interaction of the player with the game and integrate the storyline and theme, gameplay is the behaviour of the game. Following Juul, gameplay can be seen as independent of graphics or fiction, but fiction plays a large role in helping players understand the game.
Kirriemuir and McFarlane (2004) see gameplay as inherently valuable, leading to a development of skills and competences that may be transferred to other social and work-related uses of digital technologies. But it is important not to attend to gameplay as training or learning, because students won't enjoy the gameplay when they see it as training.

Competitive or collaborative gameplay motivates the students to cooperate or compete with peers within a game (Larson & Skarman, cited in Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi, 2004). Collaboration is an important ingredient for a constructivist learning environment and competition can enhance the intrinsic motivation and excitement of the students. Excitement motivates students to participate actively in the learning experience. Solving the assignments together motivates the student to analyze from different angles and solve the problems using different skills and knowledge.
By means of gameplay, the students can be motivated to talk to each other, which enhance conducting social skills (Larson & Skarman, cited in Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi, 2004). The collaboration can be motivated in different ways. Not every possible gameplay will be discussed, but the gameplay that motivates the players to cooperate or compete will be illustrated by means of certain examples.

One example of gameplay that motivates collaboration is the following. The assignments can be designed for the students to be too complicated to finish within a certain time constraint (Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi, 2004; Klopfer, Squire, & Jenkins, 2002). It should be clear for the students that they cannot solve the assignment by themselves and that it would be more efficient to combine knowledge and skills.
Within the first technology workshop held with the teachers, one teacher stated that the players should be depended of each other (TWS1). You can divide critical information over the different mobile teams in the field. The teams need the complete information to solve the assignment and therefore the mobile teams should negotiate and share the knowledge. This division of information can be designed like digital pieces of a puzzle that the students receive on the screen of the mobile phone. The mobile team should meet each other in the field and share the pieces of the puzzle in order to solve the assignment. When sharing information involves points or virtual money, the teams should negotiate the price of the information. The players should choose which information to share with whom and to what cost. This is part of strategic thinking, which is required by playing the game (Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi, 2004). The mobile teams can share information face-to-face, but sharing the interface of the mobile device or using Bluetooth.

The mobile and home team must also be motivated to cooperate by being depended of each other. The home team and mobile team need to share information in order to solve assignments and achieve goals. Home teams can observe the position of all the participating mobile teams moving around on the digital map on the interface of the computer. The mobile team can interact with the other mobile teams in the

field. This interaction can indicate that they search for other mobile teams or avoid other mobile teams. They depend on the home team to tell them where the other teams are. In several ways, the playground of the home team can contain richer information to support the mobile team strategically. This is called guide-and-follow pattern (Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi, 2004; Flintham et. al., 2003).

Location-based mobile games approach the world where we live in as a game board and the human players within this world as proactive and highly unpredictable playing pieces (Magerkurth, Cheok, Mandryk & Nilsen, 2005). To be proactive and highly unpredictable, the players in the field should move around. Gameplay can motivate the mobile teams to move. After solving an assignment, the mobile interface can project new assignments in the form of icons on the digital map. The mobile team should move to the location to receive the assignment. Furthermore, hunt rules can motivate mobile teams to move around in the field and can be very exciting for the players (Schwabe & Goth, 2005). Hunt rules indicate that mobile players hunt for each other. They are rewarded when they catch another team in the field.

During the first technology workshop the participants of the focus group discussion brainstormed about possibilities for gameplay that stimulate the students to learn independently.
One opportunity is for the students to retrieve information, but they have to buy the information with points. This way, the students will be stimulated to try and solve the assignments by themselves, before they retrieve any help (TWS1).

Storyline
According to Prensky (cited in Schwabe and Goth, 2005), the fictional story is a structural element of a game, which should exaggerate interesting aspects of reality. This storyline has a function to help the player to understand the game and to represent the problem context (Juul, 2006; Jonassen, 2002). Because the students should solve a realistic problem that relates to the authentic location, the storyline should be based on the location of the game. The storyline has a linear and narrative format and can be illustrated by a diversity of resources. The location-based mobile simulation game Environmental Detectives (Klopfer, Squire, & Jenkins, 2002) illustrated the problem context by means of a briefing from the mayor. In this briefing, the mayor introduces the pollution problem that frames the inquiry of the students. The narrative forms can help the students to imagine and empathize with other people, events from history or with potential scenarios from the future (Freitas, 2006).

Clear final goal and subtasks that contribute to reaching this final goal
A game has certain goals and objectives that the players strive to achieve (Prensky, cited in Schwabe & Goth, 2005). As emphasized by the teachers in the second technology workshop (TWS2) and the literature, the game should have one final goal that should be clearly communicated before the game begins (Rieber, 2006).
The final goal is divided in subtasks that contribute to reaching the final goal. The final goal can relate to certain learning goals, like training research skills. In that case, the final goal should be an investigation that is conducted by the students. The subtasks can contribute to the final goal and organize the research in subtasks that are trained while striving to reach the final goal. These subtasks can be collecting data in the field, interviewing an expert, analysing the data and form a conclusion.
The final goal can also relate to the competitive character of the game. For example, the final goal can be to collect as many points as possible. When finishing certain assignments, the students are rewarded with points. Finishing the assignments contribute to reaching the final goal.
The formulation of one final goal and subtasks to reach the final goal is confirm the characteristic of problem-based learning to anchor the subtasks in a wider problem that provides a context and focus for learning activities. These learning activities are subtasks which contribute to solving the main problem (Verloop & Lowyck, 2003).

Challenging and pleasantly frustrating problems

Learning activities that are designed according to anchored instruction theories should present events and problems that are intrinsically interesting, problem-oriented, and challenging (Reeves, 2000). In order for problems to be challenging, they should be adjusted to personal and realistic learning goals of the students. According to the literature, the students are most motivated to solve assignments that are neither too easy nor too difficult (Schwabe & Goth, 2005; Csikszentmihalyi, 1992). We learn best and we work best if we enjoy what we are doing. But fun and enjoying doesn't mean "easy". The best fun is hard fun, but the students should have the feeling that they can reach the goals in order enjoy it.

Non-linear structure

According to Lepper and Malone (1987) and Csikszentmihalyi (1992) personal control contributes to the engagement and intrinsic motivation of students to be actively evolved in the learning activities.

To achieve personal control in a location-based mobile game, the game should have an uncertain outcome, which is influenced by the choices the students make while playing the game (Garris, Ahlers & Driskell, 2002). Following Juul (2003), the uncertain outcome motivates the player to exert effort in order to influence the outcome and feels emotionally attached to the outcome. The game has a non-linear structure, allowing the student to decide the best strategy and choices to reach the goals. The strategy reflects the insight in the problem context and should be deliberated with team members. They explore the game, looking for new information that is meaningful for them.

When the game structure is non-linear, the student explores the location for information more freely and students will learn how to exploit contextual resources for their goals by looking for, recognizing, evaluating, and using information resources productively (Choi, 1995).

For the design of Games Atelier, the students can develop games that are both linear and non-linear structured and depends on the game genre. Role-playing games are generally non-linear structured and adventure games are generally linear structured games.

Veen & Jacobs (2005) compares the non-linear structure of video games and Internet. Video games and Internet are both based on interactivity of the students with the system, application or peers. Using the Internet to search for knowledge requires using hyperlinks and other hot-spots to find more information. This also accounts for playing video games. You need to apply a strategy and make choices to move forward in the game and find more information. Playing the game within Games Atelier involves the students of the mobile team to search for information on location, according to a non-linear game scenario. The students of the home team involve searching for information on the Internet. Both students train strategic learning skills.

The player studies conducted by the designers of Songs of the North (Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi, 2004) stressed the importance of player's control. Schwabe and Goth (2005) designed players control in the location-based mobile game MobileGame by designing different paths to reach the final goal. The final goal was to collect as many goals as possible, but the students could choose to collect the points through hunting after other players or to win points by answering certain questions. Because of the time constraint, the players chose between the two goals and preferred the hunting feature because it was more efficient to win the game. But the participants could not learn from that experience. Therefore, Schwabe and Goth (2005) advise to make the competition for points more visible on the screen, to make hunting a learning event by receiving explanation for a task when capturing a prey, or turn the hunting feature off for a while, so the participants are obligated to complete assignments.

The location-based mobile game Frequentie 1550 is also designed based on a non-linear structure. According to Raessens (2007) this non-linear structure was highly appreciated by the players.

Problem-based learning is characterized by learning that is driven by an open end and ill-defined problem (Jonassen, Hernandez-Serrano & Choi, 2000). Ill-defined problems are difficult to solve because the solutions and solution paths are not obvious, allowing the student to explore the possible solution. When the teachers that participated in the first content workshop were asked to develop a location-based learning scenario, they all developed an open research assignment. This assignment had a clear described final

goal, but the students were free to explore the solution to reach this goal and choose their own strategy. The ill-defined problems stimulate the creativity of the students.

Levels
A characteristic of games is employing progressive difficulty levels. Because the student progresses in the game, the skills and knowledge that are trained by means of the assignments and gameplay will also progress. Because the assignments should remain challenging, the assignments should progress in difficulty to stay adjusted to the level of the players (Rieber, 2006). Consequently, the game will be divided in levels organizing the difficulty of the assignments and which are delivered while playing the game.

Because the difficulty of the assignments progresses during the game, the support that is offered to the student to solve the assignment digresses. Support, like modelling, hints or examples for solution must gradually reduce and eventually be eliminated as students become more knowledgeable and skilful. This principal is called fading by Collins, Brown, & Holum (cited in Choi, 1995). Through fading, students become more self sufficient and self regulatory, and not unduly dependent on external structural support.

Direct feedback
According to one teacher in the user scenario he wrote (US teacher A), the excitement of playing the game can be enhanced when the progress of the participants during the game is made visible through the game interface. He indicates that the players should see their own scores, the scores of the other teams and the time remaining on the computer screen and screen of the smart phone. This is confirmed by the teachers who played the location-based mobile game (TWS2) and the literature. The teachers indicated that the students should receive a confirmation when they finished and send in an assignment by means of the mobile devices. Scores, remaining time and direct feedback on the achievement of the assignments allow the students to track progress toward desired goals (Garris, Ahlers & Driskell, 2002; Raessens, 2007; Prensky, cited in Schwabe & Goth, 2005). Showing positive feedback and scores to the students while they are actively learning can be motivating, because this rewards the students when they prove to have learned something (Verloop & Lowyck, 2003).

Direct feedback can also be supplied by the teacher who coaches the students while playing the game. The teacher can monitor and contact the students from a distance, being supported by the Geotracing functionalities and communication tool in the web-based application. As described in the previous section, the learning situation is characterized by fading of support that is offered by the program when the student progresses in the game. The support that is supplied by the teacher will never completely fade (Naismith, Lonsdale, Vavoula & Sharples, 2006).

Speed
In a competitive environment, speed is a prerequisite to excitement. Students that play video games in their free time expect the same speed and quick reactions of the learning environment, otherwise they will get bored (Kirriemuir & McFarlane, 2004). According to Schwabe & Goth (2005), questions and assignments that need to be solved during the location-based mobile game should not take too long to complete, in order to maintain a high speed in the game. As any missed task is a missed learning opportunity, the participants should be able to tackle most tasks. Furthermore, the assignments should be divers in order to excite the students properly, as stated by the teachers (TWS2).

Competition
Competition is very attractive for the students and leads to the players' excitement (Prensky, cited in Schwabe & Goth, 2005). According to the user studies as conducted during this research project playing against other teams is appointed as one of the most fun elements of the location-based game (TWS3;

CWS3). Most students enjoy playing games as a social activity, with or against other players. Especially boys like playing together with friends much better than alone (CWS3).

5.2.3 Summary

Section 5.2 describes characteristics of location-based mobile games that establishes effective learning effects and informs how to produce these location-based mobile games. This section provides an answer to the research questions: *What are the characteristics of effective educational location-based mobile games?* And: *How are the users be supported in creating, playing and viewing the educational location-based mobile game?*

The location-based mobile game can be seen as a lesson outside the classroom environment in the authentic context that includes elements of games. These game elements have the main purpose to motivate the students, but games can also be used to train skills and reach certain learning goals. These learning goals have been discussed in section 5.2.

Following literature important elements for intrinsic motivating location-based games are: rules, gameplay, non-linear storyline, clear final goal and subtasks that contribute to reaching this final goal, challenging and pleasantly frustrating problems, levels, direct feedback, speed and competition. From the user-analysis it was already concluded that a clear final goal should be communicated by the program and the program should give direct feedback to the students who play the game. The non-linear structure and levels are characteristics of problem-based didactics and anchored instruction (see also chapter 3).

Because the location-based mobile is a lesson in the outside the classroom environment, the students who make the game become the teachers who prepare the lesson. They select the game genre and related gameplay, and design the game scenario. Besides the strategic and motivating gaming elements, they should understand the educational contents thoroughly in order to teach their peer students about the most important concepts. The makers analyze the location in order to design a larger goal that is embedded in the location. For the mobile team they produce challenging assignments that can only be solved by analyzing the direct location, together with media that presents the information that cannot be extracted from the real-world location. This can be cognitive tools, simulations, pictures or videos. The makers should understand which information their peer students need to solve the problem on location.
Furthermore, the students design the assignments for the home team and decide what kind of information these students need to solve the problem. What information can be found on the Internet by the students themselves? What information should the digital map provide in order for the home team to visualize the real-world context the mobile students are at? When the learning goals of the game subscribe collaborative skills, the students can design gameplay and assignments that support collaboration between home team and mobile students. All these choices should be made when the students make the location-based mobile game that aims to satisfy the learning goals as stated by the teacher. The program Games Atelier supports the students in making these choices and developing the game that can be played on location.

The next section describes the results of the conceptual design phase. During this phase of the research project it is investigated how the requirements can be translated in functionalities and graphical user interfaces for the program Games Atelier in order to support effective learning.

5.3 CONCEPTUAL DESIGN OF GAMES ATELIER

This section describes the conceptual design phase, which resulted in the conceptual model, user interfaces and prototypes of the program Games Atelier. The research executed during the conceptual design phase investigates the research question: *How are the user needs, user experience goals, usability goals and user, usability, context and functional requirements be translated to the functionalities and GUI of Games Atelier?*

During the conceptual design phase, the established requirements for the program Games Atelier are translated into the conceptual model. The model captures what the product will do and how it will behave (Preece, Rogers & Sharp, 2002). The most suitable conceptual model is a hybrid model based on activities. Different interaction styles are combined, which support the students based on their activities. The interaction styles of the program Games Atelier will be described in the following section.
The conceptual model is translated into a low-fidelity prototype of the web-based application of Games Atelier, a prototype that capture three different themes and spheres that are representative for different game genres and inform the 'look and feel' of the game environment of Games Atelier. Furthermore, the design of the interface, and the structure of the program are decided on when designing the conceptual model.

The prototype of the web-based application represents the functionalities and graphic user interfaces. The program Games Atelier provides two different versions, one for the teachers and one for the students. The versions contain features that are similar, but also features that support the tasks that are specific for that user. Furthermore, the language used is different for the teachers and the students, but also for the students of different educational levels. The user interface should be dynamically modified to the personal profile of the students and teachers (Langdon, Whiteside, & McKenna, 1999). The features and information as presented by the user interface is dynamically modified to the personal profile of the user.

5.3.1 Conceptual model of Games Atelier

During the conceptual design phase, the requirements are translated into the conceptual model, which captures what the product will do and how it will behave (Preece, Rogers & Sharp, 2002).
The interaction paradigm is a source of inspiration that informs the design of a conceptual model. The interaction paradigm is meant to direct a particular way of thinking about interaction design. Most important interaction paradigms are the personal computer and pervasive devices (Preece, Rogers & Sharp, 2002).
The program Games Atelier exists of two software applications, a web-based application and a mobile application. The web-based application will be designed for the desktop of the personal computer and the mobile application will be designed for pervasive devices.
When designing for the desktop of a personal computer the software uses a WIMP interface. A WIMP interface exists of Windows, Icons, Mouse and Pull down menus and is intended to be used by single users sitting in front of a CPU, monitor, keyboard and mouse.
Pervasive computing is using a seamless integration of technologies, which allows people to access and interact with information any place, any time. The technologies are often referred to as smart devices or information appliances, designed to perform a particular activity. Commercial products include mobile phones and Palm Pilots (Preece, Rogers & Sharp, 2002). Designing for pervasive devices and in particularly mobile phones, requires specific design and interaction styles. The interface should be designed for a small screen and the users use the device when being on the move, in stead of sitting in front of a monitor. The users use buttons to interact with the device and have a similar function as the keyboard of a computer.

The conceptual models can be divided in two sorts, which are the conceptual model based on activities and the conceptual model based on objects (Preece, Rogers & Sharp, 2002). The conceptual model most suitable for Games Atelier will be a hybrid model that is based on activities. This hybrid model combines different interaction styles, which support the students based on their activities.

5.3.1.1 Interaction styles

The most appropriate interaction style for the products depends on the activities the user will engage in while using it. The interaction style refers to how the user invokes action when interacting with the device.

