Location Based Games Authoring in Education

1 Introduction

The rapid spread and integration of mobile devices, wireless networks and GPS technology have created a technological platform for location based services, including games that rely on real-time information about players’ location to control game flow and deliver context-aware player experiences.

Education seems a promising application area for such Location Based Games (LBGs), as they potentially combine the virtues of Mobile learning and Games based learning, which both have been extensively researched and discussed in the literature in recent years. Comprehensive literature reviews are given by Naismith et al. (2004) for mobile technologies and learning, and by Kirriemuir and McFarlane (2004) for games and learning.

However, while the technology has been available for some years, and was predicted in 2000 to appeal to a mass market audience and generate $26 billion by 2005 (Forrester, 2000), LBGs are still relatively unknown to the wider public and have been used in schools only in isolated instances, usually in the context of small-scale research projects (e.g. Chen et al., 2004; Cheung, 2003; Facer et al., 2005; Halloran et al., 2005; Klopfer et al., 2004; Rogers et al., 2004; Schrier, 2006).

Learners were typically assigned a user role in these projects, playing LBGs to acquire subject knowledge or to scaffold other learning activities, often in a cross-curricular context. Where researchers employed participative design methods (e.g. Verhae et al, 2006), learners additionally contributed to the design of LBGs, but again in a user or domain expert role without actually making design decisions themselves.

While playing LBGs for instructional purposes has strong theoretical groundings, constructivist and constructionist conceptions of learning suggest that it would be even more valuable for learners to switch from a consumer role to a producer role and actively develop games themselves (e.g. Kafai, 2006, Hayes and Alex, 2008). While in the past this has been problematic because low-level LBG development requires considerable technical knowledge and programming skills (cf. Girardin, 2005) that are considered far too complex for the average teacher or student to handle (Johansson and Winter, 2008), there are now mature and feature-rich high-level authoring tools available that hide technical implementation details and enable school children to build their own LBGs (e.g. Mscape, 2009, 7scenes 2009).

This literature review aims to inform the development of an LBG authoring tool for secondary school children and their teachers. It first explores educational aspects of LBG authoring by considering possible educational uses of LBG authoring mapped to learning theory and described in the literature, and then looks at existing authoring tools and design studies for LBGs and other location based experiences to derive design guidelines based on previous research and experience.

The two leading questions in this review are:

1. How can LBG authoring support learning, and how can it be integrated with educational practices?
2. What design recommendations can be drawn from existing authoring tools for location based experiences?

To answer these questions, this review draws on a wide range of studies, research reports and meta-research relating to LBGs in educational contexts, as well as the wider literature on mobile learning and game based learning where appropriate. Reflecting the emergent character of the research field, the review uses not only material published in books and peer-reviewed journals, but also includes conference presentations and technical reports produced by research groups and other agencies informing and advancing LBGs in education.

2 Definitions

2.1 Game

Games are being researched in a wide range of contexts, all of which offer different perspectives and have their own, sometimes conflicting, definitions and terminologies, e.g. Orwant (2000), taking an anthropological perspective, defines *game* as all leisure activities that are not play or sport, with play having no explicit goal and sport involving a test of physical ability, while Prensky (2001), taking an educational perspective, understands game as a subset of play that is organised and helps us to learn. Further complicating the discussion is the cleavage between narratologist and ludologist understandings of *game*, with the former emphasising representation and narrative structure and the latter focusing on the underlying abstract rule systems. In addition, while *play* has been called the primary formative element in human culture (Huizinga, 1950), games are understood differently throughout different cultures and what might be considered a game in one country might not be considered a game or even appropriate in another country (Hinske et al. 2007). Acknowledging that there is no universal understanding of what constitutes a game, this section only seeks to clarify how *game* is understood in the context of this review.

Given that LBGs are a relatively new phenomenon with many unexplored possibilities, a wide definition of *game* is used throughout this review, synthesised from Dempsey et al. (1996), Fabricatore (2000), Prensky (2001) and Hinske et al. (2007), the latter being itself an amalgam of definitions by Salen and Zimmerman (2003), Lindley (2002), Klabbers (2003), Juul (2003), Costikyan (2002) and Crawford (2003).

A game consists of actors, resources, and a set of structural elements:

- Framework of agreed constraints and/or rules
- Challenge and/or opposition and/or competition, either with oneself or others
- Management of resources and/or time
- Pursuit of objectives and goals
- Outcomes and Feedback
- Representation or Story

This definition excludes 'Emotional attachment' which is mentioned in some other definitions, usually in the context of video games and entertainment, as it would unnecessarily narrow down the design space for LBGs in education, for example in the context of serious games (Abt, 1970).
2.2 Location based games

This review uses *Location Based Games* (LBGs) as an umbrella term for mobile games that use the geographic position of players to control game flow and determine player success with respect to challenges and objectives. Depending on the type of game, player positions can be interpreted either absolute in reference to the real world, or relative in reference to a virtual playing field:

- **Context-dependent** games interpret player positions absolute and are embedded in a specific geographical area. They reference specific objects and places in that area and cannot be transferred to another geographic area. For example, Treasure-Hunt is a context-dependent game genre, and specific treasure hunts only make sense in the specific location they are written for.

- **Context-agnostic** games interpret player positions relative to a previously agreed virtual playing field. They do not reference real objects or places in a specific location and can be transferred to any other geographic area large enough to accommodate the virtual playing field. For example, Maze is a context-agnostic game genre, and specific maze games can be played in any location large enough to host them.

In contrast to Kampmann (2005), who proposes that “a location based game is a game that includes relative or absolute but static position/location in the game rules”, the definition used here does not require positions/locations to be static, thereby extending the design space for LBGs to include rules based on the position of moving objects and/or players relative to each other, e.g. in multi-player LBGs.

Various technologies can be employed to determine geographic position, including GPS\(^1\), sensor-based technologies, and triangulation of wireless network signals. While Laine and Joy (2008) identified RFID\(^2\) as the most commonly used technology in pervasive learning environments, this review focuses on GPS due to its low cost and ubiquity in modern mobile phones, PDA’s\(^3\) and discrete GPS units. In contrast to RFID, GPS requires no tagging of the physical environment, works over large distances, and supports navigation between points, which make the technology suitable for large-scale outdoor pervasive experiences. Unless otherwise stated, design guidelines for LBG authoring tools therefore assume the use of GPS technology to define locations and track player positions.

