THE DESIGN OF A LOCATION BASED MOBILE LEARNING SYSTEM INCORPORATING VISUALISATIONS OF BUSHFIRES

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Abstract

This paper describes the design of a mobile game for learning about bushfire behaviour. Cognitive science and Conversation Theory were found crucial to the design and a framework for a mobile learning system was devised incorporating these ideas Examples of other frameworks and mobile location based applications are examined. Aspects of mobile learning using the *Mscape* application and featuring a visualisation are presented, and the Bushfire Safety Mobile Learning System is introduced.

Introduction

The first author, watching his son playing *Zelda* on a Nintendo Entertainment System in 1985 or so realized it would be an excellent way to teach geography. It was a while before games with a large outdoor terrain and an included editor appeared. Home made games made in these editors can be used single player and often multiplayer. Mobile games and applications are limited in their ability to portray 3D. However recent devices run movies very well. Thus one can use a video of a computer game, otherwise a visualisation on a mobile device. However design has to take account of the limited size and capacity of the device. A wide range of mobile devices can be linked to a geographical positioning device and location can be tracked and mapped. One application that tracks location and also provides an editor is *Mscape* (available from www.mscapers.com) Areas can be marked on the base map in the editor that will automatically trigger media on the pocket computer using the player's location.. The group of devices can be thought of as a mobile learning system.

In the paper we look first at the theory mentioned above followed by some examples of mobile location based applications and finally with a description of a mobile learning system about bushfires, utilizing *Mscape*.

Conversation Theory

Much of this paper develops an idea from Pask's (1976, 1992) Conversation Theory that ideas conversed about lead to new ideas, that two atoms joining together are in a kind of conversational give and take and may form a molecule. An event like a bushfire combined with a wind change event can become a disaster event. This combining of two things at a time to make a third makes events easier to analyse, understand, predict and thus perhaps avert. It provides a way to analyse something complex like a bushfire and make it into a visualization that shows no more than two ideas, entities or events at a time forming into something new. A further notion is that when two things combine they do so because of either a physical cause or purposive cause (some sentient being has caused this for a reason) and the cause proceeds through some process. Thus in summary we have two entities or *what*, effected by a cause or *why*, through a process or *how*, making a new entity. This structure is termed a triad.

The mind understands and memorises things using a structure it understood the ideas with and this structure provides the hooks that helps bring them back again into the working memory. It is proposed that in particular the visualisations of events portrayed be designed with the notion of triads so that they are structured in a manner that makes the underlying concepts more easily understood.

This combination of Conversation Theory and cognitive science makes a new pedagogy for visualizations that is more about understanding and wisdom. Wisdom is a requirement of good decision-making. Decision making in bushfires is problematic, for householders whether to stay or evacuate and for firefighters when to make a stand and when to try another approach.

Bushfire modeling and simulation

The February 7 2009 bushfires in Victoria, Australia killed 173 people and are the most disastrous in a long series of fires since the 1800s. Many of the deaths in the recent fire on February 7 appear to have been a result of people not realizing how catastrophic fires can be in a peri- urban setting in close proximity to forest.

This paper reports on research that is attempting to model bushfire behaviour and then deliver that content in a variety of ways to communities and firefighters. This paper looks at one particular method; a game on a mobile device. Visualizations made in a computer game, are triggered at various locations by a geographical positioning system. The visualisations can illustrate grass, shrub and forest fires, all of which are covered by the term bushfire in Australia.

Maps as a new interface

The Trendwatching company of Amsterdam, The Netherlands has 8000 spotters of new ideas and trends in its Springspotter network (http://trendwatching.com/spotters/). The company has 160000 professional subscribers to its trend reports. In its top 6 trends for 2009, number 5 is Mapmania or "why maps are the new interface". It poses a question on their website (www.trendwatching.com/trends/halfdozentrends2009) asking whether all "all things contextual … (will) come together in one … (enthusiastic) … celebration of map-based tracking, finding, knowing and connecting…embraced by eager consumer(s) … aided by services that already know which streets users are on".