While creating the game, the students will use the web-based application for the largest part of the activity. While tracing the route and collecting the media in the field, the students will use the mobile application. While playing the game, the students of the home team use the web-application and the students of the mobile team use the mobile application. And when the students and teacher view the results of playing the game, the web-application is used. The teacher uses the web-application to prepare the project and monitor the students while playing the game.

The interaction styles for the web-based application of Games Atelier will be instructing, conversing, exploring and browsing, and manipulating and navigating. Table 14 gives an overview of the elements of the program Games Atelier, which are designed according to different interaction styles.

Table 14: The elements of Games Atelier are designed following different interaction styles

Interaction styles	**Elements of the program Games Atelier**
Instructing	Archives, project template and game template
Conversing	Search engines in archives, help function, project template and game template
Exploring and browsing	Informational web pages
Manipulating and navigating	Digital map

Instructing
This interaction style describes how users carry out their tasks through instructing the system what to do. Computers are designed based on this model. In Windows and other GUI systems, control keys or selecting menu-options via the mouse are used. A wide range of functions are provided from which users choose when they want to do something to the object they are working on. These systems are command-based and commands are carried out in a sequence, with the system responding appropriately as instructed. Instruction-based conceptual models support quick and efficient interaction.
Using menus that provide choices to the user supports the system to be easy to remember how to use. Interfaces that are designed using menus, icons, and consistently placed objects promote recognition rather than recall by (Preece, Rogers & Sharp, 2002). In stead of requiring users to recall from memory a command name from a possible set of hundreds, GUI provide visually based options that users can browse through until they recognize the operation they want to perform.

The archives in the program, which are the depositories with games, projects and media, are designed according to the instructing-based interaction style. The objects that are stored in the archives are presented by means of icons. Icons and images are easy for people to recognize, even though they just briefly saw the images before (Preece, Rogers & Sharp, 2002). To increase the flexibility, the users are provided with textual information about the game, when they move with the mouse point over the icons. The icons are structured carefully, supported by a table, in order for the users to have a good overview.

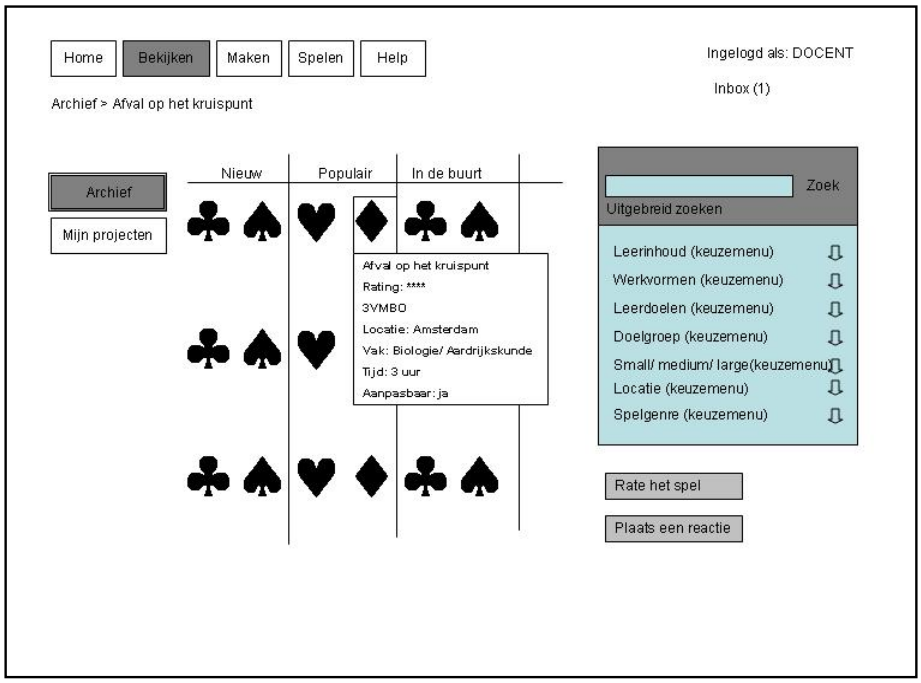

Figure 20: The archive is designed according to the instructing-based interaction style

Organizing the project environment and creating the game is supported by means of templates. These templates are designed according to the instruction-based interaction style and structure these processes by means of a step by step sequence. The teacher and students fill in the information fields and by choosing the menu button the user instruct the program to use this information properly. By using the templates, the teachers and users don't have to remember themselves what steps and information is needed to organize the project, but they recognize the options from the template.

The project template is partly designed according to the instructing-based interaction style. The project template supports the users to initiate and organize the project where students design and develop their own game. The teacher indicates some variables within this project template and these variables influence the information presented in the project environments and game template that support creating the game. The teacher needs to initiate the precise variables in order for the system to adapt according to the choices. These variables can be chosen by means of a menu. This supports the teacher in recognizing the right variables. For example, the teacher chooses the target group of the game that is to be produced. Because the program knows which game genres are suitable for this target group, the game template is adapted to the level of education.

Conversing

The conversing interaction style is based on the idea of a person conversing with a system, where the system acts as a dialog partner. The program's interaction is designed to respond in a way a human being would respond. This kind of conceptual model has been found to be more useful for applications in which the user needs to find out specific kinds of information or want to discuss and issue (Preece, Rogers & Sharp, 2002). The user types in a query to which the system responds with different answers. A disadvantage is the misunderstandings that can arise when the search engine is unable to answer the question in the way the user expects.

The input-mechanisms that allow students to ask questions, get support, and seek advice, for instance search engines and help functions promote meaningful learning. These features enable students to reflect on their own knowledge and to become ready to acquire new knowledge for achieving goals (Jonassen, Hernandez-Serrano & Choi, 2000).

The archives in the program that games, projects and media are partly designed according to the instruction interaction style, and partly designed according to the conversing interaction style. The search engines integrated within the archives allow the teachers and students type queries and define criteria that determine the games as presented on the user interface. This involves using memorized information about the required file to get as close to it as possible.
The archive is therefore a depository that pre selects the games that are confirm the needs of the user, in order to enhance the efficiency of the program.

When students make the game or play the game as being part of the home team, the students use search engines to search for information on the Internet. Searching for information requires the students to articulate the information they need and apply a search strategy in order to get the precise information. The information provided by the search engine should be analysed in order to select the right information. These cognitive learning processes promote meaningful learning, as explained earlier.

There will be a help function integrated within the program to offer support when needed. The help function will be available anytime and anywhere, during the whole program and will be designed according to the conversing interaction style. By means of a window, the user can type a query and the program will respond by means of an answer. So, the teacher can ask the program a certain question or problem and the program will generate suitable information that is stored in the program.

The project template and game template combine the instruction-based and conversing-based interaction style. The elements designed according to the conversing-based instructional styles are the text boxes where the students and teachers can fill in information, for example a project assignment or the rules and storyline of the game. The system publishes this information in the project environment or the game environment and automatically structures this information. This support enhances the efficiency of the program.

Exploring and browsing
When a system is designed following the exploring and browsing interaction styles, it provides information structured in such a way to allow users to find out or learn things, without having to formulate specific questions to the system. Knowledge on how to browse or scan through existing media (newspaper, TV, magazine) is exploited. Much thought needs to go into structuring the information in ways that will support effectively navigation (Preece, Rogers & Sharp, 2002).

The information presented in the program is designed according to the exploring and browsing interaction style. The information is available in both the teachers and students version of the program on the home page, in the project environments and the instruction pages of the games. The program and information on the web pages are carefully structured, in such a way that all users will find the suitable information efficiently and effectively. The program and information is non-linear structured, which supports the users to explore the program and information through different ways by means of hyperlinks. The users must have a high level of control. They must be able to search through the amount of data and find the information needed very quickly. The structure must be visually clear to the user, so they understand easily how they can reach the information they want as soon as possible.
The users browse through hyper linking through the data, from one relevant topic to the other relevant topic. Browsing through the information supports the users in coming up with ideas and get inspired. Therefore, the users can also easily browse through the depository with example games, in order to get

good ideas for playing these games or creating games of there own. Browsing through the visual database can give the designer inspiration and ideas for a design. Also, the designer can find a solution for a certain problem by browsing through the information database.

When the program allows the users to browse and explore through meaningful information, it supports learning by doing in a meaningful way. People prefer learning by doing to learning by instruction manuals which explain them to do step by step. But it is important that the students can undo the steps and choices easily and find their route back (Preece, Rogers & Sharp, 2002). Within the program, the menu is designed to give a good survey of the structure of the program. The menu exists of interactive buttons, to activate by means of the mouse. It is easy to browse through the pages by means of the menu. The line at the left top of the screen indicates the path one took and by clicking the hyperlinks one to go back to earlier pages.

Manipulating and navigating
The manipulating and navigating interaction style allows the student and teachers to use their knowledge on how physical objects behave when interacting with virtual objects. For example, virtual objects can be manipulated by moving, selecting, opening, closing and zooming in and out (Preece, Rogers & Sharp, 2002).

Interacting with the digital map is designed according to the manipulating and navigating interaction style. The game template supports the students who make the game to design the digital playground. In order to do so, the students can navigate through digital maps that are available in the game template. The students can zoom in and out, move the map by means of dragging and select the playground to download the selection to their computer. Within the program, students may divide the digital map in interactive zones and add gameplay to these zones.

Within the game environment, the students of the mobile and home team use the digital map to explore the location. The students of the mobile team will navigate on the map by moving around in the field. The students of the home team will be provided with tools to zoom in and out and move by means of dragging.

5.3.1.2 Dynamic user interface of the web-based application

The user interface plays the role of a bridge between the different components of the system and the users.

During the second content workshop, the teachers agree that there should be a division between inexperienced and experienced students, and between different levels (CWS2). The target group is very broad. Most students will be expert users of personal computers and mobile devices. The teachers will divers in experience of use. Some teachers will be expert users, other teachers will be novice users. The user interface should be highly flexible to be easy to use for this broad target group of users.
The user interface of the web-based application of Games Atelier should be easy to use, easy to learn and easy to remember for both frequent and infrequent users. Frequent users will take more advanced steps within the system, and infrequent users must be able to reach their goal within a minimal of steps (Millheim, 1997).
The user interface should be dynamically modified to the personal profile of the students or permitting the students or teachers to select among alternatives (Langdon, Whiteside, & McKenna, 1999). The features and information as presented by the user interface is dynamically modified to the personal profile of the user. This personal profile is filled in when the users login to the program for the first time. The user can fill in personal characteristics, like age, level of location, location of the school and personal interest. Restricting the possible functions that can be carried out by a novice to the basics and then extending these as the novice becomes more experienced is called the `training wheels` approach Carroll (cited in Preece et al., 2002).

The underlying rationale is to make initial learning more tractable, helping the learner to focus on simple operations before moving on to ones that are more complex. The information or support functions are concealed, when not needed anymore by the user. For example, this approach is applied when the project template is used to initiate and organize the project environment for the students. The template asks the teacher to fill in the profile of the gameplayers. The possible game genres are adjusted to this profile.

5.3.1.3 Design principles for the user interface of the mobile application

The program Games Atelier constructs the game interfaces of the mobile and web-based game environment, according to the choices made by the students, information is filled in and media uploaded to the game template.
Effective design of the mobile interface differentiates from the design of a web-based interface. The small screen of the mobile device makes it necessary to break long texts down into small pages. Literature about mobile learning and location-based mobile gaming is studied to learn certain design principles of the mobile user interface. Because mobile interfaces require short sentences, the game template will support and advice the students in writing short texts, restricting them to use no more than certain amount of words.

Figure 21: Mobile interface of Frequentie 1550

The mobile application has a simple design and contains five interfaces, which are the digital map, the information sources, the assignments, and the communication tools and escape procedure. The digital map serves as the main page and represents the city as a game board. The mobile players see themselves as icons, moving across the map. This page contains a hyperlinked button (or hyperlinked buttons), which direct to all the other interfaces. The user interface is dynamically adapted to the context of the user. When the students of the mobile team receive an assignment, connected to that location, the colour of the buttons changes so the student will recognize, something is received.

According to the literature, text-based messages presented on the mobile screen must be short. Proctor and Burton (2003) noted that visitors of the Tate modern in London who used a multi-media tour did not respond well to long messages, particularly those that were primarily text-based. The messages, incorporating audio-visual coherence and interactive messages were most appreciated.

Kukulshka-Hulme (2005) describes some design principles for mobile course material. Designing mobile educational material, the instructor should focus on essentials, filling the tiny mobile screen with the main content. Designers for mobile screens must ruthlessly cull their websites, eliminating even the nonessential parts of articles themselves (Houser & Thornton, 2005). The mobile web pages require a vertical design, being either a short section of text, or a menu consisting just a few links (Houser &Thornton, 2005).

Lankoski, Heliö, Nummela, Lahti, Mäyrä & Ermi (2004) recomment relating each game element to the theme and background story of the location-based game. The theme is an important tool to justify and unify the design. Within the design of Games Atelier, the students choose out of three themes. These are a

fantasy, nature or realistic theme. According to the user study, the fantasy and realistic theme have proven to be popular among the students. (CWS3). The nature theme might be appropriate when the students go on a biologic field trip in a natural environment. The theme unifies the user interfaces of the web-based and mobile application.

When designing interaction and choosing media for the application, the designer should keep in mind that the main focus of the user should be on the location. Using audio in stead of visual media or text messages supports the students to keep their eyes on the real world. When finding their way, the home team can steer the mobile team, supported by the phone, in stead of the mobile interface that indicates the route and forces the students to keep their eyes on the mobile screen. During the user analysis one teacher indicates that he prefers to use touch screen when playing the game. Schwabe and Goth (2005) also recommends using touch screens and offer multiple choice questions to be answered in the field, because these can be answered quickly, when comparing this with answer open questions by sending text messages.

5.3.2 ´Look and feel´ of Games Atelier

The following section informs about the 'look and feel' of the program Games Atelier, which comprises aspects of its design, including elements such as colours, shapes and layout. In order to determine the right 'look and feel' for the program, the second prototype was developed.

5.3.2.1 Prototype 2: moodboards

Three moodboards were constructed which capture three different themes and spheres that are representative for different game genres. The themes of the moodboards are fantasy, realistic and authentic and were determined in consult with the creative director of Waag Society. The moodboards are collages of visual elements. They were constructed to support and structure a discussion with students of the secondary school about their preference for the 'look and feel' of Games Ateliers' user interface, their association with creating and playing games, and what theme most motivates and attracts them.
Unfortunately, the moodboards could not be used to support this discussion due to technical problems. Even though, the moodboards can be used to inspire the design of the user interface.
The moodboards contain illustrations of graphical user interfaces, pictures of virtual game characters and real people playing location-based games, and digital pervasive tools that support playing video games.
The moodboards can be found in the appendices (See also Appendix E: Prototype 2 moodboards *fantasy, realistic and authentic*)

Moodboard 1: fantasy
The fantasy moodboard illustrates the design of role playing games and adventure games. Design elements used within these interfaces is historical features, knights, elves, warm colours, old parchment, magical skills, swards and more.
The most important game elements that are visualized within this moodboard are large fights, collaboration, avatars with special characteristics and tools and a fantastic storyline.
This 'look and feel' would be suitable for location-based mobile games with historical or natural themes.

Moodboard 2: realistic
The realistic moodboard illustrates the design of simulation games and sport games. The design of these game genres can be described as professional, high tech, with cool metallic colours. The interfaces show tools that measure values, like speed, heat, or other relevant variables, but also 3D worlds with avatars, like Sims or the videogame habitat hotel.
The most important elements of these games are collaboration, competition, training skills and knowledge and a realistic storyline. The tools used are modern computers, mobile applications, measuring tools.

This 'look and feel' would be suitable for location-based mobile games with themes or problems related to mathematics, physics or science.

Moodboard 3: authentic
The authentic moodboard illustrates board games and using authentic tools, like pencils, scissors and paper to design and create. It represents the opposite of interactive systems and computers. The design can be characterized by bright and primary colours. The game elements that fit board games are turn based play, levels, competition, points and solving puzzles.
This 'look and feel' would be suitable for location-based mobile games with themes or problems related to all kinds of subjects, because it is quite general.

5.3.2.2 'Look and feel' of the user interface

The learning environment Games Atelier will be supportive, functional and generic, because it supports the students in creating location-based mobile games about all possible themes that relate to a certain subject matter.

The 'look and feel' of the web pages should depend on the function. The login page should be illustrated with many pictures of the location-based experience in order to attract the users to read the text and sign up. This accounts also for the introduction page of the individual games, which should attract the users to play the game.
The templates that support the students and teachers creating the project and game environment can have a functional and neutral 'look and feel'. The authentic moodboard can be used to inspire this design of the functional web pages.
According to the user analysis, the website Youtube is very popular among the students. In order to understand the opinion of the students about the look and feel of a website, the questionnaire (CWS3) asked for their opinion about the website Youtube, which is a popular website among the target group. The design is very simple and it supports the function of the site, which is watching an archive for videos. According to the questionnaire, most students appreciate the design and look and feel of the website. Ten out of twelve students rated the website to be nice. Only one student finds the website boring. Also, all students rate the website to be easy. The 'look and feel' of the website Youtube can be used to inspire the look and feel of Games Atelier.