2.3 Class, genre and game

Mirroring the problems in formulating a universal definition for the term *game*, the literature offers no universal taxonomy of games and often uses fuzzy and inconsistent terminology in describing and classifying games. Björk et al. (2003) observe that in the literature taxonomies of games often are simple genre collections, with the definition of genres strongly depending on the popularity of various games. For the domain of computer games, Crawford (2003) suggests that no correct taxonomy can be formulated due to the great variety in computer games. In the domain of video games, Apperley (2006) talks of a “fragmented genre-based approach” and relates classification problems to tensions between narratologist and ludologist understandings of games.

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\(^1\) GPS: Global Positioning System

\(^2\) RFID: Radio Frequency Identification

\(^3\) PDA: Personal Digital Assistant
Aiming to simplify the discussion of LBGs and LBG authoring tools, and expressly without any claim of universality, this review uses the terms class, genre and game at different abstraction levels as shown in Figure 1:

![Abstraction levels for the terms class, genre and game as used in this review. Examples on the Game level refer to games developed for the LocoMatrix (2009) platform.]

Figure 1: Abstraction levels for the terms class, genre and game as used in this review. Examples on the Game level refer to games developed for the LocoMatrix (2009) platform.

### 2.4 Authoring tool

There are different design and development processes for LBGs described in the literature, with phases ranging from ideas generation and storyboarding to simulating, testing and deploying games, all of which potentially could be supported by an authoring tool. Without preempting any findings regarding design guidelines, the term authoring tool in the context of this review implies the minimum requirement of being able to generate a readily playable LBG (as opposed to a non-functional design artefact).

### 3 LBG authoring in education

This literature review in first place looks at LBG authoring in educational contexts, however, it would be problematic to separate that completely from LBG playing. Firstly, exploratory field trips (e.g. to collect media) and LBG playing (e.g. to test a game) are integral parts of the development process. Secondly, students developing LBGs in school need to tailor the experience to the needs of a specific target audience (e.g. younger students) and therefore think carefully about the player experience. The relationship between authoring and playing is therefore not mutually exclusive but containing, and LBG authoring cannot be looked at in an educational context without also considering aspects of LBG playing.

The following sections relate the specific qualities of LBG authoring to learning theory, explore pedagogical approaches, and discuss potential barriers to LBG authoring in schools.

#### 3.1 Theoretical grounding

**Learning in authentic context-rich settings**

The notion of authentic, meaningful, context-rich learning situations resonates with a range of modern learning theories. Situated learning theory addresses the separation of school learning from experience and cognition outside the school. It suggests that learning is a function of the activity, context and culture in which it occurs (Lave, 1988; Brown et al., 1989). As learning processes are inextricably
linked to, and located within, a particular context, learning is more effective in context-rich authentic settings than in school settings (Brown et al., 1989; Engeström, 1991). Closely related, Cognitive Flexibility theory is concerned with learners' ability to transfer their knowledge to new contexts, typically from a theoretical school setting to a practical out-of-school setting. It proposes that effective learning is context-dependent and that learners must be given the opportunity to construct their knowledge from concrete and detailed experiences in order to gain a deeper, multifaceted understanding, which in turn enables them to transfer skills and knowledge to other problem domains (Spiro et al., 1988).

These ideas sit well with authoring and playing LBGs for educational purposes. Context-aware games in particular enable students to explore topics in authentic settings and to relate information delivered through their handset to the real places and objects around them. For example in *Riot! 1831* (Reid et al, 2005), an interactive audio drama based on the riots in Queens Square, Bristol, England in 1831, players walk around the historic square and through their movement trigger the playback of various audio clips on headphones connected to a PDA. Instead of learning about these events in an out-of-context setting like a classroom, participants in *Riot! 1831* learned in-situ and therefore were able to directly relate the audio information to the real, authentic place they walked in, resulting in empathy with the people involved in the riots and a sense of walking in their footsteps, as reported in interviews with participants (ibid).

Context-agnostic LBGs, too, can help to make the learning experience more authentic and meaningful. For example in *AmbientWood* (Rogers et al., 2004) and *Environmental Detectives* (Klopfer et al. 2004), players carry out contextualized scientific enquiry including taking samples on site for later scientific analysis. Doing this in an authentic naturalistic environment (as opposed to a school lab, or just using samples provided by a teacher) adds valuable context to the overall scientific enquiry and makes the learning experience more authentic. Even enacting concepts on a bare field in multi-player LBGs, where learners have to use their imagination to make the experience credible, can add authenticity, as time, chance and spatial relationships between actors come into play. For example in *Savannah* (Facer et al., 2005), a research project that aimed to encourage the development of children’s conceptual understanding of animal behaviour, players pretended to be lions in an outside playing field, interacting with a virtual Savannah and exploring the opportunities and risks to lions in that space.

**Learning through collaboration and cooperation**

Collaborative learning, where students discuss and test concepts, ideas and processes, negotiate meaning, and together construct new knowledge relevant to their common task, is now widely accepted to be more effective than individual learning. Grounded in social learning theories, it draws on Bandura’s (1977) and Vygotsky's (1978) ideas of learning through communication, social interaction, and imitation, Lave and Wenger's (1990) idea that the focused exchange of ideas amongst peers engaged in the same learning activity helps them to develop a deeper understanding of the subject, and Kolb's (1984) idea that reflection, triggered and supported by feedback and discussions with co-learners, helps to conceptualise experiences and drive experiential learning.

As game development is a complex, multi-layered process involving a wide range of artistic and technical skills (Crawford, 1982), especially when it involves merging virtual content with physical spaces (Stenton et al., 2007), LBG authoring in educational contexts typically involves cross-curricular projects with collaborative and cooperative learning activities. For example, in *Mudlarking in Deptford* (Futurelab, 2006) 11 to 14 year old students set out in small teams to test an interactive
experience and add their own material to it. The project report notes that collaboration between students happened not only inside groups, but also between groups, as students talked about their experiences, gave feedback to other groups about their interactive tours, and shared information about hidden experiences (ibid).

The emphasis on cross-curricular, collaborative activities is also pointed out in Loveless et al.'s (2007) Create-A-Scape evaluation report, which mentions as key findings that LBG authoring projects tended to integrate different curriculum areas and offered opportunities for collaboration at various levels, ranging from paired activities in tutorial classes to whole year groups and even clusters of local schools.

In multi-player LBGs the game itself often requires collaboration between players. For example, in CatchBob! (Nova et al., 2005) groups of three team-mates have to find a virtual object and surround it with a triangle, requiring them to communicate and work out a common strategy, while in Savannah (Facer et al., 2005) players are part of a lion pride and have to work together to survive.