In the light of this enthusiasm for location based services that include delivery of learning as well as consumerist motivations, a recent paper by Stenton et al (2008) entitled 'pervasive media delivering ' the right thing in the moment'. They recount that pervasive networking and powerful mobile devices are driving the burgeoning provision of mobile services. Their theme is a 'need for: an extensible and scaleable context framework with privacy, trust and security policies embedded; new modes of interface between the physical and digital environment; and a programme that builds expertise amongst practitioners as the technology develops in its early stages'.

We attempt in this paper to give some examples of where aspects of this theme are occurring and then introduce an example of a pilot learning game using the mscape application (www.mscapers.com). Stenton et al (2008 p 1) also ask for: "the development and demonstration of interactivity more suited to the physical world; the creation of new design guidelines"; the "develop(ment) of a deep intellectual framework for experience design", enabling people to try out the technology and form a network for sharing these ideas, theories and practical applications. *Mscape* they suggest is an application that is more useable than the rapid prototyping or end user programming approach, especially for non-programmers.

In the next section we elaborate upon some theoretical approaches that partially answers, the aim of the 'develop(ment) of a deep intellectual framework for experience design'.

Theoretical approaches

The design of mobile location based training and learning requires the re-examination of pedagogy, mobile technologies, location finding, new ways of producing and viewing geo-visualisations and maps in real time and dynamically showing movements of people, vehicles and other mobile or dynamic data. These learning and training applications can range from a social group playing an entertaining game to school children learning about animals in the African savannah to firefighters learning and training about bushfire suppression. Training here is taken to be acquiring a particular and practical skill set, learning being the gaining of insight into why certain entities interact in certain ways to produce an outcome whether desirable or not. The first requires the transmission of a mental model of something the second often the creation of a mental model, such as an expert might make.

A literature review by Naismith et al (2004) indicates that conversation theory (Pask, 1976) with refinements (Laurillard 2002) is a useful theoretical basis for the design and analysis of mobile games. Conversation theory says that learning occurs when a teacher discusses a theme or ideas with a learner. The two-way discussion or dialectic produces learning.

> *"…conversation theory (Pask 1976) … describes learning in terms of conversations between different systems of knowledge. Pask was careful not to make any distinction between people and interactive systems such as computers, with the great advantage that the theory can be applied equally to human teachers and learners, or to technology-based teaching or learning support systems"* (Naismith et al, 2004 p 15).

A human being's system of knowledge, based on the cognitive map and a computer's system of knowledge can thus be mutually intelligible.

Pask (1992) suggests that virtual reality should be employed to make the "otherwise incomprehensible clear". This was written in 1992 and perhaps he might now advocate the employment of computer and mobile games to visualize and learn about the "otherwise incomprehensible". Pask elaborates upon conversations between people where a teacher introduces an idea and the pupil repeats it back in a cycle where the teacher corrects errors until there is shared understanding. Termed *teachback*, it is a process by which an expert's mental model is transmitted to a novice. Pask assists us here by suggesting that the joining of two ideas to make a new idea is like the creation of a 'Borromean Ring'. This is a symbol featured on the coat of arms of the Borromeo family and named after them (See: http://www.liv.ac.uk/~spmr02/rings/). Three rings are joined solely by the third ring. If any ring is broken all three fall apart. The shape can be drawn as a heart or as stick and balls with circles. This is illustrated in figure 1.

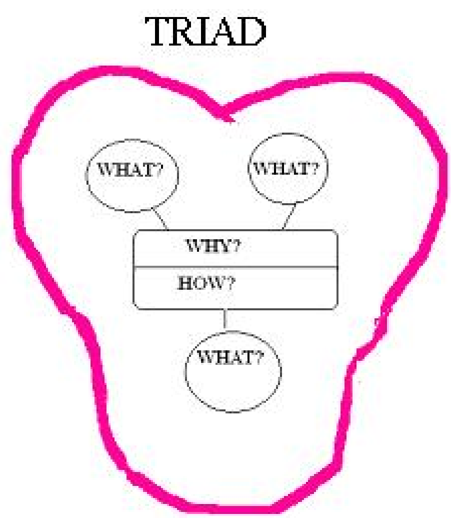

Figure 1. Borromean Ring - mental model triad.