5.3.3 Tasks description of Games Atelier

Based on the user analysis and literature review a task description has been developed to list the tasks of the user and the support of the program. Task descriptions are used throughout development, from early requirement activities, through prototyping, evaluation and testing. Scenarios use cases and essential use cases are three different kinds of task description. They may be used to describe either existing or envisioned tasks with a new device. They are often used in combination to capture different perspectives or to document different stages during the development lifecycle (Preece, Rogers & Sharp, 2002). User case description presupposes that technology is involved and this kind of detail is more useful at conceptual design stage than during requirements and data gathering. Therefore a use case is developed, that describes the tasks of the teachers and the students, divided in the view, play and make part of the learning environment.

The use case of Games Atelier can be found in the appendices (see also Appendix H: Task description Games Atelier)

The prototype represents the general web-based digital environment, by which the user can add digital content to the physical location of a city or area. This environment is called Games Atelier and serves as a

toolkit for teachers and students to make mobile games which can be integrated in the curriculum. Within this environment, users can create, play or view a mobile game, with web-based and/ or mobile applications. A home team, using the web-based environment and a mobile team, using mobile applications, than collaboratively learn and play. The mobile team is walking at a certain location and is traced within the web-based environment. The platform will send assignments to the mobile application and to the web-based environment automatically, after which the mobile and home team have to solve this assignment collaboratively. Also, they have to record or search for information, pictures or movies. Afterwards, the results can be viewed on the Internet.

5.3.4 Structure of the program

The structure of the program, the web pages and the connections between the web pages are illustrated by means of two web structure models. One web structure model illustrates the teacher's version of the program, the other model the student version. The web structure models can be found in the appendices. (See also Appendix F: Web structure model Student version and Appendix G: Web structure model Teacher version).

5.3. 5 Prototype 3: the web-based application Games Atelier

The third prototype developed for this research project represents the functionalities and graphic user interfaces of the web-based application of Games Atelier. It is developed to be evaluated by the teachers at the final formative evaluation phase of this research project.
In order to translate the conceptual model into a physical product, the designer should develop prototypes, based on the user experience and usability goals, in order to test and evaluate the designs and develop the final product in iterative steps. A prototype allows stakeholders to interact with an envisioned product, to gain some experience of using it in a realistic setting, and to explore imagined uses (Preece, Rogers & Sharp, 2002). It is a limited representation of a design that allows users to interact with it and to explore its suitability.
The prototype simulates the web pages of the interactive program, but is not interactive, because it contains no hyperlinks or real content. This can be described as a low fidelity prototype that does not look very much like the final product. These prototypes intend to be simple, cheap, and quick to produce. They are quick to modify, for exploration only and this is important in early stages of development, for example during conceptual design. The third prototype can be found in the appendices (see also Appendix I: Prototype 3).

The web-based application provides the students and teachers with a Internet-based course management system that supports some aspects of course preparation, delivery and interaction and allows these aspects to be accessible via a network.
The course management system offers tools for computer-mediated communication; tools for navigation within the course content and around the various features and tools available for learning support. All these tools, at least for student use are made available via a uniform WWW-based user interface (Collis & Moonen, 2001).

According to the user analysis, the program should provide structure and support with every step the student needs to do. It should support a variety of students with differentiated educational levels, experience with the program and interest. Furthermore, the system should support teachers with differentiated experience with the program and ICT skills.
The program should be flexible in the amount of support it provides, adjusted to the skills of the user. To provide this support, the program is suitable for both novice and frequent users, and increased productivity arising from just-in-time support. The teachers and students learn from performing, constructing knowledge without the benefit or necessity of formal instruction.

The program provides two different versions, one for the teachers and one for the students. The versions contain features that are similar, but also features that support the tasks that are specific for that user. Furthermore, the language used is different for the teachers and the students, but also for the students of different educational levels.
According to the user analysis, the program should provide structure and support with every step the student needs to do. It should support a variety of students with differentiated educational levels, experience with the program and interest. Furthermore, the system should support teachers with differentiated experience with the program and ICT skills.
The program should be flexible in the amount of support it provides, adjusted to the skills of the user. To provide this support, the program is suitable for both novice and frequent users, and increased productivity arising from just-in-time support. The teachers and students learn from performing, constructing knowledge without the benefit or necessity of formal instruction.

Within the web-based application, the location-based mobile game will be designed and developed by the teachers and the students. This location-based mobile game has the characteristics of a constructivist learning environment (CLE). The construction of this CLE has been described in section 5.2

5.3.4.2 Web pages and features of Games Atelier

In the following section the third prototype will be described in detail. It explains the individual pages of the teacher and student version and the game template of the program Games Atelier. The design of the pages is related to the requirements which are established based on the user and context analysis. The requirements are indicated by means of abbreviations and can be found in the Tables 15 to 32. First explained is the teachers' version of Games Atelier, secondly the students' version and last the game template.

Log in page
When students and teachers choose to visit the site Games Atelier, they will first enter this page. This page shows an introduction text about Games Atelier. The purpose of this text is to make the teachers and students curious about the program Games Atelier by means of enthusiastic text and pictures. Also, a demo of a location-based mobile game can be shown in order for the visitors to get a rich first impression.

New account
When teachers and students want to start using the program, they have to open a personal account. For opening the account, the users have to fill in a profile. Te program needs the profile in order to personalise the program as much as possible to the users needs. These needs mostly depend on being a teacher or a student, and what level of education the user follows or teaches. Also personal address information is asked for, in order to send information about the program to the e-mail address. Filling in the profile is supported by means of a worksheet, with text-based en menu-based fields where answers can be filled in. The profile is intelligent, because every new school year Games Atelier asks the students and teachers whether it is appropriate to adjust the profile to the new educational level of the user. By adjusting the program dynamically to the personal level, interest and experience, the program becomes effective in supporting different users (UR effective to use 1).

Table 15: Overview of the in log page: the activities, related features and requirements

Activity	**Feature**	**Requirement**
Make personal account	Worksheet personal profile	UR effective to use 1

Login
Because the teachers and students who have experience with the program want to login immediately, the page shows the login button. Choosing this button, the users enter the program's home page.
The student and teachers are led to different versions of Games Atelier. These different versions show similar, but different web pages, and similar and different features supporting the activities of teachers and students.

Help function
There is a help function integrated within the program to offer support when needed. The help function will be available anytime and anywhere. By means of a window, the user can type a query and the program will respond by means of an answer. The users can ask the program a certain question or problem and the program will generate suitable information that is stored in the program.

Teacher version of Games Atelier
The teacher version of the program, as captured in the third prototype, will be described in the following section.

Homepage
The homepage shows detailed information about the educational method Games Atelier. First the educational method and value of location-based mobile games and producing these games are explained. Furthermore, the web page tells about educational goals which can be achieved by means of these learning activities. Also, this section gives information on how to implement the method into the curriculum of different subjects. It is important for the teachers to know that the method is validated and of additional value (TWS1). This can be affirmed within this information.

Table 16: Overview of the homepage of Games Atelier: the activities, related features and requirements

Activity	**Feature**	**Requirement**
Read about the educational method	Information about: * Mobile location-based games * Producing games * Educational goals to be achieved * Integration within curriculum	URfT 3

View
The program Games Atelier is divided in three different sections, which are view, create and play. First, the view section will be described.

Archive
The archive is a depository of all finished games made within the program Games Atelier. The games are uploaded by the users from the game template. The software Web 2.0 social networks support users to share games they produced among each others.
The archive is a searchable database where the information is acquired by means of a search engine. Using the search engine enhances the efficiency of the program, because the program pre selects games, based on the criteria of need.
The games are presented by means of icons. The icons are divided in a table with three columns presenting new games, popular games and games in the neighbourhood of the school of the teacher. The icons are hyperlinks. When the teacher touches the icon with the mouse pointer, the name of the game and most important facts appear. This makes it easier for the teacher to choose between several games.
The search engine exists of two versions, the basic search engine, by means the teacher can search on title of the game, and the extensive search engine. The extensive search engine makes the teacher able to

choose between different variables, like game genre or subject matter. The teacher chooses the variable by means of menu's and can choose more variables at the time. This way, the teacher can specify the game criteria in a detailed manner. The program shows the games that qualify according to the search variables.
This page allows the teacher to rate the game and add a comment to the game they played with their class. The rating is published in the archive and the introduction page of the game (all ratings are calculated and divided, so the average rating is published). The comment is only published on the introduction page of the game. Users are able to respond to each others comments. Rating the games enable the users to give each other feedback, which is confirm the functional requirement (FR9).

Table 17: Overview of the archive for teachers: the activities, related features and requirements

Activity	**Feature**	**Requirement**
Choose game	Game repository with categories and icons.	FR 11
Search for game	(Extensive) search engine	UR Efficient
Rate and add comment	Buttons to publish rate and comment. This is published on the introduction page of the game.	FR 9

My projects
All projects executed within Games Atelier are supported by means of individual project environments. 'My projects' is a repository of all the projects the teacher worked on or is working on. The web page shows a table with three columns, which are project of the class, period and status. This table gives an overview of the projects within a school year. Menu-based search engines are integrated within the table. By means of the menu, the teacher enters the project environment of the chosen group.

Table 18: Overview of 'my projects' for teachers: the activities, related features and requirements

Activity	**Feature**	**Requirement**
Overview of projects	Table which organizes projects and additional information.	UR Efficient
Enter project environment	Menu-based search engine.	UR Efficient

Game introduction page
When a game is published in the game repository (Archive), an individual introduction page is generated by the program. When selecting an icon in the game repository (Archive), the teacher enters the introduction page of that particular game. The introduction page exists of three kinds of information, which are an introduction text, most important facts and a visual impression of the game interface.
The introduction text describes the storyline of the game and the game scenario. The most important facts support the teachers to judge whether this game is appropriate to choose. Based on the visual impression of the game interface, the teacher judges whether the game is believed to be attractive for their class. The introduction page shows also the comments of the teachers and students who already played the game and the rating of the game. This helps the teacher to judge the quality and attractiveness of the game.
The teacher can choose to activate two buttons 'play the game' and 'adjust the game'. The 'play' button directs the teacher to the game environment of that game. The 'adjust' button directs the teacher to the game template of that game. When adjusting the game template, the teacher can reuse certain elements of that game, but renew other elements in order to adjust the game to the specific target group. When adjusting the game, the teacher is not able to publish the game again.

Table 19: Overview of the game introduction page: the activities, related features and requirements

Activity	Feature	Requirement
Form opinion about game	Introduction text, facts, visual impression, rating and comments.	URfS 3 UR Efficient
Play the game	'Play the game' button	UR Efficient
Adjust the game	'Adjust the game' button	UR Efficient

Create

The following section describes the aspects of the program Games Atelier that support creating the location-based mobile games.

Organization

This web page gives information about preparing and organizing a project with Games Atelier. In particular, the page explicates the materials needed, like the smart phones and the mobile software. The user analysis indicated that teachers need to have clear insight in the processes of the project, in order to explain the project to the students and coach the students sufficiently. This webpage should provide the teachers this insight.

Table 20: Overview of the webpage 'organization': the activities, related features and requirements

Activity	Feature	Requirement
Read information about organizing and preparing the project	Information about organization and materials needed.	FR 7

Prepare project of creating the game

The web page 'make the game' shows information about creating a new or adjusting a finished game. This page also shows the buttons 'make a new game' and 'adjust a game'. The button 'creating a new game' leads directly to the project template. The button 'adjust a game' leads to the archive with finished games, but the table shows only adjustable games, which means that the makers of these games gave allowance to adjust the game. A game can only be adjusted by teachers. When a teacher chooses to do so, he can adjust elements within the game template, like the educational level (adjusting it to a different target group), game genre or gameplay. He cannot change the location of the game, because all the media is designed to be viewed on one specific location. Adjusting the game template decreases the amount of preparations for a teacher who want to individualise a game for his own class, but doesn't want to make a new game. This satisfies the usability goal efficient to use (US Efficient).

Besides information about creating the game, the web segment also shows a task structure of all activities involved in creating the game. This is required by the teacher in order to explain to the students what they are about to do in the group project creating the game.

Table 21: Overview of the webpage 'make the game': the activities, related features and requirements

Activity	Feature	Requirement
Read about creating a new game	Information about creating a new game or adjusting a finished game	FR 2
Make a new game	'Make a new game' button, directing to the project template	US Efficient
Adjust a game	'Adjust the game' button, directing to the repository with adjustable games	US Efficient
Overview with tasks of creating the game	Task structure of activities involving creating a game.	FR 2

Project template

The project template is a work sheet that supports the teacher preparing the project environments for the students in a step-by-step process. The project template exists of five web pages.

The purpose of the project template is support the teacher when he coaches the student. According to Brandt, Farmer & Buckmaster (cited in Choi, 1995) coaching includes "structuring ways to do things, providing additional tasks, problems, or problematic situations". The pages of the project template contain fields where the teacher can fill in appropriate information, or can choose one of his preferences out of a menu.

The work sheets are connected to the project environments of the teachers and the students. The information filled in by the teacher will automatically be published in the project environments. The preferences as chosen by the teacher influence the construction of the project environment. When the teacher chooses to not fill in the fields or choose a preference, the preferences remain open for the students to choose. This way the teacher can differentiate between different educational levels.

By means of hyperlink buttons, the teacher is directed to the next page and the preferences are saved. The teacher is able to return to earlier pages by means of hyperlink buttons.

The first web page the teacher fills in the educational contents, the learning goals and the criteria to assess the students' performance of the learning activities. By means of menus the teacher chooses the target group, the size and complexity of the project (small/ medium/ large), the duration of the project and the game genre.

The second web page the teacher chooses by means of a menu the personal profile of the class, being the class, level of education and experience on Games Atelier. Furthermore, the teacher can upload several educational resources. The program published hyperlinks to the resources in the project environment of the students. Adjusting the project environment to the profile and educational level of the students is confirming the coaching activities as stated by Brandt, Farmer & Buckmaster (cited in Choi, 1995):

"The coach explains activities in terms of learners' understanding and background knowledge, and provides additional directions about how, when, and why to proceed".

The third web page, the teacher is allowed to fill in a description of the assignment and fill in a roster. Also, by means of a hyperlink button, the teacher is directed to a dynamic agenda, which allows the teacher to choose a date for the game to be played and this date is published in the project environment.

The fourth web page allows the teacher to describe the reflection question for creating the game and reflection questions for playing the game. The questions can be used by the students to reflect on the learning activities after creating and playing the game. Also, the teacher can describe a final product for the students to prepare after playing the game.

The final page allows the teacher to organize the groups who work on the project together. The user analysis indicated that it is important to divide the task between students in a heterogeneous group. By means of the e-mail application the teacher can organize the groups.

The teacher fills in the e-mail addresses that belong to one group together and these students receive a web link to project environment of that group. Because these students all belong to the same project environment, the students can cooperate together within the shared environment. The teacher is able to fill in a text that is published within the invitation e-mail. By means of the hyperlink button 'invite students', the e-mail is sent to the students and the project environments are organized by the program.

Table 22: Overview of the project template: the activities, related features and requirements

Activity	Feature	Requirement
Prepare and organize project environments: * Educational criteria * Profile students * Assignment * Roster * Questions for reflection	Worksheet 'project template'.	FR 7
Navigate through the project template	Hyperlink buttons	UR Efficient
Divide students in project groups	E-mail application	FR 5
Send invitation e-mail with web link to project environment	E-mail application	UR Efficient

Project environments

The search engines in the table 'my projects' allows the teacher to enter the different project environments of different project groups. This search engine supports the efficiency of the program, because the teacher can select the project and is instantly directed to the right webpage.

Within the project environment the text about the assignment, educational criteria, roster and reflection is published which the teacher filled in by means of the project template. The text is divided over four pages and by choosing the button, the teacher is able to adapt the text.

The project environment contains two communication tools, which are a news section and e-mail application, which enables the teacher to communicate with the students when working on the project. The news section enables the teacher to publish text based news items within the project environment of the class. The teacher is allowed to attach media or web link to the news item. The e-mail application allows the teacher to contact the students while working on the project. The asynchronous e-mail application allows for reflection on the discussion. The project environment and the communication tools enable the teacher to give the student feedback when needed.

When students finished creating the game, they can deliver it to the teacher by publishing the game in the project environment.

The teacher can assess the filled in game template and the test video which simulates the scenario of the game in on location according to the assessment criteria. The assessment of the teacher is published in the project environment of the students and in the project environment of the teacher, in order to have an overview of all results. The project environment can function as a portfolio, because it provides useful collections of student work-in-progress and final products. Besides the work in the project environment being assessed by the teacher, it can also be assessed by the students themselves. Portfolios allow students to become better planners and students, because students reflect on their own cognitive growth and understand better what activities are needed to learn and how much time is needed to finish these activities (Choi, 1995).

Table 23: Overview of the project environment for teachers: the activities, related features and requirements

Activity	Feature	Requirement
Read and adapt information about the project	Project environment	URfT 2
Publish news in student's project environment	News section	URfT 2
Communicate with students within project environment	E-mail application	URfT 2
Assess the project results of creating the game	Test video and filled in game template	FR 12

Play

The following section describes the web pages that support the teacher monitoring the students while playing the location-based mobile game.