**Learning by designing and making artefacts**

Constructivist perspectives on learning, based on the works of Piaget (1970), Bruner (1973) and Vygotsky (1978), oppose the idea that knowledge can simply be passed on from one person to other, e.g. from teacher to student (Rieber et al., 1998), and instead understand learning as an active process of knowledge construction through meaningful interactions with the world (ibid). Constructionism (Papert, 1993) takes some of these ideas further and relates them explicitly to artefact creation in technological contexts. It proposes that learning is most effective when learners are involved in constructing a meaningful public product, the result and manifestation of their active experimentation. These artefacts can then serve as a focus in group discussions that offer opportunities for reflection and meta-learning.

These ideas tie in well with authoring LBGs for learning purposes, which gives students an opportunity to develop and externalise their own gaming ideas on mobile phones, a familiar and much-used medium. With 88% of 11-15 year olds in the UK playing games on a regular basis (Ofcom, 2008), 82% of 12-15 year olds owning a mobile phone (Ofcom, 2006), and 58% of 11-15 year olds regarding mobile phones as their preferred gaming platform (Pratchett, 2005), LBG authoring clearly has the potential to be perceived as a meaningful learning activity by school children.

There is a growing recognition of the educational value of design projects (Resnick, 1998) and LBG authoring involves artefact creation at several levels ranging from media collection and preparation to the development of storyboards and finally the LBG itself. All of these stages involve regular discussions and review sessions in class, where students not only talk about the created artefacts but also about the techniques and processes involved in producing them, leading to rich learning opportunities.

**Engagement and motivation**

Motivation is a key concept in most theories of learning, with behavioural theories focusing mainly on extrinsic motivation and cognitive theories looking primarily at intrinsic motivation (Weiner, 1990). Csikszentmihalyi (1990) suggests that the chief impediments to learning are not cognitive, but a lack of motivation and a failure to make learning enjoyable. Motivating learners to engage with a subject is therefore key to creating an environment in which meaningful learning opportunities can arise.
The motivating and engaging aspects of games-based and mobile learning are well documented in the literature. Jones et al. (2006) present no less than six reasons why mobile learning might be more motivating than traditional classroom activities, and the motivational effects of computer games have been recognised and studied for nearly thirty years (e.g. Malone, 1980). Drawing on this research it can be assumed that LBGs, which combine mobile learning with game-based learning, increase motivation and engagement, and in fact most research reports about LBGs in educational contexts (e.g. Cheung, 2003; Facer et al., 2005; Halloran et al., 2005; Loveless et al., 2007; Schrier, 2006) mention increased engagement and motivation as one of the more obvious learning benefits, with positive effects ranging from better participation levels to longer attention spans, deeper involvement and more independent learning.

3.2 Pedagogical approaches

This section discusses the main approaches to LBG authoring from a pedagogical perspective, exploring in which contexts LBG authoring might be used and how it can be matched to subject areas or overarching educational themes and objectives. As the literature search yielded only one single evaluation report of LBG authoring in schools, this section also takes into account research into computer games authoring in educational contexts.

*Computer programming*

Before games authoring software became available that was simple enough for students and teachers to use, computer programming seemed the most obvious educational context for games development, as the creation of digital games necessarily involved programming. In this context, games are seen as abstract rule systems (Salen and Zimmerman, 2003), and are studied in terms of their core mechanics and relationship to other games, focusing on their underlying mathematical structures. Modern LBG authoring tools typically try to shield users from the underlying technical details of games development. While some tools still provide code-based (e.g. Mscape, 2002) or diagrammatic (e.g. InStory, 2005) programming interfaces for advanced users, these seem to play only a secondary role while most of the design and development is done in map-based graphical environments by defining areas and selecting and parameterising generic events and interactions.

*ICT*

LBG authoring in the broader context of ICT education emphasises primarily the technical aspects of games development as students use a wide range of ICTs to collect, manipulate, share and manage resources, and to construct and test games. Hayes and Alex (2008) point out that the motivational aspects of games and game development also have been leveraged to address gender issues in ICT engagement and education, e.g. to get more girls interested in these technologies.

*Literacy education*

Games can be understood as interactive media. As such they have an inherent, although often non-linear, narrative (Burn, 2004), and can be examined from a literary theory perspective. In this context, games are essentially dramatic presentations and can be used to analyse how familiar narrative structures and textual components such as genre, characterisation, and audience are re-formulated in interactive texts (Beavis, 1998). Games in the context of language and literacy learning have been extensively covered by Gee (2003), and form part of the wider discussion about literacy education in the digital age, where communication increasingly shifts towards electronic media (cf. Bazalgette, 2009; Buckingham, 1993; Burn and Leach, 2003; Gilster, 1997; Hofstetter, 1998).
Game design
While game design is often seen in the context of literacy education based on the argument that literacy essentially is about texts as sharable, reproducible human communication, including image texts, moving image texts and interactive texts (Bazalgette, 2009), games can be seen as ludic configurations (Pelletier, 2005) that have their own vocabulary and mechanisms, and therefore should be studied on their own terms rather than from a literary theory perspective (Eskelinen, 2001). Trying to bridge these positions, Burn (2007) proposes the notion of game-literacy acknowledging the specific properties, structures, and semiotic affordances of computer games. However, no instances of game design as an educational activity in its own right (outside specialist schools for game designers) have been found in the literature about LBG authoring.

Other subject areas
By far the widest and most diverse application space for LBG authoring in educational contexts is based on an understanding of games as interactive media (Rollings and Adams, 2003). Here the emphasis is on representation and how the generic structural elements of a game can be realised in different ways, thereby influencing how players find meaning in games. From this perspective, the rule system and core mechanics of a game are just an empty vessel that can be filled with actual content relating to an specific educational contexts. Loveless et al.’s (2007) evaluation report of the Create-A-Scape project found that the LBG authoring tool and resources were used in a wide range of topics, usually in a cross-curricular manner, integrating curriculum areas as diverse as literacy, mathematics, geography, social studies, languages, arts and ICT. Only one of six projects was in the context of mathematics education, and, crucially, the project focused not on the underlying rule system, but on solving practical mathematical problems in an outdoor space simulation.

3.3 Barriers to adoption
The literature mentions numerous issues that can pose barriers to LBG authoring in schools, ranging from simple hardware issues to complex technological and cultural problems.