The triad symbolizes the joining of two ideas concepts or events into a new third one. Three triads can be joined into seven a triad becoming a 'heptad'. An example would be a person's family tree back to their great grandparents excluding siblings. Most people only know their complete genealogy as far back as their grandparents, indicating something crucial about the number of remembered items, namely the general limit to working memory. Though young adults can hold up to four items in working memory (Cowan, 2005), one must consider that people may not be young adults The number of items an average learner, young and old, can hold in their working memory is perhaps three items at best and the structure of it something like a triad, linking forwards and backwards like a simple genealogy. This perhaps, the reason many families' genealogies are so short.

Mary Hegarty (2004) in a literature review of how people infer and mentally model how mechanisms work. She explains the literature uses two meanings of mental model, one a model of the brain's processes and anatomy involved in understanding reasoning and prediction of a physical system's behaviour and secondly "The process referred to as running a "mental model" of a mechanical system" (Hegarty 2004 p 280).

Baddeley (2002) offered that working memory has two main channels or buffers: verbal and visuospatial and introduced the concept of an episodic buffer that held the thoughts in mind for a short while (likely meaning in the conscious mind). Hegarty (1992) in a study that asked people to reflect on how they visualised a complex pulley system found that they viewed the system piecemeal imagining the parts and their movements in causal order. This leads one to the conclusion that visualisations of how a bicycle works, should show the separate working parts in their causal sequence. This also applies to wind changes and effects on bushfires and other spatial phenomena.

Edwin Hutchins in his book *Cognition in the Wild* (1995) describes the ways that machines often contain or operate with, their designer's ideas physically embodied in the mechanism. These machines have evolved over long periods of time and are the result of many designers' ideas or mental models. Hutchins gives the example of the astrolabe: a device that captures, in its physical structure the relations between the stars and constellations at any location and at any time of the year. A sentient being or a device devised by a sentient being can manipulate the astrolabe to determine latitude. Hutchins (1995 pp 98-95) writes: "The astrolabe is a manipulable model of the heavens- a simulator of the effects of time and latitude on the relationship of the heavens to the horizon. The astrolabe is an early example of a general trend toward the representation of computational problems via the physical manipulation of carefully constructed artefacts".

In a sense one engages in a conversation with the heavens via the process of manipulating the astrolabe which itself, in its structure, is the result of experts' mental models of how to locate one self-using the stars. The user of the astrolabe does not have to create a mental model of the relationships between latitude and the stars' positions. He merely has to follow the instructions, manipulate the artefact and read off the answer. Indeed an expert may not use their deep mental model of a situation merely a summarised edition that is capable of quick calculation.

Barbara Tversky (2000) writes that the intellectual achievement that separates humans from other creatures is the development of *cognitive artifacts*. These are devices external to the human mind that extend our cognitive abilities. They increase our efficiency of thinking by storing the knowledge required by a task to the artifact thus reducing working memory's cognitive load. They can assist with the calculations necessary for a task.

Winn (2003) regrets the turning of learning researchers from traditional cognitive theory to Activity Theory which takes account of the social and cultural settings of a learner and their organization. In his view pedagogies based on this are not sufficient to understand what is happening when students use computer games and simulations for learning. He writes that cognitive science has recently achieved some breakthroughs that may assist in understanding that kind of learning.