Monitor the game live

While playing the game, the teacher can monitor the activities and results of the students behind the computer, which enables the teacher to coach the students from a distance. The trace of the individual groups is captured by the GPS and the Geotracing software. When the teacher monitors the students live, he sees the traces develop on the digital map. The interface also shows the remaining time and the scores of the team, in order for the teacher to get an impression how the teams are doing. When the teacher moves the mouse pointer over the icons on the digital map, which represent the media delivered in the field, the interface shows that particular media at the right side of the screen.

The home team structure and deliver the answers by means of a worksheet. When the answers are delivered, the teacher can see the answers directly on his screen. By tracking the results of the activities, the teacher can give immediate feedback to the students. He can contact the students by phone or by sending text messages from the computer to the mobile phone of the mobile players. Sending text messages can be appropriate, because the students can store the feedback of the teacher and use it when they need it. The students can reflect on the feedback. Phone can be more appropriate, because it is easier to explain complicated feedback. But using the phone distracts the students of playing the game. The students can also send text messages or call the teacher when necessary.

The web page 'messages' provides the phone numbers of the mobile players, the field where the teacher can type the message and the inbox. When the teacher joins the home teams in the computer room at school while playing the game, he can coach the students face-to-face. The teacher can also choose to join the mobile teams in the field, where he can coach the student personally.

Table 24: Overview of the element 'monitor the game live': the activities, related features and requirements

Activity	**Feature**	**Requirement**
Get overview of live game activities	Digital map with traces and icons, media and remaining time	URfT 1
Get overview of delivered answers live when playing the game.	Worksheet with answers send by all teams	URfT 2
Give feedback to teams while playing the game	Text message tool	URfT 2
Communicate with mobile teams	Mobile phone, voice calling	URfT 2

View

This section illustrates the functionalities that are provided to the teachers to reflect and assess the learning activities after creating and playing the game.

Results of playing the game

After playing the game, the teacher and all students come together and reflect on the location mobile game experience. The reflection is supported by the program, because the students and teachers are able to replay all traces and the media collected in the field. The trace videos show the route of the teams and the media as uploaded on location. This way, the teachers and students can monitor the activities and reflect on game strategies and answers on location.

After experiencing the results with the GPS and Geotracing software, the teachers agreed that the trace video is of great value for the reflection on the learning process and learning results (TWS2). The trace video shows the results of one trace, made by one group, but all traces can be viewed together within one screen. This way the traces and media collected in the field can be compared among the group and this can enhance the learning process.

The traces can be displayed separately and together within one screen. The user analysis indicated that the teachers prefer to compare the results of the students on a combined webpage.
The worksheets with the answers filled in are also displayed within this area of the program. The teachers and students can go over the answers together. Reviewing the results can enhance the learning results, because the educational contents are repeated. Because the students gained the real world experience within the game, the educational contents will speak to them more, which leads to better learning results?
Game statistics are published in a graph, comparing the scores, gameplay and answers. The graph enables the teacher to see directly what elements are problematic and need to be discussed within the class.
By means of a worksheet, the teacher can fill in the results of playing the game by the student groups. The teacher can safe the filled in worksheet and publish it in the right project environment of the student group or print the result and hand this over to the student personally. The teacher assesses playing the game, based on collaboration within the group, the answers given and the end product.

Table 25: Overview of the element 'reviewing the game results': the activities, related features and requirements

Activity	Feature	Requirement
Reflect on game experience and result of playing the game	Digital map with traces and icons, media and remaining time. The traces can be replayed separately per group.	URfT 1 FR 8 FR 12
Get overview of delivered answers after playing the game	Worksheet with answers send by all teams	URfT 1 FR 8 FR 12
Overview of game experience	Statistical presentation of game results	FR 12
Assess the results on playing the game, safe and publish these assessments	Worksheet	FR 12

Student version of Games Atelier
The program Games Atelier contains both a teachers' and students' version. Much functionality provided to teachers and students are similar, but some functionality is exclusively provided to the students. The web pages that are included in the students' version will be described in the following section.

Home page
The home page shows information about the program Games Atelier, location-based mobile games and educational games in general. The information is supposed to give the students prior knowledge about the products and experience the program Games Atelier has to offer. The students can access this explanation any time they need; especially when they make the game this explanation provides a good reference. The text is divided in short textboxes and the hyperlink buttons provide shortcuts to the information needed. The short textboxes makes reading the text easier for the student and the hyperlinks support the student to explore the non-linear text.

Table 26: Overview of the homepage: the activities, related features and requirements

Activity	Feature	Requirement
Read about the educational method	Information about: * Games Atelier * Mobile location-based games * Educational games	FR 1 FR 2 UR Efficient

View

The following section describes the functionalities that support the students in exploring information or location-based mobile games.

Archive

The archive in the students' version is very similar to the teachers' version. It contains the same features. Only the extensive search engine is adapted to the students. The student can search based on variables that are of interest to the student, which are location, target group, complexity of the game (small/ medium/ large) and time. According to Jonassen, Hernandez-Serrano and Choi, databases are mind tools that promote critical thinking (Jonassen, Hernandez-Serrano & Choi, 2000). When using databases, students define "fields" by identifying their goals and features of information, build records (that describe objects) by collecting and inserting information into the fields, and reorganize information by sorting it and making new links among the fields in order to answer queries and to discovery new relationship among the fields.
The icons that represent the games are hyperlinks that direct the students to the individual introduction page of that particular game.
Within the archive, the students share the location-based mobile games with peer students. The peers are able to view the product and play the game. When peer students play the location-based mobile game, the product becomes more meaningful to the student who made the game. Receiving feedback from the students when the game is played is very motivating to the makers. Furthermore, the archive becomes a depository of learning objects (Mortimer, 2006). The archive contains characteristics of communities of practice. Community of practice has a purpose of knowledge and best practice dissemination between the users of the program. CoP's are a mean of knowledge management, which means capturing and disseminating intellectual capital (Villachica, Stone & Endicatt, 1999). Members of the community can help other members out when needed or share specific knowledge or data. The students and teachers can communicate with each other by means of several communication mediated communication (CMC) tools, namely e-mail and the discussion forum. The users and teachers are able to share objects that contain educational contents, which are the location-based mobile games. The students and teachers can view these games, and gain ideas and inspiration for games they produce themselves.

Distributed cognition

As we engage in communities of discourse and practice, our knowledge and beliefs are influenced by those communities. So is our identity formation, which is also a major outcome of learning. Not only does knowledge exist in individual minds and in socially negotiating minds, but it also exists in the discourse among individuals, the social relationships that bind them, the physical artefacts that they use,
produce, and the theories, models, and methods they use.

Table 27: Overview of the archive: the activities, related features and requirements

Activity	**Feature**	**Requirement**
Choose game	Game repository with categories and icons	FR 10
Search for game	(Extensive) search engine	US Efficient
Rate and add comment	Buttons to publish rate and comment. This is published on the introduction page of the game.	FR 9

Game introduction page

The introduction page of the game is supposed to inspire and inform the students who are creating a game, or make students enthusiastic of playing that particular game. The webpage shows the name, class and school of the people who made the game. Publishing the personal information of the makers can enhance the quality of the game and the feeling of ownership. The students cannot choose to adapt a game, in order to avoid fraud amongst the students. Instead, the students can make use of a media repository, where media and playgrounds that are produced by other students within Games Atelier is stored.

Table 28: Overview of the game introduction page: the activities, related features and requirements

Activity	Feature	Requirement
Form opinion about game	Introduction text, facts, visual impression, profile makers, rating and comments	US Efficient
Play the game	'Play the game' button	US Efficient

My portfolio
My portfolio is a depository with search engine where games and projects related to the students are stored. The depository is divided in two areas, which are 'my games' and 'my projects'. The web page *my games* shows an overview of the finished games made by the student and the games that are played by the student. The web page also shows a small window which indicates whether the student received new comments on a finished game.
The icons that represent the games are hyperlinks. The finished games icons direct the student to the project environment of the game. Here the student can find all results, like assessments on the game or feedback of peer students who played the game. The icons of games played by the student direct the student to the game environment, which shows the results on playing the game, the assessment and reflection on playing the game.
The web page 'my project' shows icons representing the projects that the student is working on at the moment within Games Atelier. The icons are hyperlinks that direct the student to the project environment of that particular game.

Table 29: Overview of 'my portfolio': the activities, related features and requirements

Activity	Feature	Requirement
Overview of finished games related to the student	Table which organizes finished games and games played by the students. The icons direct the student to the game or project environment.	US Efficient URfS 3
The student is noticed when a new comment on a finished game is received	Window with notification of new comments. This notification is a hyperlink to the web page with comments.	US Efficient
Overview of projects the student is working on	Table which organizes projects the student is working on. The icons direct the student to the particular project environment.	US Efficient

Create
The following section describes the functionalities offered within the program Games Atelier that support the students in creating a new location-based mobile game.

Project environments
The project environment of the student supports the students in creating the mobile location-based game collaboratively. In the project environment of the students all information and educational criteria is published which is decided on by the teacher. The educational criteria are needed in order to integrate the project into the curriculum as good as possible and to guide the students in creating a location-based mobile game with educational value.

Important is to realize that the students who make the game first design the game during a face to face brainstorm session. After the concept of the game is developed, the tasks of developing the game will be divided among the individual students. The game template supports the process op developing the game and the project environment supports the process of designing the game.

The project environment is organized and initiated by the teacher. The teacher has divided the groups and published information by means of the project template. This information is the description of the assignment, the educational criteria for the game, the roster, the reflection questions, description of the end product and the educational sources the teachers uploaded.
Furthermore, additional explanation about the assignments and information that support learning on location and collaboration between the players of the game and the different genres of the game. This information should support the students when creating the game and is provided by the program. This information is described in section 5.2 this thesis.
Furthermore, a detailed task structuring is provided, which explicates all tasks of creating the game. The students should cooperate together and divide several tasks in order to cooperate together. The project of creating the game is divided in two parts, which are designing the game and producing the game.

Designing the game is a cooperate endeavour where the students brainstorm together in a group. When the students together decided on the topic, storyline, assignments and information provided on location, and the game genre, the tasks for producing the game is divided and the students work more separately. The student will need the information sources provided by the teacher and searching for information on the Internet and on location.

To produce the game, the students will be supported by the game template, which is a work sheet which can be filled in by the student, producing the game in a step-by-step process. Media produced within the process may be stored and shared by means of the media archive, which is a repository and can be synchronically accessed by all project members. All students can upload media and write a description of the media that is published together with the media in the media archive.
The students can communicate together and with the teacher face-to-face or by means of the e-mail application. In the project environment the students can also read the news items as published by the teacher.
The project environment contains CSCL-tools. It provides an interface that promotes collaborative interaction and tools for sharing learner-built representations of concepts. It provides synchronous, asynchronous, local and remote communication combinations that allow students to share their arguments (Jonassen, Hernandez-Serrano & Choi, 2000).

Table 30: Overview of the project environment: the activities, related features and requirements

Activity	**Feature**	**Requirement**
Read educational criteria for creating the game as published by the teacher.	Information describing the assignment, educational criteria, roster, reflective questions and assessment criteria.	FR1a FR1b
Read about assignments and information delivered on location and different game genres	Information describing assignments and information delivered on location and different game genres	FR1c
Share documents and other media, like photo's, video's, and illustrations	Media archive	FR 10
Communicate with project members and teacher within project environment	E-mail application	URfT 2
Receive news items published by the teacher	News section	URfT 2

Game template

The game template is a multimedia construction tool that supports the project group producing the educational location-based mobile game. The template structures the activities and the students can upload media, fill in fields with text and choose preferences. The program blends all elements together in the game that can be played with mobile and/ or web-based applications and automatically convert web pages designed for desktops to streamlined pages for mobile devices. The game elements that are included in the game template have been described in detail in section 5.2 of this thesis. According to Jonassen, Hernandez-Serrano and Choi (2000) multimedia construction tools permit students to structure what they are learning in the form of nodes (chunks of text, pictures, video clips, and so on), and links that connect these nodes in meaningful ways. These tools afford the students with the ability to transform the collected information into multiple representations, allow them to keep what is important and neglect what is not, segment information into nodes, link the information segments by semantic relationships, and in general allow them the flexibility to represent their ideas as they see fit.

When designing the game, all students work together brainstorming and designing. When producing the game, the tasks will be divided into writing, designing and strategy. The writers write the storyline, the assignments and information that will be received on location, the rules and introduction of the game. The designers design the playground and icons, the media received on location, like the videos, illustrations and pictures. The strategist designs the game scenario, interaction and gameplay. This is a requirement that was formulated according to the user analysis. The structure as offered by the game template can be followed linear, but it should be possible for experienced students to use the program in more freedom, deciding their own work process when creating the game (TWS2).
He decides which rule applies to who and where, when the players receives which information and when, etc. Because the decisions and activities of all roles depend highly of each other, the students must collaborate. One student, who is chairman, heads the teamwork. Furthermore, the game template can be shared between all students, so the students can monitor each other's results.
The game template exists of twelve web pages. The chairman fills in the first two pages, because these choices relate to the design of the game and influences the appearance and structure of the whole game template. The chairman chooses the game genre, the appropriate game elements and the division of teams players. The students cannot access the other pages of the template when these first two pages are not filled in.

Design

For designing the 'look and feel' of the game, the student chooses between three different styles, which are realistic, fantasy and nature. The choice should depend on the location. Is the game located in the city, the student can choose between realistic and fantasy. Realistic would be more appropriate for mathematical themes. The fantasy style is more appropriate for historical themes. Nature style can be chosen when the game is located in nature and is more suitable for biological themes. However, all students are free to choose.

When avatars are involved in the game, like in role-playing games or adventure games, the students can design avatars with special forces and aids. According to the user analysis, the students are very enthusiastic about designing avatars. These avatars will be displayed on the screen of the mobile application in order for the students to identify themselves with the avatar.
In order to design the playground of the game, the designer can select the digital map that is appropriate and download this map to the PC. In special drawing software, like paint or Adobe illustrator, the student can design the icons and additional graphics on the playground. This can be done for several layers of the digital map. When these playgrounds are finished, the designer can upload the maps to the game template. Furthermore, the designer can create videos, graphics, sounds and pictures that the players receive on location and supports the assignments and information. This data is uploaded together with the assignments and information, which are received on location.

Within the game template, the student can divide the playground in zones. These zones can be appropriate when for example the game contains different levels in different zones.

Write
The writers will fill in the text fields that are indicated in the game template. These text fields require the storyline, rules and main goal of the game, the assignments and information the players receive and a general introduction text. The texts filled in these text boxes is published within the mobile user interface. The texts boxes prohibit the student to write too much text than is suitable for a mobile display.
Writing the texts, the student should consider the target group and prior knowledge, but also the criteria for anchored and collaborative learning as described earlier. The student can use the Internet and sources supplied by the teacher. The student should also indicate whether the assignments are meant for the home team or the mobile team. In order to finish the assignment, the home team should explore information sources on the Internet. The mobile team should explore the location, where as the assignments should be adjusted to the situation the players are in.

Strategic
The strategist directs the game interaction, and game scenario and the size of the playground. The student is supported by a menu-based worksheet. The web page provides the student with tips to test the scenario at any time by means of a test video.

At any time, the students can test the appearance of the game by means of a test video. This web-based tool is important, in order to judge whether the game is exciting enough, whether the assignments, information and gameplay are well organized and appropriate. When the students are content with the end result, they can test the game on the real location. Only then, the students can really judge the end result. After this final test, the students may upload the finished game to the portfolio and invite the teacher to assess the end product. When the teacher is satisfied with the result, the students can invite peer students to play the game by means of the e-mail application.

Test the game
One of the functional requirements is to test the game before it is finished and published in the archive (FR3). The game template provides the students with a 'preview mode' and a test video, to judge the game-scenario and the constructed information, assignments and media that enrich the location. The students can judge whether the game they constructed is exciting, challenging etc. The students can test the game any time, which provides them with the opportunity of trial and error. In order to learn it is important to make mistakes and get the chance to analyze the mistakes and do it again (Stager, 2005).
The test video makes the students able to manipulate and test various solutions to the problem.
After testing the game in the web-based application, the students should download the game to their mobile devices and test the game on location. The technology should work flawless; otherwise the students who play the game become frustrated and bored.

Table 31: Overview of the game template: the activities, related features and requirements

Activity	**Feature**	**Requirement**
Compose and produce the location-based mobile game	Worksheet 'Game template'	FR 2
Test the game	Test video	FR 3
Upload the game to the archive	Hyperlink	FR 11

View

The following section describes the web pages and functionalities that support the students in reflecting on the learning activities and give peer-students feedback.

Results of playing the game

After playing the game, the results are collected together with the game in the archive, under my games.
By means of the trace video, the students see the choices made in the field and the problems they solved.
The students can reflect on the meaning of their interactions, discuss these with peer students and correct their knowledge and skills. It is important for learning that students analyze and get insight in the mistakes they made and that they get the chance to try the activities again (Stager, 2005).
In stead of reflecting on the game activities after the game is finished, the students can also gather to watch the trace video and reflect on their experiences and choices half-way the game. Then the students will be allowed to apply the insights in the second half of the game.
When the reflection takes place in the group, the student can reflect on each others´ activities and give each other feedback. The students are allowed to see the results of all groups, because the media collected in the field are valuable educational lessons.
This section contains also the answer sheets from all the groups who played the game. The students are allowed to download the data they collected from the answer sheets. The students are not allowed to download this data from other teams. The teacher indicates the reuse of the data in the end product, like a website or paper.
To reflect on playing the game and the game as a product, the students have to answer the reflection questions as stated and published by the teacher.
At the end of the learning activities concerning playing the game, the teacher downloads an assessment document in the archive, assessing the collaboration, the finished assignments during the game and the end product.

