



A User Study of the Spatial and Temporal Dimensions of Context to Support Virtual Learning Environments

Laura Crane

School of Computing &
Communications
Lancaster University,
l.crane@lancaster.ac.uk

Phillip Benachour

School of Computing &
Communications
Lancaster University,
p.benachour@lancaster.ac.uk

Paul Coulton

School of Computing &
Communications
Lancaster University,
p.coulton@lancaster.ac.uk

ABSTRACT

This paper describes a user study of two RSS based information retrieval widgets to support mobile learning within a higher education environment. Created and deployed for implementation on a GPS enabled Nokia devices, the user is presented with arbitrary information from the virtual learning environment based upon either their schedule or location. The study aims to identify whether integrating location context awareness can override the utility of temporal based mobile electronic alerts. The major function of both the mobile applications is to disseminate information surrounding course updates and deliver these in a context of either time or space, aiming to identify if there is precedence between these two dimensions of context. Results from both quantitative and qualitative data indicate that both applications were evenly helpful for receiving information and supported the way in which the students organized their learning. The other outcome of interest was that both the space and time applications were deemed equally unobtrusive in their personal space, although utilizing location information was deemed a less comfortable form of ambient information.

Author Keywords

Mobile Learning, Virtual Learning Environments, Location Based Services, Information Retrieval, Context Awareness

INTRODUCTION

The abundance and availability of wireless mobile devices has created the requirement for information retrieval to grow at the same rapid pace. Simultaneously, mobile applications and widgets have exploded in popularity and provided users with the ability to receive updates for information such as news, shopping, and social media or email updates. These automatically executing services are mostly defined and instructed to do so by time or by a frequency of time. Although these are effective they do have issues such as those discovered in the previous studies by Crane et al (2010). Yet, with the integration of GPS functionality in most smart phones, context dimensions such as location can now be used as update points, mostly known as location based services. It is the concepts of temporal and spatial dimensions, therefore schedule based services and location based services which are deemed the two fundamental points for context aware applications (Smailagic et al, 2001). Integration of location based services into mobile applications has given proliferation to a range of application fields such as shopping, advertising, travel

information and entertainment. Although location based services have been utilized successfully for many domains, their use in the organisation of learning has remained primitive. One clear example of how location based services can be included to support flexible learning is given by Sohn et al (2005) where reminders were created and deployed on a specific location rather than at a specific defined time of the day. Yet this service unexpectedly discovered the points of reminders were often used for creating motivational reminders of the individual's priorities. The relationship between time and location is of interest to this project, as to provide a ubiquitous learning environment understanding the context of the user must be of paramount importance for information retrieval and delivery. Although temporal updates are the standard for most information retrieval, using locative aware technologies to automate updates may offer an alternative to the regular temporal system. Rather than a constant stream of information channeled through to the device based upon time, which itself is a measurement which cannot be personified, location which completely denotes the situation may offer an alternative.

Previous research was undertaken to identify student's trends and attitudes towards both accessing the virtual learning environment and also their mobile device activities (Crane et al, 2010). This study showed student access to the virtual learning environment majorly remained by laptop or netbook, with few accessing it via mobile devices. User trials for a temporal based information retrieval mobile widget have shown that user engagement can be sustained when a motivational design framework is integrated with mobile information delivery. The study used the ARCS model (Keller, 1979) of motivational design and instruction theory (attention, relevance, confidence, satisfaction) as a tool to enhance student learning experiences and subject engagement using a mobile widget for RSS applications. A further study comparing RSS and Twitter, as delivery mechanisms based on the same theory of motivational design and instruction, was also implemented and presented in by Crane et al (2011). User feedback from these studies revealed the following conclusions: although users were given flexibility with regards temporal updates where they could choose how often they would like daily notification, feedback confirmed that all participants preferred temporal updates at specific times (once a day preferably at the end of the day) and not in real time. Secondly, the network coverage on campus which was designed to support nomadic computer use not necessarily mobile phones, where the wireless LAN network is limited to buildings. This also conveys a lack of wireless access around the open areas which are used for communal use by the students, as well as the on campus accommodation and therefore a major area which students use as part of their routes on campus. Subsequently this paper aims to investigate if locative aware services can provide an alternative solution compared with a purely temporal service. Research on spatial dimensions (user locations) is being explored to gain insights into location-based electronic alerts. Further, an understanding of the benefits and limitations of the different context dimension (spatial and temporal) will enable application designers to utilize context fully to engage end users in their applications. The paper explores also the order of precedence when using contextual dimension for mobile information delivery in order to understand students' reaction and experiences when using these differing contexts.