Scaife and Rogers (1996) examined using cognitive science research for how graphics can induce a mental model in an observer's mind. They use the term external cognition, which is similar in meaning to thinking with cognitive artefacts. They list *external cognition* or cognitive artefacts as having three useful characteristics: they *off load computation*; *re represent* the problem, for example a multiplication sum can be done with Roman or Arabic numeral notation, Arabic simplifying the calculation and *graphical constraining*, that is formalising the way that a geometry problem is drawn in a diagram. This then limits or focuses thinking to solving the problem in the simplest manner. This constraining is from the thinking of an expert and will usually be effective and efficient. They divide animations into: *multidimensional*, for example that show the parts of a bycycle moving in proper relation to each other; *partial* only certain parts move; *artificial* key parts are emphasised and made explicit . They suggest that a major design need of virtual reality is that the learner needs to be guided to the important aspects of what is to be learned. The learner needs to be assisted by a learning designer or teacher supplying a structure or scaffolding. They also argue for theoretical frameworks based on cognitive science like Hutchins (1995).

Mobile learning systems

Designers of mobile learning systems should be aware that a cognitive artefact is being constructed. Its parts must not overload the working memory and they must join together like a conduit between the real world and the mind, simplifying and reformulating entities, events, purposes and processes so as to flow with little effort into the working memory. In this section we look at some examples of frameworks developed for mobile location based services.

Dransch (2005) provides a framework for mobile geo-services that use the internet to access information for spatial tasks. Mobile geo-services use a geographical positioning system or cell tower locations for finding a user's location. The user can find services that relate to their location. The provision of useful location based services requires understanding the user: who they are; tasks they might wish to perform and problems they may want to solve. Thus a range of data and services needs to be prepared for the user in a workable framework.

Dransch suggests using a scenario to develop mobile geo-services. The goals, sub goals and actions or process for the determining the route of a pipeline are used to plan how mobile geoscience services will be delivered by the mobile devices in a network. The use of a scenario requires understanding of the context of a problem and the devices you are going to use in order to design the system and what it delivers.

Dix et al (2000) analyse the context for location based devices and include: the technical *infrastructure context*, the efficiency and effectiveness of links between people and devices; the overall *system context* with for example the operation of geoservice delivery and a geographical information system behind it; an application *domain context* such as a scenario and the identities of users in such a scenario and how they need information delivered and shared, and the *physical context*, the actual location of the mobile devices and users.

Mishra and Koehler (2006) and others have introduced the technology, pedagogy, content and knowledge framework (TPCK) for learning using technology. Schulman's, (1986), original concept is termed PCK and resembles a triad in that two concepts conjoin to form a third (a triad in the terms presented above) and Mishra and Koehler's framework adds technology, resulting in the TPCK framework (technology, pedagogy, content and knowledge). TPCK emphasizes that teaching or training requires that we design lessons or training taking into account not only the content and pedagogical processes but also the technology.

A framework for the design of lessons and training using mobile devices may be assisted with changes to the TPCK framework using the ideas outlined above from cognitive science and Conversation Theory. Pairs of ideas or sets of entities combine to form new entities as described earlier. In this mobile learning system framework cognitive science and Conversation Theory combine to form a new pedagogy, this pedagogy combines with required content to create the knowledge in a context suitable for learning. Knowledge is delivered with location based technology to make a mobile learning system. In Fig.2 the triads are joined to make a linear heptad. The seven entities in the circles are labeled and joined by lines that stand for the purpose they were joined and the processes involved in that joining.

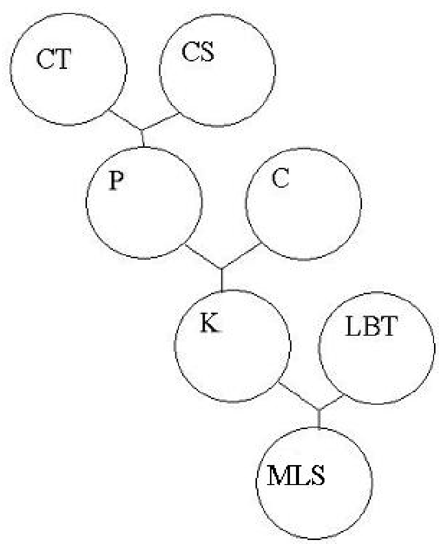

Figure 2. Framework for a mobile learning system. CT= Conversation Theory, CS=cognitive science, C= content, P= pedagogy, LBT= location based technology, K = knowledge, MLS= mobile learning system.