Table 32: Overview of program segment View: the activities, related features and requirements

Activity	Feature	Requirement
Reflect on game experience and result of playing the game	Digital map with traces and icons, media and remaining time. The traces can be replayed separately per group.	FR 8
Get overview of delivered answers after playing the game	Worksheet with answers send by all teams	FR 8 FR 9
Download media from collected in the game	Download feature in answer sheet	FR 10
Reflect on playing the game and the game as product	Reflection questions, published by the teacher	FR 8
Receive assessment on playing the game	Assessment published in archive	FR 12

5.3.6 Summary

Section 5.3 described the conceptual design phase, which resulted in the conceptual model, user interfaces and prototypes of the program Games Atelier. This section provides answers to the research question: *How can the user needs, user experience goals, usability goals and user, usability, context and functional requirements be translated into the functionalities and graphical user interfaces (GUI) of Games Atelier?*
During this research project requirements have been identified and categorized in user requirements, usability requirements and functional requirements. The requirements are translated into the conceptual model and a prototype that displays the functionalities and graphic user interfaces of the program Games Atelier.

The focus lies on the design of the web-based application for the personal computer. The web-based application provides the support for developing the game that is unique for this target group. Only when the students and teachers are properly supported by means of information and cognitive tools in the web-based application, they can construct a location-based game that offers effective learning opportunities. The web-based application provides the students and teachers with a course management system that supports some aspects of course preparation, delivery and interaction and allows these aspects to be accessible via a network. The choices made for designing the program are described systematically in this section, and related to the requirements. The most important characteristics of the program as designed during this research project are the following.

The program is highly flexible and dynamically adjusted to the individual needs of the broad target group. The dynamic web-based user interface accommodates to the personal profile of the teachers and students and the behaviour when using the program. The program provides two different versions, one for the teachers and one for the students. The versions contain features that are similar, but also features that support the tasks that are specific for that user. Furthermore, the language used is different for the teachers and the students, but also for the students of different educational levels.

The location-based mobile games are collaboratively developed by a group of students. Every game in construction is embedded in an individual project environment, which supports the collaborative endeavours of the students. The project environment provides information, cognitive tools, communication tools and features that support sharing documents between the mutual team members and with the teacher.

The project environment is initiated and organized by the teacher. A project template supports the teacher step-by-step and provides the teacher with menu-options and input-mechanisms to make choices and upload media (text, pictures, videos etcetera) as necessary. Based on the choices made and the supplied information, the information and cognitive tools as provided by the project environment is dynamically adjusted to the personal needs of the project members.

The project environment provides the students with a game template that offers step-by-step support when creating the location-based mobile game. The game template operates similar as the project template, using menu-options and input-mechanisms for the students to make choices and upload media (text, pictures, videos etcetera) as necessary. The game template constructs the location-based mobile game and the mobile and web-based user interfaces of the location-based mobile game.

The project environment functions as a portfolio that provides useful collections of student work-in-progress and final products that can be assessed by the teacher.

When the game is played by the students, the program stores the results of the learning activities in a trace video and organizes the answers to the assignments on digital worksheets. The teacher and students can access the trace video and answer sheets while playing the game and after the game is finished. These tools support the teacher to monitor the playing activities of the students and coach them when necessary.

When the game is finished, the students can reflect on the choices they made during the game and the educational contents they collected. The answer sheet allows the students to download and reuse the media they produce while playing the game, in order to produce an end product, for example a website or a paper.

The following chapter describes the results of the third prototype being formative evaluated by two teachers and three experts of Waag Society. They evaluated the graphic user interfaces and functionalities of the program Games Atelier, based on the requirements as identified in this research project.

6 FORMATIVE EVALUATION OF THE THIRD PROTOTYPE

This chapter describes the formative evaluation of the third prototype of the program Games Atelier.
The prototype is evaluated by a group of teachers and experts of the Waag Society. The main goal of the formative evaluation is to improve the quality of the program under development, to investigate to what extent the users consider the intervention as appealing and usable, and assess how well the design or particular aspects of it satisfies users' needs.
The responds of the teachers and experts to the prototype is analyzed and explained in this chapter. Analyzing the results of this formative evaluation hopefully gives answer to the question *How can the user needs, user experience goals, usability goals and user, usability, context and functional requirements be translated into the functionalities and graphical user interfaces (GUI) of Games Atelier?*

6.1 GOAL OF THE FORMATIVE EVALUATION

In the final phase of the research project, the third prototype, which is designed according to the established requirements, was formative evaluated by representatives of the target user group. The established requirements are translated into an acceptability and usability checklist, and according to this checklist and the 4E-model the product will systematically be evaluated.

Generally, in early stages of a design project, the intervention is poorly crystallized. When early prototypes, which are draft versions, are evaluated, the priority should lie in detecting the weak points of the intervention and in generating suggestions on how to make the intervention stronger (Sweeney, Maguire & Shackel, 1993).
The main goal of the formative evaluation in this research project is to improve the quality of the program under development, to investigate to which extent the users consider the intervention as appealing and usable and assess how well the design or particular aspects of it satisfy users' needs. Based on the evaluation, the product can be adjusted and evaluation phase can be repeated. This is the iterative character of interaction design.

The third prototype communicates the way the teachers can interact with the web-based application of Games Atelier. Because of time constraints, the evaluation was 'quick and dirty'. 'Quick and dirty' means that designers get informally feedback from users to confirm that their ideas are in line with the users' needs and that the users like the program (Preece, Rogers & Sharp, 2002).

6.2 ACCEPTABILITY CHECKLIST

The needs and usability goals of the teachers and students are reflected in the acceptability and usability checklist. The construction of the acceptability and usability checklist is based on the usability requirements efficient to use, 'effective to use', 'easy to learn', 'easy to remember how to use', and 'have a good utility'. Furthermore, the checklist includes the user and functionality requirements.

The usability requirement 'effective to use' is a very general requirement and refers to how good a system is doing what it is supposed to do. Is the system capable of allowing the students to learn well, the teachers and students to carry out their work efficiently, and access the information they need? This usability requirement is closely related to the functionality requirements, because these requirements describe what a system should do, and the usability requirement efficient to use. The requirement also resembles the 4E factor educational effectiveness, because both requirements describe the ability of the program to support learning.
The usability requirement efficient to use refers to the way a system supports users in carrying out their tasks. Can the user carry out many tasks through a minimal number of steps? Once the users have learned how to use a system to carry out their tasks, can they sustain a high level of productivity?

The system needs to 'have a good utility', meaning that the system should provide the right kind of functionalities for the user to do what they need or want to do.
The usability requirement 'easy to learn' refers to the systems' ease of use. Online tutorials can help (Preece, Rogers & Sharp, 2002). This requirement resembles the factor Ease of use in the 4E-model, which is also used to evaluate the program and the user requirements. The user requirements reflect the abilities and capabilities of the users. Are the users capable of understanding and using the system properly?
To remember easy on how to use the system, it should be logically sequenced and well structured (Preece, Rogers & Sharp, 2002).

6.3 4E-MODEL

The prototype is evaluated according to the 4E-model (Collis & Moonen, 2001). The 4E model illustrates the relation between the factors Ease of use, Engagement, Effectiveness and Environment of an educational product. According to Collis and Moonen (2001) the likelihood that a target user will use a technological innovation for a learning-related purpose is a function of four groups of factors, namely the Environment, meaning the institutional context, the perceived or expected educational Effectiveness, the Ease of use and Engagement, meaning the personal response to technology and to change.
In the 4E-model, the Environmental factor determines the level of the success threshold. This means, the stronger the institutional support and environmental climate for implementing the program will be, the lower 3E vector-sum of Educational effectiveness, Ease of Use and Engagements needs to be (Collis & Moonen, 2001).
It is not easy to determine or predict the Environmental factor for the program Games Atelier. The institutional support depends on the administration of all individual secondary schools, but the decision makers for using the program will be the teachers. The teachers will not be obligated by the administration of the secondary school to use the program. This probably weakens the Environmental factor, so the Ease of use, Educational effectiveness and Engagement should be relatively high. The open source program is offered to the teacher for free. This can strengthen the Environmental factor.
Using the program Games Atelier will not change the educational practice at the secondary school dramatically. The program will be used complementary to the traditional education methods being used .The engagement of the users will fully depend on the response of the teacher to technology. This will differ for each individual teacher. One teacher will be a pioneer in using technology and other teachers will follow when the system is proven to be successful. Because the teachers who evaluate this prototype are ICT experts, these teachers are pioneers.
This formative evaluation will mainly focus on determining the educational Effectiveness, the Ease of use and Engagement of the users.

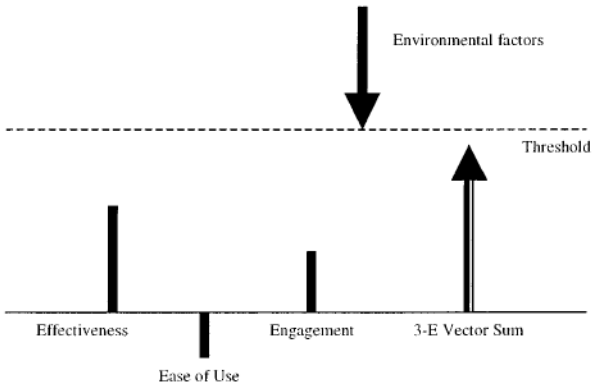

Figure 22: 4E model (Collis & Moonen, 2001)

6.4 SAMPLES OF RESPONDENTS

The respondents who evaluated the prototype of Games Atelier are two teachers and three experts from the creative learning lab of Waag Society. The teachers are both ICT experts and teach VMBO level learners at two different secondary schools in the Netherlands. Due to confidentiality reasons, the teachers will be indicated by teacher A and teacher B. The teachers evaluated the acceptability of the program for all users, as well the teachers and students. It would be better to evaluate the prototype by as well the students as the teachers. However, the prototype is a draft version of the program, communicating the structure and functionalities of the program. It would be difficult for the students to evaluate such a poorly crystallized version effectively. It would be better to involve the students in a later phase of the development project, in order to evaluate the software programme in a naturalistic environment.

The experts have all different functions within the organization, which are program manager, concept developer, and educational developer. The developers were involved in developing the location-based game Frequentie 1550 and now all experts are involved within the project Games Atelier.

In early formative evaluation, efficiency of procedures is crucial. Samples of respondents and situations for data collections will usually be relatively small and purposive, in comparison with sampling procedures for other research purposes. When evaluating the prototype of Games Atelier, the sample of respondents were small, only five respondents in total.

6.5 DATA ACQUIRING TECHNIQUES

The prototype was evaluated in two different sessions.

First, the prototype was demonstrated to the teachers. After this presentation, the teachers received the questionnaire that included the screens of the prototype and an explanation of every page of the program (see also Appendix J: Questionnaire formative evaluation for teachers). The questionnaire is constructed according to the 4E model and the acceptability and usability checklist. A questionnaire is a well-established technique for collecting users' opinions (Preece, Rogers & Sharp, 2002).

The questionnaire included screens of the prototype and every screen, some closed questions were stated. This way, the teachers followed the program step-by-step through the program and could directly commend to the web pages and the features included. In order to collect rich data by means of the questionnaires, the teachers were asked to argument all their answers. They made use of this opportunity. The teachers also received the digital version of the prototype, to illustrate the questions of the questionnaire. Because this digital version is a PowerPoint document, the teachers were able to walk through the screens chronologically. The hyperlinks were designed in a recognizable way by means of buttons and explained in the text, but the teachers weren't able to make use of the hyperlinks and therefore not able to explore the website in a non-linear way. To support the teachers to understand the non-linear structure of the website, the teachers were provided a web structure model, which indicates the connections between the different web pages.

The three experts of the Waag Society evaluated the prototype by means of a walkthrough. Walkthroughs are an alternative approach to heuristic evaluation for predicting users' problems without doing user testing. They involve walking through a system and noting problematic usability features.
The walkthrough is executed by the designer, showing and explaining the prototype screen by screen. The experts were asked to react on the screens and discuss the screens together in a focus group discussion, focusing on the logical structure of the system, the included functionalities and pedagogical effectiveness. The researcher participated in this group discussion and made notes of the comments of the experts. Due to time constraints, the experts only evaluated the teachers´ version of the program and the game template.

6.6 ANALYSES OF THE FORMATIVE EVALUATION SESSIONS

The acquired data is analysed by means of coding. The acceptability and usability checklist and the 4E-model provided the frame for the analysis. This paragraph describes the questions used in the questionnaire to acquire the right data and the analysis of the answers given by the teachers and the experts. Table 33 gives overview of the analysis frame according to the acceptability checklist and 4E-model and the functionalities of Games Atelier which were analysed.
The teachers evaluated the teacher and student version of the program and the experts evaluated the teacher version of the program and the game template.

Table 33: Overview of the analysis framework and evaluated functionalities

Acceptability checklist / 4E model	**Functionalities of Games Atelier**
Usability requirement : Good utility	- Hyperlinked icons - Adapting games when finished - Project environments - Monitoring the playing activities
Usability requirement : Efficient to use	- Program in total
Usability requirement/ 4^E factor : Easy to learn	- Program in total
Usability requirement: Easy to remember how to use	- Program in total
Usability requirement: Effective to use	- Login - Home page - Introduction page - Organization - Creating the game
4^E factor: Educational effectiveness	- Creating accounts - Search engine - Rating and comment the game - Initiating new projects for creating the game - User profile - Educational criteria - Information resources - Digital roster - Adjusting the games - Support of independent performance of students when creating the game - Dividing roles when playing the game - Coaching while playing the game - Reflection questions - Results of playing the game - Reuse the media - Assessing the learning results
Game template	- Game template in total

6.6.1 Usability requirement: good utility

When measuring the utility of the program, it is investigated whether the system provide the right kind of functionalities for the user to do what they need or want to do.

Good utility - questions

The questions to measure the practicality of the functionalities had the following format: I find the [functionality] useful/ practical. The teachers can respond by choosing strongly agree, agree, neutral, disagree or strongly disagree.
The evaluated functionalities are the following: the hyperlinked icons, representing the games that are stored in the archive; the schematic overview of projects in the teachers; the visual preview on the introduction page of the game, and the hyperlinked buttons indicating the choice whether to adjust an existing game or make a new game; the individual project environments; the digital news bulletin, e-mail tool and data-archive within the project environment; the trace video and worksheet that collects all information on the learning process while playing the game; the page with statistics for reviewing the results of playing the game; and the test video in order for the students to formatively test the game.
Table 34 gives an overview of the questions asked to measure the utility and the answers given by the teachers.

Table 34: Overview of answers concerning 'good utility'

Screen	Question	Teacher A	Teacher B
4	When I notice that icons in the archive are hyperlinks, I click on it automatically.	Strongly agree	Agree
5	I find the schematic overview of 'my projects' practical.	Agree	Strongly agree
	I find the menu options in 'my projects' to go directly to project environments practical.	Agree	Strongly agree
7	The visual preview is useful.	Disagree	Neutral
7	It is useful when student scan adjust games that are created by other people.	Strongly agree	Strongly agree
7	An individual project environment for every new game is useful.	Agree	Agree
22	The digital news bulletin is useful	Agree	Agree
27	The e-mail application has additional value.	Agree	Strongly agree
29	I find it important that, while the students play the game, I can monitor the progress of the students behind the PC.	Strongly agree	Agree
29	I want to see all traces of the mobile teams that play the game on one screen at the same time.	Agree	Agree
29	I want to see the traces of the mobile teams on separate screens.	Strongly agree	Agree
29	While playing the game, I want to see the remaining time on the computer screen.	Disagree	Strongly agree
30	While playing the game, I want to see an overview of the scores of all the teams on the interface.	Agree	Agree
31	While playing the game, I want to monitor the answers given to the assignments on the	Agree	Agree

	interface, so I can coach and assist the students when needed.		
31	For coaching the students from a distance while they play the game, I prefer instant messager.	Agree	Agree
33	Reviewing the results of playing the game by means of the trace video is useful.	Strongly agree	Agree
34	Collecting the answers in separate answer sheets per Group is useful.	Strongly agree	Agree
x	The statistical representation of the answers and rewarded points is useful.	Agree	Agree

Good utility -analysis

Hyperlinked icons
The hyperlinked icons in the archive are appreciated by both of the two teachers. Teacher A arguments that using these icons will trigger the curiosity of the users to explore the games.
The schematic overview of the projects in the teachers' archive is appreciated by both of the two the teachers, but Teacher A comments that the left column integrates different sorts of information (class and theme of the project), which can be confusing.
The visual preview, presenting interfaces of the game on the introduction page, is not appreciated by the teachers. Teacher B wonders what the value will be, because the students can only choose between a limited number of user interfaces. He argues that the preview should have a different form than the static user interface. Teacher A suggests the use of a slideshow to give a visual impression of the game.