The paper is organized as follows: Section 2 describes and discusses the rationale for context aware mobile virtual learning environments and how dimensions of context can be used to support mobile learners by automatically adapting the contents to the individual's current context. Based on previous research in the field of context-awareness, it is argued that similar solutions can be constructed for virtual learning environments to provide a dynamic solution for learners. Section 3 details the study and technology used to implement the spatial and temporal dimensions of context for supporting students and virtual learning environments; it also covers the challenges presented with respect to network coverage and the framework used for assessing user feedback. In Section 4, the responses to the quantitative and qualitative feedback are evaluated with particular focus on four key points: intrusion into student's domain, support for the student's organization of learning, perceived helpfulness for receiving course information and user contentment (satisfaction) when using student's ambient information. Section 5 addresses the order of precedence of context dimensions, and the understanding of context-awareness to be beyond location. In this section, a preliminary study is carried out which observed the order of precedence when interviewing cohorts of students in three different contexts: a lecture theatre, a learning zone and student accommodation. Finally, discussion and concluding remarks are presented in Section 6.

CONTEXT AWARE MOBILE VIRTUAL LEARNING ENVIRONMENTS

Previous studies (Figure 1) have been conducted to establish the methods of access of students when using the virtual learning environment, this conveyed a large proportion of students still relied upon both wired and wireless network access. Only a slight amount of the 122 respondents accessed the virtual learning environment by a mobile device; many citing the lack of adaptability with mobile browsers, subsequently defeating the usability of the virtual learning environment on a mobile platform. Yet, with the majority of respondents stating they use the virtual learning environment on a daily basis, it can be argued that mobile access is now the natural advancement to maintain the support it already provides for the students. Mobilization derives new challenges and opportunities to heighten the experiences which can be provided by educational institutions for the new generation of digitally native and naturally mobile students.

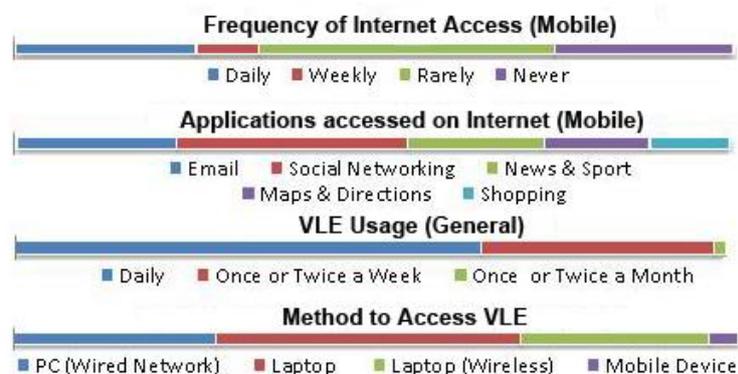


Figure 1. Previous research into use and access of VLE

With the most advanced virtual learning environments providing a well demonstrated and recognized system for supporting and organising learning, their place in modern education is now well identified. They are mostly inherited desktop based systems, and still provide appropriate augmented provision for traditional face to face learning. But with the prominence and prevalence of mobile devices as primary information access tools; virtual learning environments require portability of the significant information which is readily available. Creating functionalities which discover and denote 'online presence' within virtual learning environments have discovered students responded well when they feel a sense of personalized presence within that community (Anetta & Holmes, 2006). But with online presence only being one possibility which utilizes a meek form of context to engage students, the possibilities for context integration are far more excessive.

Contemporary mobile communications now create the possibility for ubiquitous learning environments. Previously, computer assisted learning relied on desktop 'tethered' systems which by their very nature prevented the prevalent availability of information (Traxler, 2005). In comparison, mobile learning ultimately aims to increase learners' capability to move within their own environment and between differing contexts. As a term mobile learning encompasses any device which '...any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies' (Taylor et al, 2006). These devices can be utilized to fill the void which exists between web based and ubiquitous learning, creating a seamless environment for which learning can transpire. Mobile devices can connect to the web

with wireless communication technologies and therefore enable learning at anytime and anywhere. Subsequently, this requires migration from learning which used to be delivered “just-in-case,” can now be delivered “just-in-time, just enough, and just-for-me” (Traxler, 2010).