Stenton et al (2008 p 3) state that 'beyond the research community there are a number of efforts underway to develop services and applications that use or capture context. The initial commercial efforts are fairly basic and focus almost exclusively on physical location and location based services'. In the next section we take a look at research into producing practical designs for these services and applications.

From Theory to Design

The framework for the design of a Mobile Learning System is based on cognitive science and conversation theory producing a pedagogy where cognitive artefacts for learning are designed for a limited working memory, scaffolded, and broken down for inspection. The break down is based on triads so that one idea or event is entailed by two previous ideas or events linked by clear causal processes. This pedagogy and the desired content, which may be researchers' and experts' ideas and rules for bushfire safety, together form structured knowledge in a format suitable for efficient and effective learning and decision making. In the next section we examine theory, technologies and applications that may be suitable for the delivery of this structured knowledge at a location using a mobile device.

Research efforts

A Location Based Service has been created at the University of Twente in Belgium (Kobben et al, 2007). It uses a wireless local area network (WLAN) for detecting the location of users of the system and delivers maps and mobile applications using cartographically aware database objects. An application called *FLAVOUR* was implemented for a conference and delegates could access services to find facilities and contact other participants.

MoGeo (Mount et al, 2006) is an application that works on a pocket computer. This has a geographical positioning system, Internet mapping applications and connections that allow for server side delivery and manipulation and interrogation of geospatial information. Exercises and lessons for students can be given in the field and the classroom about geographical information science. In the field the geographical positioning system detects if the student is within range of a pre- recorded location and the pocket computer receives media particular to that place from the server via a wifi network. The order of triggering places can be an important part of the learning task and only the correct order will be rewarded. In a remote area a laptop server can supply a group of pocket computers with server side data and connections. The application appears not to be available to the general public for download and use.

Plesa and Cartwright (2006) evaluated the effectiveness of non-realistic 3D maps for navigation versus realistic images using photographs, both displayed on a mobile device. The test results showed that subjects preferred and better understood the non-realistic 3D map rather than the photorealistic rendering. This preference for non-realistic illustrations is underlain by the fact that someone has prepared the material using a mental model and so has simplified the scene into entities relationships and context or processes and purposes. Thus they are a virtual cognitive artefact and not just an image. A photograph is focussed on a scene and frames aspects of it but not in a way that explicitly extracts the important parts and relationships.

This application and others build upon ideas developed by Cartwright and Petersen (1999, pp 2-10) that maps transformed into multimedia applications allow for direct and intuitive interaction and thus are suitable for more naïve geographical information seekers.

Schilling et al (2005) used mobile *Cortona*, a VRML viewer for iPAQ pocket computer and an OpenGL based program for the Nokia 7650 and 9200 mobile phone. This was for creating dynamic 3D maps for a mobile tourism application, The devices were connected by *Bluetooth* to a global positioning system (GPS) device. The application is called the *TellMarisGuide* and was designed to assist boat tourists visiting the harbour side. The study looked at the useability of 3D maps in comparison to paper maps. Most users preferred the paper maps. The most useful features of the 3D map were the naming of buildings and roads, as well as street numbers and landmarks. The researchers also found that direction of view from the GPS was inaccurate due to loss of signal in an urban area. Correct orientation in the viewer was judged by the researchers to be crucial to the post pilot application's usefulness and success.