Technical
Hardware issues, including interoperability standards and battery life (Ley, 2007, Sharples, 2007) as well as inadequate display technology for outdoor use (Futurelab, 2006) can be expected to be resolved in the future as handsets are continually improved and further standardised. Likewise, familiar limitations of GPS, such as reliability under cloudy conditions or next to buildings (Benford et al., 2005; Futurelab, 2006; Ley, 2007) and limited coverage and accuracy (Iacucci et al., 2004; Opperman, 2006) can be expected to be addressed as the technology matures.

While technical issues can be frustrating in individual use, they can become a critical issue for teachers responsible for a whole group of students grappling with these problems. However, users are often able to overcome technical and interaction issues if they find the task itself engaging, as research in other contexts has shown (e.g. Gutwin and Greenberg, 2000). Application developers, too, have shown creative ways to deal with such problems, e.g. Chalmers et al. (2005) have developed a game inspired by Weiser’s (1994) concept of seamful design, where players equipped with a GPS enabled PDA collect virtual coins from outside the wireless network, and then run back into network range to upload the coins and gain points.
**Conceptual**

Conceptual issues include problems thrown up by the outdoor use of mobile devices that impact on the anticipated benefits of this use. For example, one of the key arguments for LBGs is that it supports situated learning in authentic locations, the rich details of which are taken in by players as they engage in the game. This however can be defeated by a phenomenon known as the *heads-down effect* (Lyons, 2009) where users of visually rich mobile applications constantly look at their screen instead of the environment the applications relate to. On a similar note, for mobile applications promoting co-located collaboration, Benford et al. (2005) found that complex interactions between player behavior and the underlying technologies can inhibit players from establishing a shared context, even though they are physically co-located, leading to difficulties in coordinating their actions. Whether these are just user interface issues deriving from bad design or in fact deeper rooted conceptual issues remains to be seen.

**Cultural**

Cultural issues include a lack of relevance to the current curriculum in schools which does not encourage the use of novel technologies like LBG authoring, objections from parents relating to games in general and the perceived inappropriate nature of game content in particular, and teachers’ lack of knowledge about games, platforms and related software (Williamson, 2009). More profoundly, Facer et al. (2005) point out that the use of games is unlikely to sit well with traditional classroom power relations as gamers typically control their own learning alongside more knowledgeable peers and subsequently act as mentors to novice learners, which may require some degree of courage from teachers and some reorganisation of the school setting. In combination, these issues can pose significant barriers to LBG authoring in school.

**Logistical**

Logistical issues include lack of technical support in schools, problems accessing equipment, and considerable costs for handsets and network contracts (Williamson, 2009), all of which pose serious challenges that can prevent the use of games in classrooms and do need addressing.

## 4 Existing LBG authoring tools

The literature describes a number of LBG authoring tools ranging from concepts and design studies to prototypes and fully functional production systems, that can be used to create location based experiences. These tools vary considerably in their approach, scope and functionality, ranging from in-situ to desktop authoring, and supporting different authoring phases ranging from ideas generation and storyboarding to simulating, testing and deploying LBGs.

While there are some recurring concepts like maps based authoring, graphical editing and support for simulations, the tools in general are too diverse to make a meaningful direct comparison. Instead, the following sections briefly describe some of the more prominent authoring tools with the aim of illustrating the variety and breadth of available authoring approaches.

As the review aims to draw design recommendations and guidelines for LBG authoring tools, only authoring tools for which sufficient technical information is available, and which have been evaluated in some form, are described. Not included for this reason are WildMap (WildMap, 2009) and the Games Creation Kit for Environmental Detectives (Klopfer et al., 2004).
4.1 Mscape and Create-A-Scape

Mscape (Mscape 2009) is a collection of tools developed by Hewlett Packard (HP, 2009) and Mobile Bristol (MB, 2009) to create, play, manage, test and share location-based experiences, games and tours. The authoring tool allows non-technical authors to associate physical locations with digital media including video, flash, music, images, text and html. This can be done via a graphical interface (Figure 2b), where authors import maps and media, specify regions on the map, and then drop media content onto the regions where they should be played. More advanced authors can use the built-in scripting language (Figure 2a) to program complex experiences based on trigger events and state variables.

Mscape has a modular architecture that allows technically inclined users to extend the platform, e.g. to add new contexts and drivers for additional sensing devices. A key architectural concept in Mscape is the development and use of the XML-based markup language MBML\(^5\), which is used as a common format to define, share and interpret LBGs (Hull et al, 2004a).

The system has been used in numerous educational projects (cf. Stenton et al, 2007). For example, a trimmed-down version of Mscape was used in the Create-A-Scape (Create-A-Scape, 2009) project which aimed to promote LBG authoring in schools by providing a rich set of high-quality support materials that help to further structure and simplify the authoring process. Teaching materials included tutorials, step-by-step instructions, project ideas, and detailed accounts of other LBG projects, as well as an online community for teachers to share and discuss their ideas and experiences.

The developers of Mscape propose that authors with a broad range of skills and perspectives should be able to explore new applications of the technology, and that the challenge therefore is to keep the authoring interface simple and accessible as the complexity of sensed activity and context states increases (Stenton et al., 2007). Based on their experiences in designing, developing and supporting the Mscape range of tools, they postulate that an authoring tool should support:

- an extensible language for describing context

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\(^4\) XML: eXtensible Markup Language

\(^5\) MBML: Mobile Bristol Markup Language
• the specification of context events and consequences
• a representation of contextual state
• the storage and management of media files
• an authoring interface that allows nonprogrammers to explore new genres of mediascape
• an emulator for testing the contextual states and consequences.

The Create-A-Scape project, and by extension Mscape, was extensively evaluated (Loveless et al., 2007) and led to specific requests for improvements, including:

• ability to associate multiple resources or multiple layers of resources with a given zone
• ability to use other formats including video, html and PowerPoint slides
• easier ways of obtaining maps and images
• transparent map regions

4.2 7scenes and Games Atelier

Figure 3: Screenshots of (a) the 7scenes authoring tool and (b) the player experience. Source: 7scenes (2009)

7scenes (7scenes, 2009) is a commercial platform for creating and playing LBGs and tours with tracing and multi-user functionality as well as real-time communication (chat, messaging). The platform is completely web based, subscribing organisations get their own web space where authors can create, edit, share and discuss LBGs online. The powerful online authoring tool is implemented as a Google Maps application, augmenting the map interface with highly dynamic widgets and forms to describe game content, rules and triggers (Figure 3a).