Unfortunately, navigation of large virtual learning environments sites using iterative, task specific elemental queries is primitive and in fact not mobile device friendly as previously stated by Yee et al (2009). With the need for more personalized, timely and concise information now a pre-requisite for mobile learning environments, investigating how we can use current advances in technology to deliver this information is important for engaging users with these new systems. An example of this is context-awareness. Context-awareness is the field of computer science which relates to ‘*...any information that can be used to characterize the situation of an entity*’ (Dey, 2001). Of course, in order to use context itself, the definition of its associated dimensions must be understood; five categories of context have been specified; these being time, location, identity, activity and relationships to other entities and objects (Zimmerman et al, 2007). Although there are five possibilities for context-aware applications the most obvious and widely adapted are that of time and location. The overall objective of this field is to use the ambient information which exists in any given situation or context effectively to deliver an optimized service to the user. The three branches of services states are that of presentation of information and services to a user, automatic execution of a service for a user; and finally tagging of context to information for later retrieval (Dey, 2001). All three of these parts could be utilized in virtual learning environments in order to deliver information to the user, execute services automatically based or tag their time or position for future reference or learning activity. Previous projects such as ‘eBag’ successfully demonstrate using context awareness by supporting and engaging nomadic learning using location as the primary dimension by Bluetooth enabled mobile device (Brodersen et al, 2005).

Providing context-awareness into mobile virtual learning environments can be an efficient method of refining the usability of mobile virtual learning environment access and services by automatically adapting the contents to the individual’s current context. Although other dimensions of context could be utilized, the most obvious and feasible to implement is that of location. The abundance and availability of wireless mobile devices has created the requirement for information retrieval to grow at the same rapid pace. Simultaneously, mobile applications and widgets have exploded in popularity and provided users with the ability to receive updates for information such as news, shopping, and social media or email updates. These automatically executing services are mostly defined and instructed to do so by time or by a frequency of time. Although these are effective they do have issues such as those discovered in the previous studies by Crane et al (2010). Yet, with the integration of GPS functionality in most smart phones, context dimensions such as location can now be used as update points, mostly known as location based services. It is the concepts of temporal and spatial dimensions, therefore schedule based services and location based services which are deemed the two fundamental points for context aware applications (Smailagic et al, 2001). Integration of location based services into mobile applications has given proliferation to a range of application fields such as shopping, advertising, travel information and entertainment. Although location based services have been utilized successfully for many domains, their use in the organisation of learning has remained primitive. One clear example of how location based services can be included to support flexible learning is given by Sohn et al (2005) where reminders were created and deployed on a specific location rather than at a specific defined time of the day. Yet this service unexpectedly discovered the points of reminders were often used for creating motivational reminders of the individual’s priorities. The relationship between time and location is of interest to this project, as to provide a ubiquitous learning environment understanding the context of the user must be of

paramount importance for information retrieval and delivery. Although temporal updates are the standard for most information retrieval, using locative aware technologies to automate updates may offer an alternative to the regular temporal system. Rather than a constant stream of information channeled through to the device based upon time, which itself is a measurement which cannot be personified, location which completely denotes the situation may offer an alternative.

DESCRIPTION OF THE STUDY: SPATIAL AND TEMPORAL DIMENSIONS

In order to test both spatial and temporal dimensions of context for supporting students and virtual learning environments; two new mobile applications were designed, constructed and deployed using Nokia's Web RunTime frameworks, the first using location information coupled with contextual information to deliver relevant RSS updates, and the second using purely temporal information. Both these mobile applications will be constructed using a compound of HTML, CSS, JavaScript and XML technologies to download and present the user with information which ultimately supports their learning experience. The temporal mobile application was a simple RSS mechanism which disseminated virtual learning environment electronic alerts for a defined frequency of times per day, according to the user's preferences. The spatial application centered on receiving the user's position by the integrated GPS option within the phone itself. Once the coordinates were received, these were input into the adaption engine of the application; in which the user's location was correlated with the nearest news source. The concept was to provide course updates from the virtual learning environment as well as the option of personalized content for their geographic location within the campus site.