Mscape

Mscape is an application provided free for education purposes and available from www.mscapers.com and developed by Hewlett-Packard. *Mscape* is a suite of applications including an editor, a player and a map maker. It runs on certain Hewlett Packard iPAQs as well as some smart phones either with in built or *Bluetooth* enabled geographical positioning systems. Facer et al (2004) describes a novel application running on iPAQ pocket computers being used by teams of students to learn about the African savannah. The children play the roles of lions and acquire points as they find food and avoid angry elephants and hunt down prey. As the students enter certain areas their location triggers particular sounds or multimedia. The much-reduced scale of the playground area was a difficulty. With ease the students understood the game rules featuring behaviour and also the geographic constraints. There were competing realities in that there was no interaction with the real space they were playing in, in the sense that the students would not be slowed down by a virtual river, mountain range or forest. Indeed roads or tracks would not need to be followed.

Mscape is relatively easy to use and there is a repository of information at the website www.mscapers.com as well as an active forum. The latest edition is in beta. It is a significant advance on the older versions. The editing part of the application (on a desktop computer) requires a geo-registered image or map. Fig 3 shows the *Mscape* editor in the background with the base map and a highlighted circular trigger area in a square outline. The script editor is to the left of centre at the bottom. To the bottom right is the tester application, here overlayed on the editor. The tester shows a game in progress on the desktop computer. A small icon representing the player is in the trigger circle and to the left is a view of the screen which opens over the base map area on the mobile device. The screen is showing the visualisation of a bushfire made in *Crysis* that would fill the screen of the pocket computer after being triggered. *Crysis* is a science fiction video game made by Crytek Frankfurt, Germany and published by Electronic Arts.

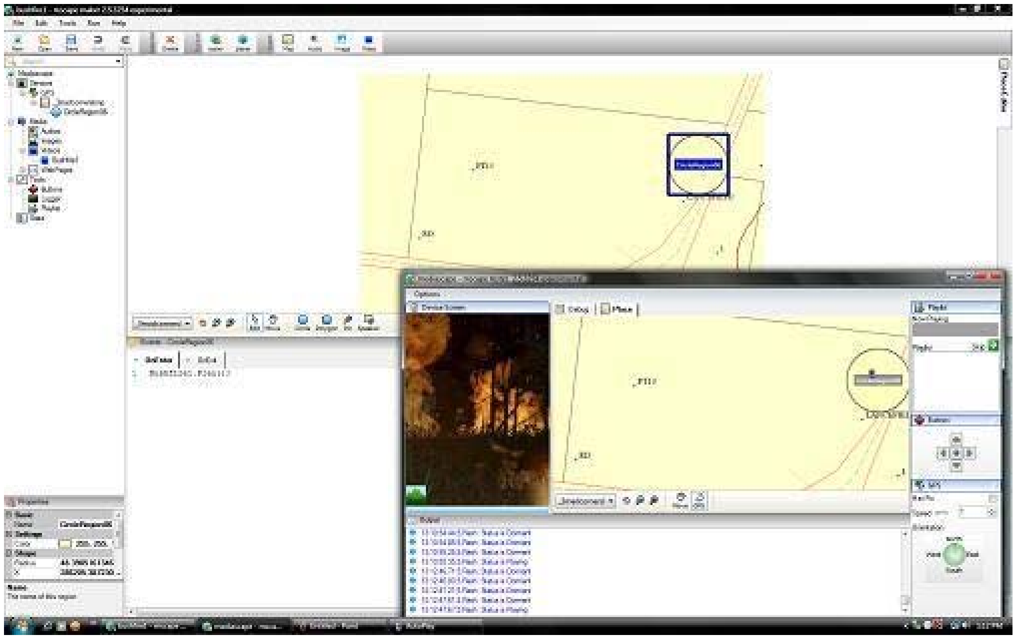

Figure 3. The *Mscape* editor and tester.