Adapting games when finished
Both of the two teachers strongly agree with the buttons which enable the users to adapt an existing game or make a new game.

Project environments
Both of the two teachers appreciate the learning environment to provide a project environment for every individual project. Teacher A comments that individual project environments are especially useful for organizing and storing the results and communication per project.
The communication tools within the project environment, which are the news bulletin and the e-mail application, are highly appreciated by teacher B. Teacher A agrees that the e-mail application would be appropriate, but not truly necessary. According to him, most schools already make use of a learning environment that supplies e-mail or messaging applications. The news bulletin is appreciated by both of the two the teachers.

The program manager of Waag Society argues that an integrated e-mail application within the project environment would organize communication about the project in one program. When the students work on the project within the program Games Atelier, the students will immediately see whether they received mail that concerns the project. The students will not need to login to another e-mail program and be unnecessarily disrupted from their work.

Monitoring the playing activities
For monitoring the activities of the students while playing the game behind the computer, the program provides the teacher with an interface that represents the traces developed live on the digital map and the worksheets which collects the results during the game. Both teachers prefer the possibility to follow the activities and the learning results during the game. The teachers both prefer the opportunity to view all the traces on the same time and to view the traces of the separate groups. Teacher A argues that he wants to

join the students in the field when playing the game, and not behind the computer. Teacher B appreciates the computer to show the remaining time on the screen, because this supports him coaching the students concerning time related elements. According to teacher A; it should be for the users to choose whether the screen shows the remaining time or not, depending on the circumstances. Both teachers prefer to see an overview of the scores by all teams on the computer screen and both teachers appreciate using a text message tool to coach and steer the students from a distance.
In order to support the users to reflect on the activities after playing the game, both teachers appreciate the trace video, the worksheet that collects and gives an overview of the answers and collected media in the field, and the statistical representation of the answers and rewarded points. Teacher A appreciates the data to be collected in the worksheet and the trace video and additionally wants the possibility for comparison to bring the videos of all groups together. Teacher A also argues that the usefulness of the statistical representation depends on the game genre. Teacher B argues that the statistical representation gives an impression of the difficult questions and wants to understand whether the assignments are properly understood by the students.
Both teachers appreciate the possibility to test the game in the program within the game template.

6.6.2 Usability requirement: Efficient to use

The usability requirement 'efficient to use' refers to the way a system supports users in carrying out their tasks. Can the user carry out many tasks through a minimal number of steps? Once the users have learned how to use a system to carry out their tasks, can they sustain a high level of productivity?

Efficient to use - questions

Concerning the efficiency of the program, the teachers are asked whether the program offers enough support in order for the students to carry out the project independently. Because the students are supposed to carry out the project independently, with the teacher only to facilitate the process, the support of the program is of great importance.
The introduction page of the games provides the users with a shortlist that summarized the most important facts. This helps the user to judge quickly whether he wants to play the game.
The teachers are asked whether this list of facts would be useful, whether they miss certain facts and which facts they consider not important.

Efficient to use - analysis

Teacher A remains neutral to the question whether the program offers enough support in order for the students to carry out the project independently. He agrees that the list of most important facts will be useful, but he would like to read a short story about the game.

6.6.3 Usability requirement: Easy to learn

The usability requirement 'easy to learn' refers to the systems' ease of use. This requirement resembles the factor Ease of use in the 4E-model.

Easy to learn how to use - questions

The teachers were asked in general whether they consider the program for teachers and students easy to use and specifically whether the game template is easy to use for the teachers and students to make a game. This question is asked, whether it is important for the project that creating the game does not require any technical skills.

Easy to learn how to use - analysis

Teacher A strongly agrees to the question whether the program in general is easy to use for both the students and teachers. Only Teacher B responded to the question whether the game template is easy to use for creating a game. He strongly agrees.

6.6.4 Usability requirement: Easy to remember how to use

Easy to remember how to use the system; it should be logically sequenced and well structured. The structure of the program influences the efficiency of the program and the ability of the users to find the information they need. Also, the structure determines whether the users are able to learn the program easily and remember how to use it. This is important, because the program will be used irregularly. The teacher agrees that the program is properly structured.

Easy to remember how to use - questions

First, the teachers are asked the general questions whether the process of creating, playing and viewing the game is properly structured. More specific, the teachers were asked whether the archive for the teachers and for the students is properly organized. The teachers' archive is divided in 'archive' and 'my projects'. The students' archive is divided in 'all finished games', 'finished games made by the student himself' and 'my projects environments'. Table 35 gives an overview of the questions asked to measure how easy the program is to remember, and the answers given by the teachers.

Table 35: Overview of answers concerning 'Easy to remember how to use'

Screen	Question	Teacher A	Teacher B
x	The process of creating, playing and viewing the game is properly structured.	Agree	x
4	The 'view' part of the teachers' version is divided in 'archive' and 'my finished games' and 'my projects'. I find this logical.	Disagree	Disagree
11	The 'view' part of the students' version is divided in 'archive' and 'my projects'. I find this logical.	Neutral	Agree

Easy to remember how to use - analysis

Only Teacher A responded to the question whether the program is properly structured and he agrees.
Both teachers disagree on the names of the elements in the teachers' archive. Teacher B argues that 'my projects' also belongs to the 'archive'. He suggests renaming the categories in 'my archive' and 'extended archive'. Teacher B suggests to insert an overview of games made by the own school. This should support thematically collaboration between different subjects.
Teacher A suggests when the teacher is logged in to rename the sections in 'my archive', indicating the finished games and 'my projects', indicating the projects in progress. When the teacher is not logged in, the program should only project the finished games.
The students' archive is divided in an archive including all finished games, a portfolio, including the finished games made by the student himself and the unfinished games in progress, which are embedded in a project environment. Teacher B agrees that the organization of the students' archive is sufficient. Teacher A is neutral and argues that division in my games, my projects and my portfolio is confusing.

The experts of Waag Society agree that the topics on ´my projects´ should be better organized, especially the left column of the table.

6.6.5 Usability requirement: Effective to use

The usability requirement 'effective to use' is a very general requirement and refers to how good a system is doing what it is supposed to do. Is the system capable of allowing the students to learn well, the teachers and students to carry out their work efficiently, and access the information they need? This usability is closely related to the functionality requirements, because these requirements describe what a system should do, and the usability requirement efficient to use.

Effective to use - questions

The questions asked in the questionnaire in order to evaluate the effectiveness of the program refer to the information as presented on the web pages and the ability of the users to access this information.
The information on the following web pages are evaluated, which are the login page, the homepage, the individual introduction pages of the games, the information needed for creating the game and the project environment. These pages provide text with a certain function, in order to initiate enthusiasm to use Games Atelier or play the game, or educate about the educational value of the method, and what the criteria for creating an educational location based mobile game are. Because the prototype evaluated by the teacher contains fake text to support the design, the teacher judge the information based on the headers and the hyperlinked buttons in the vertical menu. Table 36 gives an overview of the questions asked to measure how effective the program is to use, and the answers given by the teachers.

Table 36: Overview of answers concerning 'Effective to use'

Screen	Question	Teacher A	Teacher B
1	The information provided on the login page is sufficient.	Neutral	Agree
2	The homepage contains useful information.	Neutral	Agree
7	The game introduction page contains useful information.	Agree	x
7	The information provided on the game introduction page is sufficient (introduction text, preview and facts).	Agree	x
8	The overview with most important facts of the game is useful.	Agree	x
11	The topics 'preparation' and 'what do I need to start a project' are useful.	Agree	Agree
12	The webpage 'Create a game' contains useful information I need to start a project.	Agree	Agree
13	The project environment in the students' version contains information that is useful for the students.	Agree	Agree

Effective to use – analysis

Login
The information provided on the login page is the introduction text in order to make new users enthusiastic and curious about Games Atelier. The page provides hyperlink buttons in order to login and make a new account. Teacher A finds the information on the login page complete, but teacher B needs a clear indication that the users enter the program.

Home page
The homepage of the teachers' version provides pedagogical information about location based mobile games as a learning method, learning goals that can be reached by means creating and playing these games

and how these learning goals can be reached. Both of the two the teachers have the opinion that these topics and information should be further specified. Teacher A indicates that the topics are too arbitrary.

Introduction page
The introduction page of each individual page provides the introduction text, the visual preview and the shortlist of facts. Teacher A agrees that the information provided is complete and would be useful for the teachers and students. However, he suggests using either Dutch terms or English terms, not a mixture of both.

The educational developer suggests to begin with the facts. In the prototype, the introduction page starts with the longer text and this shortlist with facts is at the bottom of the page. The expert argues that the teacher needs a quick summary of the game first. In case, when the teacher is interested, he may read more detailed information about the content. The visual impression and the facts can be combined. In the prototype, these are separated.
The order of the facts should be thought through carefully. What is the most important information for the teacher? This can be the target group or the location.
The program manager indicates that the shortlist of facts misses information on the subject matter. She argues that when the published games contain the personal information about the maker, the quality of the games in general might improve.

Organization
The web page 'organization' provides the teacher with information needed for preparing the project and a checklist that lists the materials needed to start the project. Both Teacher A and Teacher B agree that these topics are useful for the teachers. Teacher B argues that this information provides clarity. Teacher A needs information about where the teachers can hire or reserve the smart phones and GPS when the teachers do not have these available at school.

Creating the game
The web page ´creating the game´ provides teachers with information on how to create a new game technically, supported by the web-based program. The teachers are provided with examples of location based mobile games, the project template is explained and the web page provides a task structuring, indicating the tasks of creating the game for teachers and students.
Both teachers agree that the information provided by this web page is needed and they don't miss any information.

The project environment in the students´ version provides the students with information about the game genres, gameplay, how to formulate assignments that are location-based and pedagogical. This information supports the students while designing the game. The project environment also provides a task structure, which lists the tasks of the students creating the game and the division in roles.
Both teachers agree that the information provided by the project environment is sufficient for the students when creating the game. Teacher A argues that the language used should be adapted to the level of the student. The program should contain different versions and should automatically adapt to the profile of the user. Teacher A also indicates that the header ´educational criteria´ is too difficult for the students. He suggests to call this topic ´what are you suppose to learn from the game´. Even though, this topic would be difficult for the students to understand.

6.6.6 4^E factor: Educational effectiveness

The perceived or expected educational effectiveness is one of the factors of the 4E model. This factor indicates whether the program allows the students to learn well and support the teachers in the educational practice. The educational effectiveness is the main focus of the formative evaluation of this prototype, because the main research question asks for an effective web-based learning environment.

Educational effectiveness – questions

The questions asked to measure the educational effectiveness of the program are specific questions about specific elements of the program. For example, the teachers were asked whether they find the educational criteria as stated sufficient, whether the reflection questions as stated are sufficient and what role the teachers prefer when playing the location based mobile game. Table 37 gives an overview of the questions asked to measure the educational effectiveness, and the answers given by the teachers.

Table 37: Overview of answers concerning 'Effective to use'

Screen	Question	Teacher A	Teacher B
1	Choose from: The teacher initiates the account for the students*; or* the students initiate the accounts themselves.	Both	The teacher initiates the account for the students
4	The search criteria in the search engine are practical.	Agree	Agree
4	It should be clear whether a comment and rating is written by a student or a teacher.	Neutral	Agree
4	A comment can only be published by users who have played the game.	Strongly agree	Neutral
15	Filling in a profile of the student that uses the project environment is useful.	Agree	Neutral
14	Digital preparation of educational criteria when initiating the project is useful.	Agree	Don't know
14	The following criteria are not useful	End product - complexity	x
15	Which educational sources do you want to upload to the project environment?	Weblinks, Word doc., PDF doc., photos, videos, Excell doc., audio	Weblinks, Word doc., PDF doc., photos, videos, Excell, audio
16	Is it useful to publish a digital roster in the project environment?	Yes	Yes
x	The project environment supports the students sufficiently in executing the activities independently.	Neutral	Neutral
x	While playing the game, I prefer the role of:	Coach in the field	Coach in the field/ Coach behind a PC at school.
17	How will you use the reflection questions?	I will offer the questions in the classroom and digitally.	I will offer the questions in the classroom and digitally.

23	The students should review the results of all the teams that played the game.	Strongly agree	Strongly agree
23	It is useful for the students reusing the data collected in the field for an end product.	Strongly agree	Strongly agree
26	The subjects that are assessed after playing the game are sufficient.	Disagree	Agree
26	Collaboration during the project is assessed based on the reflective report written by the students.	Disagree	Disagree

Educational effectiveness – analysis

Creating accounts

The teachers are asked whether they should organize new accounts for the students or whether the students make new accounts themselves. Teacher B indicates that he prefers that teachers register the students, but individuals should be able to make new accounts when they are registered. Teacher A indicates that both of the two the teachers and the students should be able to make a new account for themselves and for students.

Search engine

The extended search engine in the archive of the teachers' version contains several search criteria, which are educational contents, didactical approach, learning goals, target group, duration (small/ medium/ large) and location and game genre. Both teachers find these criteria practical and they will not need other criteria. Teacher A indicates that a didactical approach is integrated within the game genre.

Rating and comment the game

Within the archive where the finished games are stored, the teachers and students have the opportunity to rate the game and publish a short personal comment about the game. The teachers are asked whether they need an indication by the program whether the comment is written by a student or a teacher. Teacher B agrees, because the comments account for a difference in experiencing the game and didactical quality of the comment. Teacher A is neutral, because according to him, the difference between the teachers' and students' comments will be clear without any indication.

The teachers are asked their opinion about whether the comment can only be published by users who played the game. Teacher A strongly agrees, and argues that otherwise there will be a risk that the games are assessed based only based on the storyline and theme and not on the content of the game. Teacher B remains neutral to this question.

Initiating new projects for creating the game

By means of the project template, the teacher can initiate and organize a new Games Atelier project. The teachers are asked whether the students should have the opportunity to initiate new projects by means of Games Atelier independently. Teacher A argues that he prefers the teacher to initiate and organize the project. The students design the game, but the teacher will determine the conditions.

Teacher B agrees the students should have the freedom to initiate the project on their own. He values the possibility for the students to explore the program on their own.

User profile

The project template that supports the teachers to organize a new project environment, asks the teacher to fill in the profiles of the target students. By doing so, the project environment will be adjusted to the educational level of the students. When asked for his opinion, Teacher A finds the profile useful, because the teacher can steer the choice of the students when they choose a certain game genre. The choices will

be limited and this should make the choice easier for the students. Also, the teacher can prevent students to choose a certain game genre. Teacher B remains neutral to this question.

Educational criteria
In the project template, the teacher can indicate educational criteria that influence the project environment and the assignment the students receive for creating the game. The criteria are the topic or theme, the learning goals, the assessment criteria for the game, the game genre, the target group of the game, the complexity and duration of the game, and the end product after playing the game.
The teachers are asked whether they find it useful for the teacher to determine these educational criteria digitally, or whether they prefer to announce these criteria face-to-face or let the students choose these criteria. Teacher B agrees that it is useful for the teacher to determine these educational criteria digitally. Teacher A is confused about the meaning and purpose of the educational criteria. When asked which criteria are not applicable, Teacher A indicates that complexity and the end product are not necessary. According to his opinion, complexity is too vague and the end product is depending on the game genre.
Teacher B indicates that the developers of the program should think the educational criteria carefully through. What do you want to achieve and is that possible within the game? He also indicates that the students should be able to make a game in free mode.
Teacher A argues that the terminology ´educational criteria´ is difficult to understand for students and that handling these criteria will remain challenging in general.

The educational developer argues that because the students need to make choices in order to select and develop a certain game genre, careful consideration is required on what choices the students have and what is to be decided by the program and the teacher. In this prototype, the teacher has the opportunity to select certain educational criteria's that influence the amount of choices the students can make to develop the game. The concept developer argues that it can also be decided that the users fill in what they want to learn within the game, and that the game format is automatically generated by the program. You start open and based on the educational criteria the game is formulated by the program.

Information resources
The teachers can upload certain information resources and publish hyperlinks in the project environment of the students. These resources can the students use when creating the game. The teachers are asked which resources they want to upload to the environment. The teachers indicate both that they want to upload external web links, word documents, PDF documents, pictures, video's, excel sheets, and audio records or MP3 files.

All experts are enthusiastic about the concept of uploading information resources within the project template. The only question is what is the prior knowledge of the students before they make or play the game?

Digital roster
The teachers are able to fill in a project schedule and publish this in the project environment of the students. Both teachers agree that a digital project schedule will be useful. Teacher B argues that teachers will probably handle the schedule differently. He prefers to do a project that will not last for weeks.

Adjusting the games
The teachers and students have the opportunity to adjust a finished game, but only when the maker of the game gives permission for others to adjust the game.
Both teachers strongly agree that adjusting other games will be useful. Teacher A argues that the adjusted game should be saved as a new game and the original game should always remain available within the archive.

The experts of Waag Society discuss together the issue of adapting the finished games by other persons. The program manager argues that this should only be possible when the maker of the game gives permission to adapt it. Perhaps the person who wants to adapt the game might write an e-mail to ask permission. There is a risk that when small aspects of games are adapted to the preferences of other users, and published in the archive, the archive will eventually contain similar games.