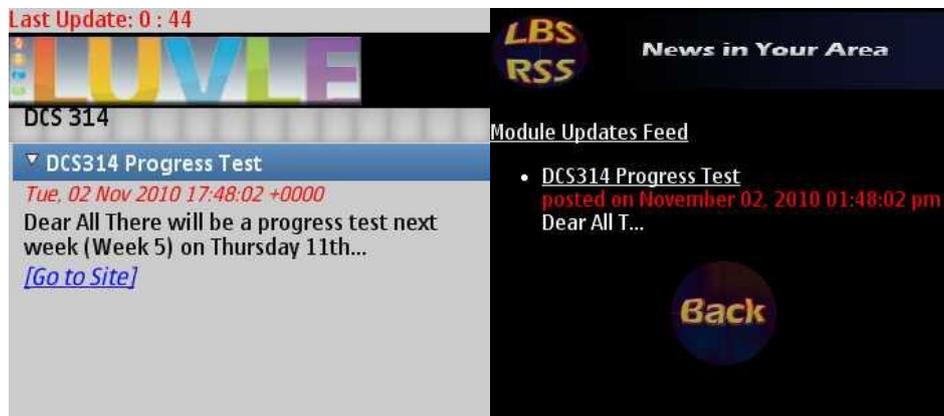


Figure 2. Screen view of the two applications



Figure 3. Demonstrates the overall principle to the location based (spatial) adaptive campus information service.

Rather than relying upon the nomadic free wireless access to provide connectivity to the mobile devices, pre-paid mobile network data cards were provided to alleviate the problems faced in previous studies in which users struggled to access information. This meant the students were no longer bound by the inconsistent and unreliable network which plagued earlier projects. Both sets of students were selected randomly from a third year consumer technology module, with differing lives and circumstances. When the field study was implemented, a participant survey was completed by all the test-base; this is to provide quantitative feedback of the students experience with this assistive technology. The survey consists of statements for which the student's responses was measured by a limited scale, such as the five-point Likert scale. Subsequently, the differences between firstly, the students attitudes after their experience with mobile information updates and secondly, the differences between location and time based virtual learning environments aggregators. From here, random sampling was used to assign the participants into two separate, but equal groups; one set for the location widget and one set for the time based widget. The other form of feedback generated was of a qualitative nature, with the responses from an in-depth interview with the participants after the study was completed. This qualitative study aimed to gain more of an insight into how they found dealing with their context-aware applications on a more operational basis.

QUANTITATIVE RESPONSES FROM LOCATION AND TEMPORAL BASED UPDATES STUDY

Four key points were focused upon during the results stage of the study, these were of the highest interest to the project, and were posed to students during both quantitative and qualitative points of the feedback exercises. These were: intrusion into student's domain, support for the student's organization of learning, perceived helpfulness for receiving course information and contentment when using student's ambient information. These points were deemed the most important in measuring if locative information retrieval can overcome the challenges which were faced by the typical time based information systems. Once the study had ended, the students were asked to complete a feedback form individually to provide a measured response to their experience. This survey included the four key points, (denoted in Figure 3) amongst other questions, and the results of which can be seen in Figure 4. The key points which can be deduced from the graph were that both sets of the students considered the mobile applications equally

unobtrusive within their own domains. Although time was deemed a slightly more comfortable utilization of ambient information. Furthermore, both sets of user sets valued the application identically for supporting the organization of their learning and helpful for receiving course information. Again, a positive outcome for the study can be argued with both sets of users responding positively to using mobile virtual learning environments in the future.