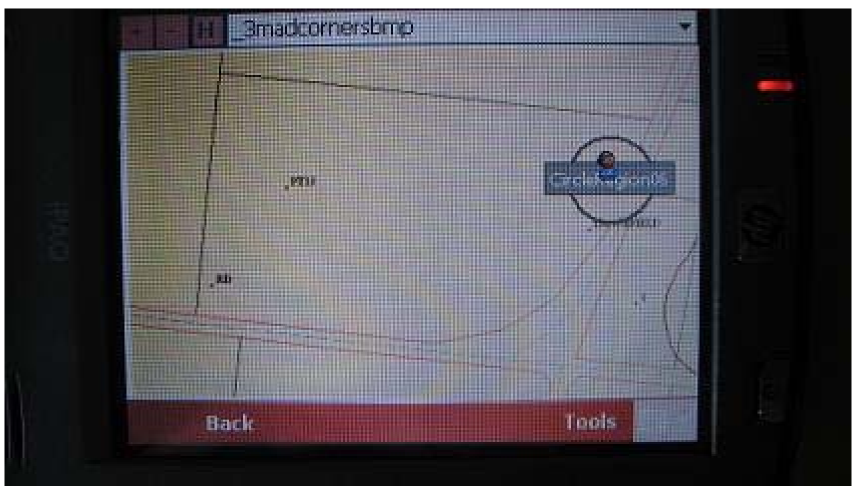

Figure 4. Mscape showing cadastral map and player location as small icon in trigger area.

Figure 4 shows the iPAQ with game running and the player icon centred in the trigger area. The geographical positioning system has been turned off so the visualisation does not display. In Fig. 5 the geographical positioning system is running and the player has activated the visualisation which is a recorded scene from a modified version of *Crysis*. Vegetation and fire and explosions are graphically excellent in the *Crysis* game.

Figure 5. *Mscape* showing bushfire visualisation made in *Crysis*.

From Design to Product and Service

FLAVOUR, MoGeo, *Tellmarisguide* and Mscape use location based technologies to establish position. FLAVOUR uses wifi, a very local form of location finding whereas the rest use the global positioning system (GPS). Thus FLAVOUR is unsuitable for an Australian wild, rural or peri- urban area.

MoGeo, Tellmarisguide appear to be unavailable for the public to download or trial. Mscape however, is available free, has an active developer's forum at the webscapers website where examples are shared and useful tutorials are provided.

MoGeo uses a server and wifi network to deliver data to a pda and thus is restricted to a wifi network's range. TelMarisGuide uses GPS and a VRML 3D view of a place which needs to be constructed in great enough detail for a location to be recognizable. This would VRML scene would be difficult to create and utilize in a forested area with few iconic features.

Mscape on the Ipaq PDA can play media from the storage card, or connected by Bluetooth through a mobile phone and using a data network can access web pages. The mobile data network downloading is however costly and the storage card media is preferable. Mscape can play Flash based video. The interface is suitable for primary school students and thus will not be difficult for most adults to use.

Mscape thus has been seen as most suitable to triall for the deliver location based learning about bushfire safety. It will provide the location based technology which is at this stage most suitable for delivering the knowledge for the Bushfire Safety Mobile Learning System which is being developed.

Conclusion

We have presented a theory for analyzing and understanding events like bushfires. The analysis or breaking into sub- events resembles the structure of our memories and perhaps provides the hooks by which we retrieve those memories or parts of them.

Designing a visualization that is also structured in that way, namely in triads should ease the entry into the working memory and the long-term memory and be available for more expert spatial decision-making. A framework for mobile learning systems has also been proposed with cognitive science and Conversation Theory forming a new kind of pedagogy, which joins with required content to make a structured knowledge and this knowledge is delivered with location based technologies. Examples of mobile learning systems were provided showing their advantages and some flaws as well as examples of mobile location based services and the game Savannah. A pilot mobile learning system, the Bushfire Safety Mobile Learning System created in *Mscape* will endeavor to promote knowledge of bushfire safety for communities and firefighters was presented.

Mobile devices are becoming less expensive and more powerful often with an inbuilt geographical positioning system. These devices loaded with carefully crafted mobile learning systems can provide learning in a location-based context. The context either virtual and at a small scale in a schoolyard or parking area or real at a historical fire site where the progress and decision making of a real fire can be examined at its true scale. Pervasive or mobile learning may well be the ‘the right thing in the moment’ (Stenton et al, 2008).

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