Support of independent performance of students when creating the game
The project environment provides the students support in collaboratively producing the location-based mobile game. The teacher prepares the project, but the students execute the project activities independently. This requires the project environment and game template to steer and support these activities intensively.
Both of the two teachers cannot formulate an opinion about the possibility of the project environment to support the activities of the students independently, based on this prototype. Teacher A strongly agrees and Teacher B agrees with the statement that the game template supports the student in creating the game independently. When asked whether the game template supports the collaboration between the project members, Teacher B disagrees and Teacher A agrees. Teacher A argues that the game design process, which is group process between the project members face to face, should be included in the evaluation of the collaboration between the project members.

Dividing roles when playing the game
By means of the game template, the students determine the groups of students who play the game. Teacher A argues that this depends, in some cases the teacher determines the groups, and in other cases the students can determine the groups. He does not specify the situations.
Teacher B argues that the teacher should always be able to influence and determine the division in groups.

Coaching while playing the game
While playing the game on location, the teacher can coach the students in the field or stay at school. The teacher can participate in the game, being a game leader or team member. According to the questionnaire, both Teacher B and Teacher A prefer to coach the students in the field. Teacher B adds that he also prefers to coach the students from a distance, behind the personal computer.
The web-based application supports the teacher to coach the students from a distance, by means of live registration of the trace and media collected in the field, and the answers to the assignments. Furthermore, the teacher can contact the students by means of a text message tool and calling them.
Both teachers agree that the live registration and presentation of the location based activities and results of playing the game would be appropriate. Teacher B adds that it should maintain possible for the students to play the game without supervision of the teacher. Teacher A argues that the live presentation would be useful to help the students solving difficult questions. This in case when the questions are not well formulated.

Reflection questions
The teachers can publish reflection questions in the project environment. The students can answer these questions in order to reflect on the learning process and collaboration with peer students. The questions may steer the reflection of the students during a group discussion or are used for writing a reflection report.
The teachers are asked whether they will fill in these questions digitally to support the reflection of the students. Both teachers prefer to publish the questions digitally and discuss them face to face with the students.

Results of playing the game
The program registers the activities and results of the students while playing the game. These results are represented by the program by means of a trace video, and an answer sheet. All users are able to look back

on the results and reuse the media as collected in the field. The students can access the finished assignments and the media collected in the field of all students and use these results to reflect on their own results and the results of their peer students.
Both teachers agree that reviewing the results of all students is appropriate.

Reuse the media
The students can reuse the media they collected in the field to produce a certain end product, for example a website or paper.
According to the questionnaire, both teachers strongly agree that reusing the media would be useful.

Assessing the learning results
After playing the game, the teacher can publish an assessment in the project environment of the students. The teacher assesses the finished assignments, the media produced during the game and the collaboration between the students while playing the game.
Both teachers agree that it would be appropriate to print these results.
Teacher B agrees with the subjects that are assessed. In order for the teacher to assess the game, he suggests that the teacher publishes an assessment of the game template and the game concept.
Teacher A does not agree with the subjects. He misses the criteria to assess whether something goes right or wrong. He argues that the reflection has a function to get insight in whether the students understand the subjects. In order to assess the results by means of grades you need criteria. You can also do a test after the reflection in order to test knowledge.

The program manager argues that the students would like to know on what criteria they would be assessed. All experts agree.

Teacher A indicates that it is very difficult to assess the collaboration between students while playing the game. He argues that the assignments during the game should have ingredients, which function as measurements. When the assignments do not contain these ingredients, assessing the collaboration will not be appropriate. In these circumstances of playing the game, Teacher A assesses collaboration based on observation and intuition. Teacher A suggests that collaboration can best be assessed when the students make plans, divide roles and choose a certain strategy. The teacher can observe whether these plans are conducted. The students can describe this in the reflection reports.

Both teachers disagree on assessing the collaboration between students based on a reflection report written by the students. Teacher B argues that this information will not be sufficient.

6.6.7 Game template

The game template is elaborately discussed by the experts. The game template is a worksheet that guides the students step-by-step through the process of creating the game.

Following the concept developer, the sequel of the steps and order of choices being made by the students when creating the game is important. For him it is not self-evident to start with the choice of the game genre. He argues that the program can determine the game genre, according to other choices the user makes.
However, the group of experts agrees that the chosen game genre and the educational level of the target group of the game determine the choice of gameplay.
The program manager argues that choosing the ‘look and feel’ of the game is a choice that is made in an early stadium of the design process.

The game template asks the student to write and fill in the storyline of the game. The purpose of the storyline is to inform the players about the theme and story of the game. The concept developer argues that the storyline depends on the game concepts and cannot be described in a linear text.
The program manager asks how to describe the game rules. These rules are an explanation for the players of the game. The program manager suspects that this will be difficult for the students to describe.

The tool to test the developed game is discussed by the group of experts. The concept developer asks whether the tools' function will be to get an impression of the game structure or to test whether the game technically functions. Because the tools' function is used to test the structure of the game, the concept developer argues that the rhythm should be tested, whether it is entertaining and whether the result is according to the objective. The structure and chosen game scenario and gameplay can be tested and changed easily.

The concept developer argues that the students would enjoy designing avatars for the program in general and attaching this image to the games they finished and publish in the archive.

The program manager suspects it will be difficult for the students to decide behind the computer how large the playground of the game should be and what the distance should be for the players to walk during the game. The concept developer argues that the program should generate the size of the playground automatically, based on the indication of the user.
In order to produce the game, you should go outside. The student should trace a route and collect media. The media will automatically be attached to the location on the digital map.

Selecting the map within the game template and adding media to the digital map should be a visually manipulating interaction style, with dragging and dropping the media on the map. The prototype is designed for the students to fill in the coordinates of the location the media will be attached to the digital map. The conceptual developer argues that filling in coordinates is unnecessarily complicated for the user. It should not be a problem to show the coordinates on the user interface, if that is needed by the user.

6.7 SUMMARY

Chapter 6 described the results of the formative evaluation. The prototype of the web-based application Games Atelier as developed during this research project is evaluated by a group of teachers and experts of the organization Waag Society, according to the acceptability and usability checklist and the 4E-model. The main goal of the formative evaluation is to improve the quality of the program under development, to investigate to which extent the users consider the intervention as appealing and usable and assess how well the design or particular aspects of it satisfy users' needs. The outcome of this evaluation provides answers to the research question: *How can the user needs, user experience goals, usability goals and user, usability, context and functional requirements be translated into the functionalities and graphical user interfaces (GUI) of Games Atelier?*
The most crucial findings of the formative evaluation concern the following topics: introduction pages of the game, adapting games that are created by others, the project environments, and the game template, coaching the students and assessing the learning results.

The introduction page of each individual page provides the introduction text, the visual preview and the shortlist of facts. In the prototype the introduction page starts with the longer text and this shortlist with facts is at the bottom of the page. One teacher agrees that the information as provided is complete and would be useful for the teachers and students. The educational expert from Waag Society indicates that the introduction page should begin with the list of facts and that the visual preview should be integrated with the facts. Furthermore, the order of the list is very important. The list should start with the fact that includes the most important information for the teacher.

The teachers strongly agree that adjusting finished games, made by other users, will be useful. The adjusted game should be saved as a new game and the original game should always remain available within the archive. The experts of Waag Society argue whether adapting each others games would be appropriate. When only small aspects of games are adapted to the preferences of other users and published in the archive, there is a risk that the archive will eventually contain games that are all similar to each other.

Both teachers appreciate the individual project environments for every single game. The project environment is especially useful for organizing the project, storing the learning results and support communication concerning the project. They find the information provided sufficient for the students when designing and developing the game. One teacher argues that the program should provide the students with text that is adapted to the educational level of the student.
The teachers are supplied with a project template that supports them to initiate and organize a project environment for the students. One teacher agrees that only teachers initiate the project, while students make the game, but the conditions will be determined by the teacher. The other teachers prefer the students to have the freedom to explore the program and initiate the project on their own.

The project environment provides the students and teachers with an e-mail application and a news bulletin, for the teacher to post news messages. Especially the news bulletin is appreciated by both the teachers. One teacher arguments that most schools already make use of e-mail applications and that an e-mail application integrated in the program Games Atelier will not truly be necessary.
The program manager of Waag Society argues that an integrated e-mail application would be appropriate, because this organizes the communication about the project in one place. When the students work on the project, they will immediately notice that they received mail about the project. There is no need for the students to login to another e-mail program and get unnecessarily disrupted from their work.

The teachers can upload information resources and publish hyperlinks in the project environment of the students. These resources can the students use when creating the game. The teachers indicate both that they want to upload external web links, word documents, PDF documents, pictures, video's, excel sheets, and audio records or MP3 files. All experts are enthusiastic about the concept of uploading information resources within the project environment.

The game template supports the students step-by-step in developing the game. These steps and choices can be made randomly. The educational developer argues that because the students need to make choices in order to select and develop a certain game genre, careful consideration is required for what choices the students have and what is to be decided by the program and the teacher. The concept developer argues that it can also be decided for the users to fill in what they want to learn within the game, and that the game format is automatically generated by the program. Than the students will have less freedom to develop a game scenario that they personally enjoy the most, but perhaps it will be easier to use.

The web-based application supports the teacher in coaching the students from a distance while they play the game. The teachers can view live registration of the trace, the media collected in the field and the answers to the assignments. Furthermore, the teacher can contact the students by means of a text message tool and calling them. Both teachers appreciate using a text message tool to coach and steer the students from a distance and both agree that the live registration of the location-based activities would be appropriate. Teacher A argues that it would be useful to help the students in solving difficult and ill-formulated questions.

One functional requirement is that the program should support the teachers in assessing the learning results. The program provides support in the project environment, where assessment criteria and

eventually the assessments are published, and the opportunities for the teacher to monitor the activities of the students when creating and playing the game. The teacher assesses the finished assignments, the media produced during the game and the collaboration between the students while playing the game.
One teacher indicates that it is very difficult to assess the collaboration between students while playing the game. The teacher suggests that collaboration can best be assessed when the students make plans, divide roles and choose a certain strategy, and describe this in the reflection reports. The teacher can observe whether these plans are conducted. The assessment can be based on observation and intuition. In general, the teachers strongly agree that the program in general is easy to use for both the students and the teachers.

In the following and final chapter the conclusions that can be drawn from this research project will be discussed.

7 CONCLUSIONS AND RECOMMENDATIONS

The following section describes the conclusions that can be drawn from this research project. The main goal was to determine the design principles, functionalities and user interfaces that are most suitable for the target users of the constructivist program Games Atelier.
First the program will shortly be described, together with the main research question which has been investigated during this research project. Secondly, the research question will be answered by describing the main characteristics of location-based mobile games, mobile learning and game-based learning and the conceptual design of the program Games Atelier as designed during the research project. Finally, recommendations will be stated for future investigation on the Internet-based learning environment Games Atelier.

Games Atelier is the first learning environments in its kind to be developed with and for secondary education in the Netherlands. Within this Internet-based learning environment, students and teachers of the secondary school create, play and view location-based mobile games. The research project is conducted in commission of Waag Society, the organization which developed Frequentie 1550, the first educational location-based mobile game in the Netherlands. Their experience in developing this location-based mobile game is reflected in the design of Games Atelier. The program is supported by GeoWorx, which is context-aware software developed by Waag Society. This innovative and unique technology contains Geotracing functionalities that enable users to experience just-in-time enhanced authentic experiences in a user-friendly way.

Because learning by means of location-based mobile games is a relatively new area in the field of educational science and technology, the design principles, but also the design and research approach will be informative for researchers interested in designing a similar learning environment to support learning by creating and/ or playing mobile location-based games.
The use of context-aware, locative and mobile technologies satisfies a general demand of a market that is larger than the educational practice and research area alone. The daily life of the global society gets more and more involved with and dependent of interactive computer technology. The computers evolve and become more intelligent and mobile. For journalistic purposes for example, it can be attractive to use context-aware applications to sent news items from the ‘crime scene’ directly to the mobile devices of the news consumers by means of locative devices.
Games Atelier as a constructivist learning environment enables students to produce digital media and share this media with peer students. The digital and locative media is embedded in game scenarios, which turn the outdoor location in a gaming field. Games Atelier can be highly interesting for secondary schools in the Netherlands. Secondary education is in need for learning methods that fit the personal interest of the contemporary students, which are designed according the constructivist learning theories. Playing the mobile game fits the interest of the students, which was also confirmed by the user study in this research project, and fits the modern learner-centred and flexible education practice. Constructivist learning elements that are reflected in the program Games Atelier are learning by constructing artefacts, in collaboration with others, and learning in an authentic context.

The GeoWorx platform which supports Games Atelier is a technological platform that combines KeyWorx and Geotracing functionalities. The tools provided by the GeoWorx platform are real time communication, locative and Geotracing functionalities, Content Management System and Web 2.0 social networks. The platform exists of three different parts, which are the community, the web-based environment and the location-based mobile application.
In order for the students to collaboratively create and share the game, they make mainly use of the web-based environment on the personal computer. The web-based environment provides the students and teachers with a course management system that supports some aspects of course preparation, delivery and

interaction and allows these aspects to be accessible via a network. The community as supported by the Web 2.0 social network enables the users to share the produced games with others.
In order for the students to play the location-based mobile games, they are provided with mobile and computer-based application. The technology used to support the location-based mobile game, is Internet, GPS-technology and mobile phones (UMTS), combined with Geotracing functionalities. The web-based application and mobile application both contain Geotracing functionalities, multi-user gameplay functionalities and real time communication.
By means of locative and tracing functionalities people can be traced with a dynamic map of the area and voice and image recordings can be added to these traces. The trace and records added to this trace is automatically saved on the Internet.
These functionalities enable both teams to cooperate from a distance, communicating and sharing digital media. The mobile device will be used to collect information from the environment by means of video, photo, text-based or voice-recording, to receive instruction or assignments just-in-time, linked to the location where the learner is at, and collaboration between mobile and computer-based students. Because the trace and records added to this trace is automatically saved on the Internet, the users are able to view the results of their activities within the Internet environment.

During this research project, a user-centred interaction design approach has been applied to iteratively develop a conceptual design for the program Games Atelier. The intended users, which are the students and teachers of the secondary school, have been involved from the start of the project. During the analysis phase, the needs of the users were analyzed and data was collected by means of user scenarios as written by the teachers, an observation session and six workshops. In total, three prototypes have been developed and tested. The first prototype is a location-based mobile game. During the conceptual design phase, the second and third prototype has been developed. The second prototype consists of three moodboards, reflecting the possible 'look and feel' of the user interfaces and the third prototype is a low-fidelity design of the web-based application of Games Atelier.

The research project resulted in a prototype of the web-based environment which supports the students in creating and viewing the location-based mobile game. Only when the students and teachers are properly supported by means of information and cognitive tools in the web-based application, they can construct a location-based game that offers effective learning opportunities to the students who play the game.
The most important features of the Internet-based learning environment, as designed during this research project, are the archives in which the games are stored and can be shared, the project environments, which supports collaborative learning while creating the games, and the project and game templates, which are multimedia tools that support the students and teachers in organizing the project and creating the location-based mobile game. Reviewing on the learning results of creating and playing the game is supported by means of a trace video and dynamic answer sheets.

Main research question

The design of Games Atelier captures the needs and requirements of the students and teachers and has been embedded in state-of-the-art literature, in order to determine validated design principles for the program and location-based mobile games that can be created in Games Atelier.

This research project leads to answering the following main research question:
What are the design principles for an effective Internet-based learning environment in which students and teachers of secondary schools in the Netherlands can make, play and view educational location-based mobile games?

Before the discussion of these design principles, first the most important characteristics of location-based mobile games, game-based learning and mobile learning will be illustrated.

Main characteristics of educational location-based mobile games

For designing a learning environment that enables students to produce and play location-based mobile games, it was most important to understand the main characteristics of these games.

Location-based mobile games as provided by Games Atelier are game-based lessons in an authentic context, related to the learning goals of the school. When playing the game, the students collaboratively solve problems and obstacles. Location-based mobile games combine the virtual domain of the computer and the physical and social aspects of the real world. The games are played outside the classroom environment and uses personal computers in combination with context-aware mobile devices. Computers and mobile devices can complement each other. The game is played by teams, divided in home teams using the personal computer, and mobile teams using mobile context-aware devices. The home and mobile teams cooperate together during the game.

Both teams receive different assignments, based on that location. In order to build knowledge that is meaningful to the students, the learning activities are closely related to authentic environments and students reflect on their own learning results. In order to solve the authentic problem, the mobile team searches for information on location, in close cooperation with the home team, which search for information on the Internet. Both teams are supplied with a mobile phone. In order to collaborate, they can call each other, or use video conferencing.
The home team is supplied with Geotracing functionality. The digital map displays the exact location of the mobile team and enables the home team to monitor the mobile team and visualise the authentic context of the mobile team, in combination with the just-in-time information and the voice calling. The teacher is also supplied with this Geotracing functionality, in order to monitor and coach the mobile teams from a distance when needed.