Games Atelier (Games Atelier, 2009) is an educational project based on the 7scenes platform, promoting LBG authoring for secondary education in the Netherlands. Games Atelier enables students to create, play, share and view LBGs. The website provides a range of educational resources ranging from tutorials and workshops to lesson plans and background information.

The Games Atelier project draws on the work of Veelo (2007) and Pape (2008) who carried out empirical and theoretical research, with the aim to inform the on-going improvement and development of Games Atelier. Their works contain detailed recommendations and guidelines. While most of these recommendations relate to educational objectives and uses of Games Atelier, some of them imply specific functionality for the authoring tool and player software.
Veelo’s (2007) recommendations include:

- Adapt interface to the individual level of teachers and students, based on their educational level, interest and experience with the system (dynamic, personalised interface)
- Offer support to the teacher and students when needed (help-function and tutorial)
- Support the student in reflecting on their learning activities and giving each other feedback (provide a simulation mode and the possibility to trace players for later review).

Pape’s (2008) recommendations include:

- A messaging tool or chat function could be added to enable communication between players, with tool availability possibly being part of the game rules and constraints.
- Players could receive text messages from the system that are not linked to specific locations but give them more information about the story (time-based or random events).
- Players could have to find RFID tagged objects in the streets, which flash on their screen as soon as they get close to them, earning them additional points (RFID sensor support).

4.3 Chawton House Project

Weal et al. (2006a, 2006b) describe their experiences developing an authoring system based on a reusable pervasive information infrastructure at Chawton House Library, a historic building that now operates as a study centre of early English women’s writing and is frequently visited by tourists and schools. The system consists of in-situ (Figure 4a) and desktop-based authoring tools that enable curators and teachers to build up and edit a network of digitally annotated locations on the grounds of Chawton House, and use this material to create visitor tours and augmented literary fieldtrips for students. With a view to better integrate the system with educational practices, the system can automatically record the playing experience in a replay journal (Weal et al, 2007), where challenges and actions (e.g. questions and answers) are logged. The replay journal is used later in the classroom to facilitate individual and group-based reflection, which is a critical aspect of the learning process.

In order to identify requirements for the system, the project used a co-design approach involving two workshops, one with curators and one with teachers, authoring content and location based experiences. Identified requirements include:

- Support for quick and simple ad-hoc authoring to capture new ideas

Figure 4: Screenshots of (a) recording audio in-situ and (b) replay journals used in the classroom to facilitate reflection on the outdoor experience. Sources: (a) Weal et al. (2006b) and (b) Weal et al., 2007.
- Support for in-situ authoring, particularly for context-dependent mobile experiences
- Support for revisiting and refining content; content should be open to ongoing changes.

Observations when testing the authoring tool with teachers and curators include:

- There may be a need at the outset to fill the system with basic content.
- There should be different ways to define locations both a-priori and post-hoc
- There should be an option to ‘relocate’ content after creating it
- The trial confirmed the viability of incremental building up and changing of content
- In a two-phase authoring process, support preliminary audio notes capture in-situ; the notes can later be expanded and typed in on a desktop
- Using the same device for authoring and experiencing tours facilitates rapid development as users can utilize the device as a feedback mechanism

4.4 Geogames Creator

Figure 5: Screenshots of the Geogames Creator authoring tool prototype. Source: Johansson and Winter (2008)

Geogame Creator (Figure 5) is the result of a design study aiming to inform the development of authoring tools for educational games that rely on location-based services (Johansson and Winter, 2008). The emphasis in the project was on user interface design, not on implementing the underlying technical functionality and infrastructure.

With the aim to address pedagogical aspects of LBG authoring and integrate it with formal education, the authors carried out seven design sessions with participating teachers, resulting in a detailed prototype that addressed teachers’ needs and goals.

A fundamental design decision taken early on was to limit possible formats to games that consist of a series of tasks and events triggered at different geographical areas, as teachers agreed that this would be a game design approach simple enough for them to grasp. To avoid restricting the authoring tool to
linear games, the authors introduced an action library that allows conditional branching in narrative and play. Example triggers and control structures suggested by Johansson and Winter (ibid) include:

- onEnterArea
- onExitArea
- onAreaTime
- ifCorrect
- ifFalse

In addition, the authors (ibid) suggest to automate the following design aspects:

- manage geographical coordinates by letting the user mark areas on a map
- manages tasks as questions and answers (with conditional branching)
- manage layout in a WYSIWYG approach (eliminate need to write any code)
- add and manage content from inside authoring tool
- drag and drop to connect media files such as video, sound or text to a geographical area
- user can decide and control when the player should get access to features such as distance measure tool and communication tools
- support emulating a game on a virtual mobile device in order to be able to test it without first having to export (publish) it.
- export (publish) via Bluetooth, serial connection or by sending a text message containing a WAP link

An overview of the Geogame design process is available in Appendix A1.

4.5 Urban Tapestries

Urban Tapestries (Urban Tapestries, 2009) enables members of the public to create an organic local archive of memory and history. Local residents and visitors can add GPS coordinates and associated media items such as pictures, short movies or sounds, either in-situ using a PDA, or on a web site (Figure 6), making the system a dynamic public authoring platform for non-technical users.
Building on the infrastructure of tagged locations, authors are able to create their own threads (paths) through an area, usually consisting of their specific points of interest, and then upload them to the system for others to experience the area in an organised way.

The project has been researched from a range of perspectives including social research, cultural production and interaction design (Lane, 2003; Lane and Thelwall, 2005). Observations and findings with relevance to the design of LBG authoring tools include:

- users wanted to be able to take a call or send a text while authoring / playing
- the map interface was deemed to be problematic, although there was not much agreement amongst participants as to what would make the map interface easier to use
- despite technical problems, nearly all participants responded favourably to the concept of mobile authoring, and expressed a strong desire to engage with it further in the future
- the addition of sound and image capturing would make authoring more spontaneous as events and locations could be 'grabbed' on the fly

4.6 Topiary

![Figure 7: Topiary’s Active Map workspace for designing location based applications. Source: Li et al. (2004)](image)

Topiary (Li et al., 2004) is a high-level tool for prototyping location-based applications, focusing on interaction and user experience rather than technical implementation. The system enables users to create an active map (Figure 7) showing the location of people, places and objects. In addition, the authoring tool supports storyboarding and simulation of mobile experiences. The tool can model indoor or outside locations and is independent of any specific sensing technology.
The authors (ibid) emphasise that the design of location-based applications is fundamentally different from GUI applications, because they have a wider input space and more complex interaction sequences due to additional sensor input and the location-dependent interpretation of user input. In addition, location based applications are more difficult to test because they depend on the location context. The authoring tool therefore offers a simulation mode to make testing easier for designers.

The requirements analysis for Topiary was based on the analysis of a range of different location based applications, resulting in a common subset of functionality:

- display current location
- find specific or nearest person, place, or thing
- dynamically update maps to show location of people, places, and things
- triggers to activate arbitrary functions based on own or other's location
- tagging, associating location data to another arbitrary piece of data

To address these requirements, the authoring tool is split into the three workspaces Active Map, Storyboard and Test. The system was evaluated by a small number of users (eight), the majority of which found the visual Active Map approach easier to understand than textual or logic based approaches.

4.7 M-Studio

M-Studio (Pan et al. 2002) is a desktop based authoring tool for context-aware stories that are viewed in mobile environments. The tool provides authors with a graphical interface to associate video content with geographic locations (Figure 8). In addition, the tool supports storyboarding and simulated located playback to support the design process (described in Appendix A2).

To test and evaluate the functionality of M-Studio, the authors (ibid) designed and produced a location-aware video story. Findings included:

- as context-aware multimedia exists on two platforms, the desktop for authoring and the mobile consuming, it is difficult for authors to imagine and examine multimedia content as viewed in mobile environments while engaged in the desktop-based authoring process
users found the story simulator helpful, as it allowed them to browse through a sequence of clips as they would appear along the game path.

4.8 eDiary

![Figure 9: eDiary with (a) media recording and Atelier environment and (b) Path Creator. Source: Iacucci et al. (2004)](image)

eDiary (Iacucci et al., 2004) was developed for architecture students to record their paths during site visits and map photos and notes to locations. It consists of a mobile tool to record GPS locations, take photographs and notes, and a desktop tool to edit and calibrate the paths for specific maps, and to move and expand notes (Figure 9a, 9b). The tool was not aimed at authoring mobile location-based experiences, but instead was used in multi-media presentations.

The tool was evaluated in laboratory and field studies with various user groups over the duration of one year, informing the on-going development. Lessons learned include:

- it would be useful to be able to combine the multimedia content and path locations of multiple students to provide richer representations of a visit
- editing of paths and multimedia content has proven to be essential in order to integrate the media paths in the ongoing work after the visits

4.9 InStory

![Figure 10: InStory authoring environment comprising (a) the InAuthor graphical story/game editor and (b) the InContent visual editor for creating screen areas. Source: Barrenho et al. (2006)](image)

InStory (Barrenho et al., 2006) is a platform for mobile storytelling, gaming and tours. It focuses on the exploration of cultural and historical spaces, promoting interaction between users. During their explorations, users have access to contextual multimedia, either for knowledge acquisition or for engaging in story/gaming activities together with other users. The authoring environment comprises
InAuthor (Figure 10a), a graphical story/game editor, and InContent (Figure 10b), a visual editor for creating screen areas to be associated with activity nodes created in InAuthor.

Key design objectives for the InStory platform and authoring environment included:

- ability to visually create and edit stories/games
- support for non-linear stories/games
- support for a wide range of media
- support for multiple sensing technologies (GPS, Wi-Fi triangulation, explicit positioning)

5 Design guidelines for LBG authoring tools

This section aims to formulate a set of design guidelines for LBG authoring tools by synthesising the main requirements and recommendations described in the reviewed literature. The synthesis primarily draws the requirements analyses, implemented functionality and empirical evaluations of the authoring tools described in the previous section, but also includes findings from the evaluation of player experiences that highlight the usefulness of specific functionality.

5.1 Support authoring of non-linear games

A common theme in the reviewed literature is support for non-linear stories and games (e.g. Barrenho et al., 2006; Johansson and Winter, 2008; Stenton et al., 2007), an idea that seems to reconcile educational and developer perspectives on LBG authoring: While teachers seem to like the idea of limiting the design space to genres involving a series of tasks and events triggered at different geographical areas (Johansson and Winter, 2008), developers emphasise the need to provide authors with a rich set of tools that enable them to come up with novel applications for the technology (e.g. Stenton et al., 2007).

Johansson and Winter (2008) propose to manage tasks as questions and answers with conditional branching, and suggest providing authors with an action library consisting of basic triggers and events that can be used to design non-linear games where users find their individual path through an experience. In addition, the authors (ibid) suggest that game designers should be able to control when players get access to specific features such as communication tools.

Taking a more technical stance, Stenton et al. (2007) argue for an abstract and universal approach as implemented in Mscape. They propose that authoring tools should offer an extensible language for describing context, specifying context events and consequences, and representing contextual state in a game. Their argument is that while such a programming language requires more initial investment from authors, it offers a far greater design space potentially resulting in richer and more efficient authoring in the long term.

Other ideas for functionality to create non-linear games include the ability to associate multiple resources or layers of resources with a given zone (Loveless et al., 2007), and the option to send time based or random text messages to players during game play that are not linked to specific locations but provide additional information or give feedback on players’ performance to augment the gaming experience (Pape, 2008).
5.2 Support visual authoring

Stenton et al. (2007) call for an authoring interface that allows nonprogrammers to create novel location based experiences. Eight out of the nine tools discussed in this review answer this by supporting map-based authoring as their primary authoring environment, or plan to implement a map-based interface to complement an in-situ authoring tool.

Map interfaces generally seem to be more intuitive for LBG development, as geographic trigger areas can be laid out graphically. The majority of users in Li et al.’s (2004) evaluation found a maps based approach easier to understand than textual or logic based approaches. Only one single evaluation report mentions that users found the map interface problematic, however the same report points out that there was not much agreement amongst participants as to what would make the map interface easier to use (Lane and Thelwall, 2005).

The preference for a visual interface extends to familiar GUI interaction metaphors, e.g. users want to drag and drop media files onto a geographical area, mark geographical areas directly on a map, and manage their layout in a WYSIWYG approach (Johansson and Winter, 2008). As illustrated by the call for transparent map regions in Loveless et al.’s (2007) Create-A-Scape evaluation report, users’ wishes in this respect can be quite detailed and seem to be informed by the use of sophisticated end-user software.

5.3 Support in-situ authoring

A frequently recurring theme in the literature is the gap between desktop based authoring and outdoor, location based playing of LBGs, for example Pan et al. (2002) point out that because context-aware multimedia exists on two platforms, the desktop for authoring and the mobile consuming, it is difficult for authors to imagine and examine multimedia content as viewed in mobile environments while engaged in the desktop-based authoring process.