The most appropriate didactical approach is problem-based learning. Problem-based learning prescribes ill-structured and authentic problems to be solved collaboratively, analyzing the problem from multiple angles. The authentic location serves as the problem-context. The problems received are closely related to this location and information and cognitive tools are presented to support the student. The assignments are challenging and the support fades while students progress in the learning activities. The information as received on location enhances the reality. Because the mobile team solves the problem by analyzing the real-world location, the digital information they receive contains information they cannot find on location, but is necessary to solve the problem. This can be video, text, pictures or illustration, or cognitive tools like simulations or determination tables.

Main characteristics of mobile and game-based learning

The location-based mobile game encompasses characteristics of mobile learning and game-based learning. Mobile learning supports learning in the authentic location, when the students are most motivated to learn. The game-based learning principles support the intrinsic motivation of the student, but also support collaborative learning.

Within Games Atelier, Geotracing functionalities obtain context-aware abilities, and mobile devices are used to collect and receive data in the authentic environment.
Most mobile devices have special functionalities, like photo cameras and video cameras, which support collecting data and information of the authentic environment. This data can be shared easily with other mobile devices or computers. Context-aware devices deliver educational contents on the right place and the right time and support just-in-time pedagogy. The students receive learning objects within an authentic location when they need the support the most. Therefore, the students are more motivated to learn, while

the concepts are most meaningful to them. While the learning is triggered by the educational content, the authentic location functions as real-world examples and illustrations of the abstract educational concepts. Within mobile learning, the mobile devices and computers are used complementary. Data can be shared easily between the PC and mobile device. For certain activities, like writing documents or exploring the Internet, the PC is better usable. Within Games Atelier, the home team can search for information on the Internet, using the personal computer.

Games Atelier is designed according the principles of constructivism and active learning. Intrinsic motivation is from severe importance for flexible and learner-centred learning environments, because the initiative for learning lies with the students and not with the teachers. The students should be willing to engage in the learning activities in order to learn effectively. Intrinsic motivational elements relate to the personal interest of students. Videogames possess characteristics that are highly motivational for students. Researchers have analyzed the motivational aspects of videogames to apply these to the design of learning environments. According literature study, the structural and intrinsic motivational aspects of games are rules, gameplay, a storyline, one clear final goal and subtasks that contribute to reaching this final goal, challenging and pleasantly frustrating problems, levels, direct feedback, speed and competition and a non-linear structure. These aspects are the base elements of the game template, which is a multimedia tool that supports the users in designing the location-based mobile games. The user analysis as conducted during this research project confirms the interest of students in playing videogames, but also in using the mobile phone and sharing media by means of Internet. These activities are all combined within the program Games Atelier.

Design principles and the related functionalities and user interfaces of Games Atelier

In conclusion of this research project, it can be stated that the most important design principles for the Internet-based learning environment Games Atelier are the following: the program should support the students in collaborating together and constructing the games, offer students personal control over the learning activities and support the students in learning independently, challenge the students while offering problems and support that fits their personal level, provide direct feedback during and after the learning activities, offer experiences that are intrinsic motivating, and support the students and teachers in reusing the data, media and learning objects that are produced within the learning environment. Table 38 gives an overview of these design principles.

Tabel 38: The design principles for Games Atelier

Design principles
Support social learning
Support learning by producing
The students have control over the learning activities
Support students to learn independently
Challenge the students while offering problems and support that fits their personal level
Give direct feedback
Intrinsic motivating
Reuse of the learning objects

In the following section the design principles will be discussed elaborately and related to functionalities and user interfaces that are included in the conceptual design of Games Atelier. The design principles, functionalities and user interfaces account for the program supporting the students creating, playing and viewing the games. At the end of the research project, the functionalities were evaluated by teachers of the secondary school.

It was already discussed that from most importance for constructive learning environments are the support of learning by discoursing and constructing artefacts. Following the constructivist learning theories, students build knowledge actively when they are involved in producing artefacts and/or discoursing this knowledge together with others. Therefore, the program Games Atelier is designed in order to support collaborative learning and to support students to construct location-based mobile games themselves.

Support social learning

The Internet-based learning environment Games Atelier embeds every individual game into a project environment. The project environment is especially useful for organizing the project, storing the learning results and support communication concerning the project.
The project environment offers the students with information about location-based mobile games, and tools that support collaborative learning. The game is made by a project group which shares the project environment.

To support collaborative learning, it is from most importance to divide the roles of creating and playing the games over the heterogeneous group of students. This way, the students have their personal responsibilities; the students will execute tasks that fit the personal knowledge and interest. The students can learn from each other and discuss the problem from different angles.
The program Games Atelier stimulates the division of roles while creating and playing the game, by informing the students and teachers in the project environment and divides the roles automatically among the students. Furthermore, the students and teachers who create the game are advised and informed how to design assignments that obligate the students of the home and mobile teams to collaborate together. Also gameplay can stimulate students to negotiate and collaborate together.

Games Atelier supplies the students with communication tools that support collaborative learning. When creating the game, the students use e-mail application to discuss the learning activities, besides face-to-face discussions. E-mail has the advantage that students can read and react to the message in their own time and pace. The teacher is supported in coaching activities by means of the e-mail application and a news bulletin. This way the teacher can post news messages in the project environment.
According the formative evaluation session, especially the news bulletin is appreciated by the teachers. An integrated e-mail application would be appropriate, because this organizes the communication about the project. When the students work on the project, they will immediately notice that they received mail about the project. There is no need for the students to login to another e-mail program and get unnecessarily distracted from their work.

While playing the game, the students use mobile devices and an instant text messaging tool to collaborate. Mobile devices facilitate collaborative learning from a distance, by means of voice calling, video conference and text messages. According the evaluation, teachers appreciate using a text message tool to coach and steer the students from a distance.

Support learning by producing

When the students develop a location-based mobile game about a certain subject matter, they practice cognitive skills, like analyzing and relating knowledge. They need to stand above the knowledge in order for them to teach their peer students about these topics. The learning process while constructing the game is more important than the end result of the game.
It is from importance that students understand how to make a location-based game themselves and how to write meaningful assignments to accomplish learning goals as stated in one of the functional requirements. The developers must understand how the game can teach peer students about a certain topic which is

related to the real-world environment. Students and teachers must write these assignments and develop the information and digital media that supports the players when solving problems on location.

Developing the game is supported by a multimedia tool, called the game template. The game template offers step-by-step support. It was important for Games Atelier that developing the game requires no technical skills, because the focus should lie on the knowledge construction. According the formative evaluation of the prototype, the game template is considered easy to use by the teachers. The students can fill in or upload data to the game template, which the program generates into the web-based and mobile user interfaces of the location based mobile game.

The structure of the game template reflects the structural and intrinsic motivating game elements, according the literature study, which are rules, gameplay, a storyline, one clear final goal and subtasks that contribute to reaching this final goal, challenging and pleasantly frustrating problems, levels, direct feedback, speed and competition and a non-linear structure.
An important feature offered in the game template is the opportunity to test the game within the program in the form of a trace video, because both the students and the teachers appreciate this functionality according the user analysis. By means of a test video, the structure and chosen game scenario and gameplay can be tested and changed easily. The rhythm should be tested, whether it is entertaining and whether the result is according to the objective.

It is important for the teacher to start the project without many preparations or needs for ICT-skills. The teachers prepare the project environment for creating location-based mobile games using a project template. The project template is a multimedia tool that can be filled in step-by-step.

Playing the game can be considered the same as creating the game. When creating the location-based mobile game, the students should analyse the authentic location and produce the media that enhances the location. This can only be done when being at the outdoor location, using mobile devices.
While playing the game, the students can also learn by producing. This can be achieved by means of the game assignments. The students can be assigned to make videos and pictures in answer to the assignments. Collecting data in the field and producing media is especially suitable when conducting research assignments. During the user analysis, it was emphasized that the teachers have little time to do a project with Games Atelier. Combining the creation with playing the game is a most efficient approach. Also, when the program enables research in different time and places, because the data collected in one time can easily compared with data collected in another time.

The students have control over the learning activities

A much appreciated characteristic of videogames and Internet by students is the fact that they have a non-linear structure and the students can freely browse through the information, providing them with control over the learning activities.
Both the Internet-based learning environment and the location-based mobile games that are made within Games Atelier should be characterized by a non-linear structure. To achieve this, the learning environment is supplied with hyperlinks and search engines.
The location-based games provide the students with a non-linear structure, in order for them to choose their own game strategy and explore the authentic environment freely. Therefore, multiple goals and assignments should be designed. According the teachers during the user study, the assignments should have an open character, in order to stimulate the creativity while playing the game. This open character is reflected in the game template, because students are free to choose the game genre and gameplay out of multiple options.

Support independent learning

Within a learner-centred learning environment, the students learn independent and the teacher coaches the learning activities. Because the teacher will not interfere intensively with the learning activities and the teacher will not have much time to prepare the project, Games Atelier should support the independent learning activities of the students. This way, the program takes over and support tasks of the teacher.

According to the user analysis, the program should provide structure and support with every step the student needs to do. It should support a variety of students with differentiated educational levels, experience with the program and interest. Within the Internet-based learning environment, this structural support can be seen most clearly in the game template. According the formative evaluation session both teachers agree that the program offers enough support in order for the students to carry out the project independently.

Challenge the students while offering problems and support that fits their personal level

According to the literature, students are most motivated to learn, when the learning activities are neither too difficult nor too easy. When the students are being challenged by the problems and the assignments, they enjoy learning the most. Because the target user group of Games Atelier is very broad, the program should adjust the activities, problems and support to the different educational levels of the students. This accounts for as well the Internet-based learning environment which supports the students in creating the game, as the location-based mobile games as played by the students.

The support of a broad group of target users in creating location-based mobile games is accomplished by means of dynamic user interfaces and templates that offers personalized support. The project template that supports the teachers to organize a new project environment, asks the teacher to fill in the profiles of the students who create the game and who play the game. The project environment adjusts to the personal profile of the students who create the game, based on the choices the teacher makes in the template. The teacher can steer the choice of the students when they choose a certain game genre within the game template. The choices will be limited and this should make the choice easier for the students. Also, the teacher can prevent students to choose a certain game genre.

During the research project it became clear that the more experienced students need more personal control and less support and structure than the non-experienced students. Therefore the program adjusts dynamically to the support as needed.
The program should be flexible in the amount of support it provides, adjusted to the skills of the user. To provide this support, the program is suitable for both novice and frequent users, and increased productivity arising from just-in-time support. The teachers and students learn from performing, constructing knowledge without the benefit or necessity of formal instruction.

The creators of the location-based mobile games should adjust the assignments that are offered to the players to their educational level. The creators should understand how to develop educational and challenging problems. Because the skills and knowledge progresses while playing the game, the assignments should be adjusted to this progress in order to stay challenging. This can be achieved by designing different levels, which is a characteristic of videogames.

Location-based mobile games are designed following the principles of problem-based learning. One principle of problem-based learning is that most support is offered to novice students, because solving problems can be too difficult, which is called fading. The more experience is gained the less support is offered. The support offered by the program while playing (as designed by the creators of the game), are the information sources and cognitive tools, together with the coaching endeavour of the teacher. The

mobile and context-aware devices enable the players to receive the support from a distance and just-in-time in an authentic context.

While the students play the location-based mobile game, the Geotracing functionalities enable the teacher to monitor the activities and steer and offer support when the students need it the most. Furthermore, the teacher can contact the students by means of a text message tool and calling them.

Give direct feedback

It can be concluded from this research project that receiving direct feedback supports the learning activities in several ways. Direct feedback can be highly motivating for the students and it support effective learning following the constructivist learning theories. Reflecting on the personal learning activities and the activities of peer students is essential for meaningful learning.

It was emphasized by the teachers who tested the prototyped location-based mobile game, which while playing the game the user interfaces of the mobile and computer-based application should provide the players with direct feedback on the game activities. This feedback should be a time and score indication and confirmation that the media was sent successfully. Especially an indication of the score is perceived as motivating following the literature and user study.

The game activities and data collected in the field while playing the game are stored on the Internet and displayed in a trace video. The answers given by both the mobile and home team are collected and organized within an answer sheet. After playing the game, the students can access the finished assignments and the media collected in the field of all students and use these results to reflect on their own results and the results of their peer students. The students can immediately reflect on the choices they made while playing the game. Supported by the game experience, the learning activities will become more meaningful and effective.

The constructed location-based mobile games are stored within the archive. When students and teachers have played the game, they can comment to it and rate it. This can contribute to higher quality of the games and the feedback on the game makes the learning activities more meaningful for the students who created the game.

Intrinsic motivating

According game-based learning, video games own elements that motivate students to learn. These elements are integrated in the game template. The game template enables the students who develop the game to choose from different game genres and game elements. The game genres that will be chosen depend on personal interest of the students and the learning goals. In practice and according the literature game elements of different game genres will be mixed.

During this research project, the personal interest of the students has been investigated. Most students play videogames regularly, approximately three times a week. Moreover, all involved students own a mobile phone. Audio functionalities, like voice calling, audio recording and MP3 players have been found to be more popular than using text-messages.
When asked, students indicated designing the graphical elements of the user interfaces and the avatars to be the most popular activity of developing the location-based mobile game. These activities are supported by means of the game template. Especially designing avatars is very popular. Avatars are digital representations of the player of a game, most used in role playing games. Furthermore, adventure games and fantasy storylines were popular under the students.

When the teachers were asked to design a location-based mobile game during the user study, they all chose the game to be a research assignment. Supported by the mobile devices, the students investigate an outdoor location and collect data from this location, to be analyzed behind the computer. The research assignments contain less intrinsic motivating game elements.

Reuse of the learning objects

Supporting the reuse of both the location-based mobile games and the data collected while playing the games was a central theme during this research project and therefore is an important design principle for the program Games Atelier. The reuse of the learning objects, being the games or data collected in the field, has different objectives and forms, namely the archives that enables the students and teachers to share the games and data, the data being transformed into an other end product, for example a presentation or website, and research within different time and places.

When the game is finished, the games are stored in the archives and the students who created the game invite peer students to play the game. As confirmed by the literature study, sharing the game makes the learning process more meaningful to the creators. The archives are integrated with search engines, so the users of Games Atelier can easily and quickly find a game that satisfies a certain demand, like learning goals to be achieved when playing the game, target group or subject matter, and improves the efficiency of the program.

Especially the teachers who were involved during this study, emphasized the need for reuse of data as collected in the field, while playing the game. Therefore, the data (text, pictures, audio records or video) can be downloaded from the answer sheets and be reused as learning objects. The students can access the learning results from all the peer students, so they can give each other feedback and learn from the educational contents as collected during the game. Furthermore, this data can be used for making a different end product, like a GIS map or website.

Within this conceptual design of the program Games Atelier, the teachers are allowed to adjust finished games which are stored in the archive by other creators. This way, a location-based mobile game can be adjusted to the individual needs of different classes and enhances the efficiency of the program. During the evaluation, this functionality was discussed by the experts. The teachers agreed on this possibility, but the developers at the Waag Society were afraid that this way the program would eventually contain games that differ very little from each other. This can be solved while making sure that the adapted games cannot be stored again in the archives, only original games. Furthermore, the original creators of the games should give permission to adapt the finished games.

Recommendations

Because this research project is conducted in a limited amount of time, not all subjects that are necessary to design and develop the Internet-based environment Games Atelier could be properly investigated. Therefore the following section describes recommendations for future research projects in this research area.

This research project is assigned by the Waag Society, the organization that will design and develop the learning environment Games Atelier. The design principles and functional requirements which are formulated by means of the research project are meant to be supportive for the design and development process of Games Atelier.

Within this research project, Games Atelier is designed according the user-centred interactive design approach, as described by Preece, Rogers and Sharp (2002). This approach contains five phases for the development of successful interactive products. This research project only incorporated two of the five phases, which are the analysis phase and the conceptual design phase. The other phases, which are the developmental phase, the implementation and evaluation phase, will be executed by the Waag Society. The user centred design approach is described extensively in this thesis and it is recommended to follow this design approach in the further development of the program.

The prototypes as developed during this research project are low-fidelity prototypes. The second prototype that was developed during this research project, which contains the moodboards, can be used to inspire the graphical design of the program. It is recommended to use the moodboard in *authentic* style to inspire the design of the general program, and the moodboards in *fantasy* and *realistic* style to inspire the game interfaces. It is also recommended to use the third prototype that was developed during this research project for further iterative development. It can be used in research sessions with larger groups of respondents, in order to understand better what the most important requirements are, and make these requirements most specific. It is also recommended to design different versions of this prototype, till the requirements are fully crystallized and the program is designed after full satisfaction of the target group. Eventually, an interactive prototype should be developed, that resembles the final version as close as possible.

The group of respondents as informed and analyzed during this research project is relatively small. The small groups of respondents are allowed for such an early design project, but it cannot be stated with great certainty that the design principles which were concluded on are truly valid. Therefore it is recommended to conduct the evaluation and research activities in a later stadium of the design project with a larger group of respondents.

Furthermore, the final prototype was only evaluated by the teachers. Because the program will be used by both the teachers and the students, it is recommended to evaluate future prototypes by both the teachers and the students. The third prototype is evaluated according the 4E-model (Collis & Moonen, 2001) which predicts the possibility of implementing an innovative interactive program in the educational practice. This model is described extensively in this thesis and it is recommended to use this model in the implementation phase of the program Games Atelier.

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