With respect to in-situ authoring, Lane and Thelwall (2005) found in their evaluation of Urban Tapestries that despite technical problems, nearly all participants responded favourably to the concept of mobile authoring, and expressed a strong desire to engage with it further in the future. The authors point out that functionality to capture sound and images would make the authoring process even more spontaneous as events and locations could be ‘grabbed’ on the fly.

This view is supported by Weal et al. (2006b), who report that curators and teachers found it much easier in-situ to come up with facts and anecdotes relating to specific locations, resulting in richer, more relevant, expressive and lively content than that produced in a desktop authoring process. They suggest that in-situ authoring is particularly suitable for context-dependent mobile experiences, as it allows for quick and simple ad-hoc capture of new ideas. As some activities, like refining text or optimising images, are better suited for a desktop environment, the authors propose a two-phase authoring process with rough and ready in-situ authoring complemented by later refinement and expansion on a desktop (Weal et al., 2006b).

The authors (ibid) also point out an additional benefit of in-situ authoring: using the same device for authoring and playing enables the rapid development of LBGs, as developers can test their games immediately in location and users can utilize the device as a feedback mechanism when testing and evaluating games. In-situ testing is more reliable than desktop based game simulation as it overcomes the emulation gap (Hull et al., 2004b), which is created by the authoring tool emulating an idealized
representation of the real world, free of the noise and uncertainty that distinguishes the real from the virtual and needs to be factored into games to make them work.

5.4 Support simulation mode

Several reports mention the importance of a simulation or emulation mode that enables authors to test LBGs as part of the authoring process without actually being in location. As LBGs have a wide input space and complex interaction sequences involving user and sensor input, functionality for on-the-fly testing is seen as critical.

Stenton et al. (2007) mention an emulator for testing the contextual states and consequences as one of their six basic requirements for LBG authoring tools, and this view is supported by Johansson and Winter (2008), who found in their requirements analysis for an LBG authoring tool that the ability to emulate a game on a virtual mobile device is critical as this enables authors to test an LBG without first having to publish it. These calls are echoed in empirical evaluations with users, e.g. Pan et al. (2002) report that users found the story simulator helpful as it allowed them to browse through a sequence of video clips as they would appear along the game path.

5.5 Support communication

Support for communication while playing or authoring an LBG is often mentioned a common theme in the literature, mentioned in various contexts: It enables students to collaborate remotely while playing an LBG, it allows communication with a central ‘command centre’, and it provides a basis for location-independent messages that can augment the game experience.

Lane and Thelwall (2005) report that users wanted to be able to take a call or send a text while authoring / playing. Pape (2008) in her recommendations on how to improve Games Atelier suggests that a messaging tool or chat function could be added to enable communication between players. She also points out that game authors should be able to control the availability of these communication tools by making them part of the game rules and constraints.

5.6 Support reflection

Reflection is an important part of experiential, project based learning, as it promotes meta-learning and helps students to analyse and conceptualise their own and others’ experience. To aid reflection, classes usually have group discussions after an event, where learners talk about their experience and the artefacts they created.

LBG authoring tools should support this process by providing functionality that scaffolds discussion between learners. For example, Veelo (2007) proposes a simulation mode where groups of learners can simulate a game together, and a tracing tool that traces players’ outdoor actions for later review, while Weal et al. (2007) describe a replay journal that logs players’ actions and later presents them in a journal format to aid reflection.

5.7 Support collaboration and cooperation

Collaboration and cooperation are key aspects of LBG authoring in educational contexts. While this point is partly covered in the design guidelines to support communication while playing and authoring, and to support reflection through functionality to simulate, log and review outdoor experiences, LBG
authoring tools should additionally provide functionality to combine the multimedia content and path locations of multiple students to provide a richer playing experience and to support distributed LBG authoring (Iacucci et al., 2004).

5.8 Support re-use and re-editing of games

Most of the discussed authoring tools support editing of existing location based experiences that allow authors to refine, share and re-appropriate work. Iacucci (2004) reports that path editing has been essential in the eDiary project, which is echoed by Weal et al. (2006a, 2006b) who emphasise that content should be open to ongoing changes to enable authors to revisit, refine, relocate and build up content incrementally. Game paths, too, should be editable, including the possibility to define locations both a-priori and post-hoc (Weal et al. 2006b).

5.9 Support multiple media formats

Support for a wide range of media has a high priority in existing authoring tools and is mentioned as essential in several research reports (e.g. Barrenho et al., 2006; Loveless et al., 2007). While support for text, images and audio seems to be the minimal functionality implemented in most existing authoring tools, some systems offer far more sophisticated capabilities including support for HTML formatted text, various video formats, and Flash files (e.g. Mscape, 2009).

From a user point of view, the list of supported media types and formats can never be long enough, as illustrated by the call for PowerPoint support in Loveless et al.’s (2007) evaluation report of the Create-A-Scape project. The project was based on the Mscape authoring tool which already has fairly comprehensive media support.

While some of these formats would be nice to have (e.g. HTML, Flash), others are based on more fundamental requirements. For example, Stenton et al. (2007) emphasise that in some situations using audio to augment the visual nature of the physical environment is necessary to keep the fusion of the physical and digital in balance and spare users to spend most of their time looking at a mobile device’s screen. This point is also emphasised by Reid et al. (2005), who interviewed 563 people for their evaluation of Riot 1831, and note that in every interview remarks were made on how great the sounds were. Secondary effects, too, can impact on the player experience. For example Riot 1831, which is played using headphones and requires no manual interaction, was evaluated in cold weather and participants noted that they enjoyed the act of 'strolling' and having their hands free: “I did find on a cold day like today it was nice to be able to put your hands in your pockets and not have to hold anything and just listen” (ibid).

5.10 Support multiple sensing technologies

Several reports mention support for multiple sensing technologies in their requirements analysis or their recommendations based on evaluation results. This not only applies to different positioning technologies like GPS and Wi-Fi triangulation as mentioned in Barrenho et al. (2006), but also to other sensor based technologies like object identification as in the example by Pape (2008) where players have to find RFID tagged objects in the streets, which flash on their screen as soon as they get close to them.
5.11 Support adding and managing content

The storage and management of media files is mentioned as a basic requirement for LBG authoring tools by Stenton et al. (2007), and the idea is extended by other authors to include support for the acquisition of content like maps or images from inside the authoring tool (Johansson and Winter, 2008; Loveless et al., 2007). Li et al. (2004) further extend the idea by suggesting that authors should be able to tag content and associate it with multiple locations, while Weal et al. (2006b) point out that it may be useful in some cases to fill a system with generic, re-usable content at the outset.

5.12 Support customisation and personalisation

As an LBG authoring tool may be used by teachers and students of varying abilities and age groups, it is important that users can adapt the user interface to their individual needs, based on their educational level, interest and experience with the system (Veelo, 2007). This not only relates to the layout and availability of tools and functionality, but also the help system as the authoring tool should offer support to teachers and students when needed and appropriate to their level of expertise (ibid).

6 Summary and Conclusions

The aim of this literature review was to explore educational aspects of LBG authoring and to compile a set of design guidelines based on a review of authoring tools and experiences described in the literature. The dual focus on educational aspects on the one hand, and design guidelines on the other hand, naturally divides the review into two parts. While these parts may seem only loosely connected, they are in fact two perspectives on the same problem: enabling students to author location based games in educational settings.

Regarding educational aspects of LBG authoring, the specific research question was:

1. How can LBG authoring support learning, and how can it be integrated with educational practices?

It was found that LBG authoring has a solid grounding in learning theory. As learning takes place in authentic contextualised environments, it resonates with key aspects of situated learning that emphasise relevant and transferable knowledge and skills. Because LBG authoring involves a wide range of different skills, it usually is embedded in collaborative cross-curricular projects offering rich opportunities for social learning where students discuss contents and processes, engage in peer tutoring, and give each other valuable feedback for reflection. These learning activities promote active experimentation and knowledge construction, and result in meaningful artefacts that can scaffold further discussions, as proposed by constructivist and constructionist ideas of learning. Last but not least, LBG authoring offers an engaging and motivating learning context that relates to students’ out-of-school interests, thereby making the experience more enjoyable and removing one of the chief impediments to learning.

Pedagogical approaches to LBG authoring in the main derive from narratologist or ludologist perspectives on games. Based on narratologist understandings of games as interactive media, game authoring can be integrated with literacy education, and by extension with a whole range of other subject areas, as the emphasis here is on representation and how generic game structures can be implemented and made meaningful in different ways. By contrast, ludologist conceptions of games
focus on the underlying rule systems, and game authoring therefore can be a platform for learning about logic, systems design and computer programming. A more perfunctory approach is to focus on the technological aspects of LBG authoring in the context of ICT education.

Balancing the potential applications and benefits of LBG authoring, a wide range of issues have been identified that can pose barriers to its use in education. These include technical issues like interoperability standards, battery life and service reliability, conceptual issues like the conflict between learning in authentic environments and the heads-down effect, cultural issues like a bias against game based learning frequently expressed by parents and teachers, and logistical issues like technical support and the costs for handsets and network contracts. While some of these problems will inevitably be addressed by technological advances, others seem rooted more deeply and will require changes in policies and mindsets.

The second part of this review focused on existing LBG authoring tools and what can be learned from their design and evaluation. Specifically, the second research question asked:

2. What design recommendations can be drawn from existing authoring tools for location based experiences?

To answer this question, a range of authoring tools for location based experiences was reviewed, including design studies and prototypes as well as fully functional production systems. As these authoring tools vary considerably in their remit, approach and implementation, no direct comparison was made. Instead, the tools were briefly discussed, and their specific functionality, design guidelines and recommendations based on evaluation results were identified.

The discussed functionality and recommendations were then synthesised into twelve design guidelines for educational LBG authoring tools:

1. **Support authoring of non-linear games** - provide tools for conditional branching that allow the construction of more complex, non-linear stories and games
2. **Support visual authoring** - provide an interface to visually layout interactive areas and assign triggers, media and activities
3. **Support in-situ authoring** - provide tools for in-situ definition of locations and game paths, including note-taking and recording of different types of media
4. **Support a simulation mode** - provide a simulation or emulation mode that enables authors to test location based games inside the authoring environment
5. **Support communication** - provide tools for ad-hoc communication between players, and tools for authors to control this functionality
6. **Support reflection** - provide tools that support reflection by scaffolding discussions on game authoring and game play
7. **Support collaboration and cooperation** - provide tools supporting collaboration, communication and content sharing between authors
8. **Support re-use and re-editing of games** - use an editable, flexible and shareable format to define games and provide appropriate editing tools
9. **Support a wide range of media formats** - provide support for popular media formats that authors are used to work with
10. **Support multiple sensing technologies** - provide support for alternative sensing technologies that widen the design space
11. **Support adding and managing content** - provide integrated resource management that reduces complexity and the need to switch programs

12. **Support customisation and personalisation** - provide support for customising the user interface according to personal needs and preferences

Together, these design guidelines reflect the most salient points described in the literature on end-user authoring tools for location based experiences in educational and other contexts. Some of the guidelines overlap, for example support for communication, reflection and collaboration are all based on key aspects of social-constructivist learning. Other guidelines can be in conflict with each other, for example support for in-situ authoring conflicts with many other guidelines if not implemented as part of a two-stage authoring process involving both, ad-hoc in-situ authoring and more reflective refinement and expansion of LBGs on the desktop.

In conclusion, LBG authoring seems well suited for educational applications. It resonates with many key ideas in modern learning theory and supports various pedagogical perspectives and subject areas. There are however many potential barriers that need to be overcome in order to realise the educational potential. This review provides a set of design guidelines to inform the development of suitable LBG authoring tools that meet the needs of students and teachers, and thereby hopefully can contribute to efforts to make learning more enjoyable.

**References**


Appendices

Appendix A1: Overview of the geo-game design process

Summary:

1. New project
   - choose map method
     - Google maps
     - custom map

2. New task
   - enter task name
   - define location
   - design the task
     - write text
     - import media
       - image
       - textfile
     - video
     - sound
     - single-choice
     - multiple-choice
     - Q & A
     - text
     - functions
       - communication
         - voice
         - IM
         - video
       - map
       - dist. measure
       - camera
   - choose action
     - Go to new task
   - Game over

3. Simulate game
   - game OK?
     - No
     - Yes

4. Export to mobile device
   - serial cable
   - bluetooth
   - SMS

Overview of the geo-game design process. Source: Johansson and Winter (2008)
Appendix A2: M-Studio design process overview

Overview of the M-Studio design process. Source: Pan et al. (2002)