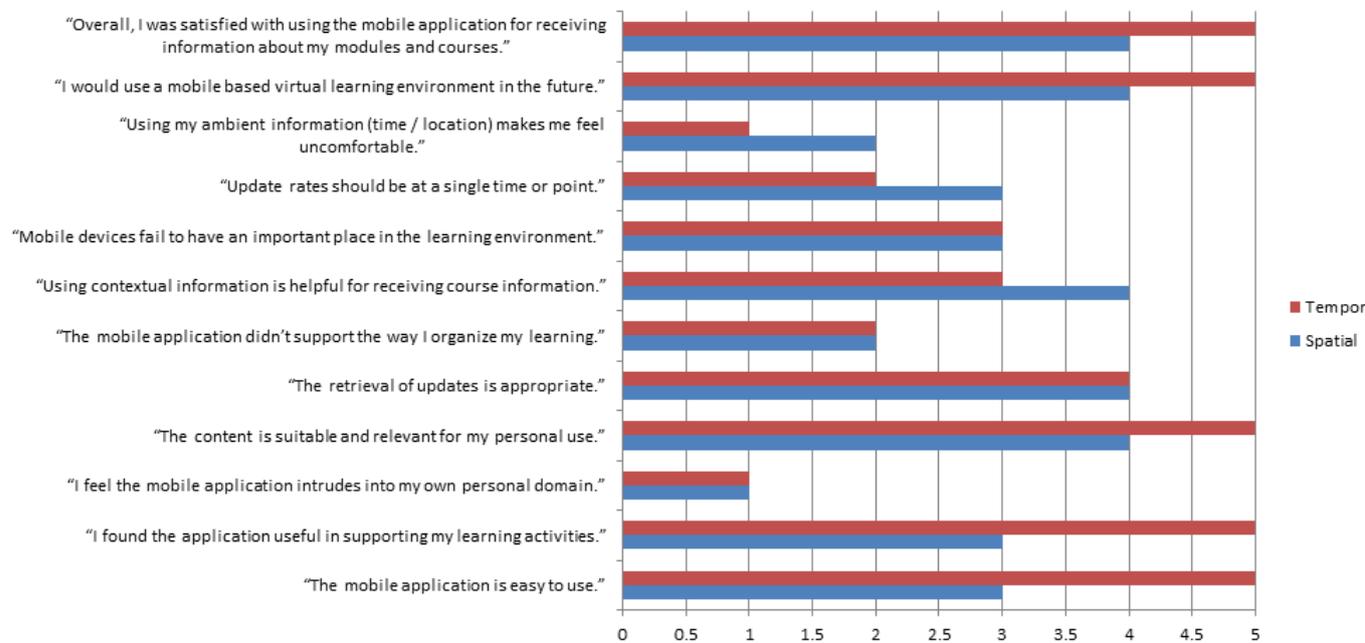


Figure 4. Quantitative Responses from Study

After the six month period which spanned two taught modules, the students were interviewed in depth about their experiences. The results feedback was recorded by an audio recorder, but their experiences were summarized in the following table:

Point of Interest	Temporal Response	Spatial Response
Intrusion into students domain.	"No, unless the movements are collated and recorded for an alternative purpose."	"No, unless the movements are recorded for other purposes. Always the option of simply ignoring the message or turning off phone."
Support for the students organisation of learning.	"It did, but not schedule and routine changes on a daily basis, therefore the application must also understand this."	" I generally do the same routes around campus, and visits the same places on a daily basis."
Perceived helpfulness for receiving course information.	"Still have to make a conscious decision to read the updates. May be useful, but overall the individual has the choice to read them or not."	"Yes, but 'Exit Checkpoints' on campus, when you hit a checkpoint it could update before you go home."
Contentment (Satisfaction) when using students ambient information.	"No – not at all. Only those who have something to hide."	"Level of interest, depends on usage by those who are running the systems. If this was the case I would be concerned."

Table 1. Responses of the four users surrounding their experiences

Both interviewees agreed that they didn't object or disapprove of the intrusion into their own domains, provided the information was safe, secure and not used for alternative purposes. Location did override the issue of time being a changing variable on a day to day basis, as patterns of loci do not change to the same degree. The notion of exit checkpoints for the campus environment was raised by the location user arguing an automatic update when arriving or leaving the campus environment would be extremely useful for supporting her learning.

PRECEDENCE OF CONTEXT DIMENSIONS

Understanding context-awareness to be beyond location is again important in understanding the possibilities available for delivering information in context. Since Barwise (1987) aimed to describe situations over three decades ago, the importance of other contextual aspects such as the individual and the relationships to other objects were understood. More recent work (Schmidt et al, 1999) investigated and promoted the idea of context being more multi-faceted than that of location awareness. The most recognized model for context dimension is that of a pentagonal form consisting of time, location, activity, identity and relationships (Dey,2001; Zimmerman et al,2007).

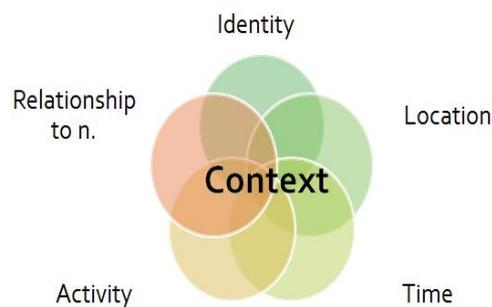


Figure 5. Dimensions of Context

Although Dey (2001) argues that “*We cannot enumerate which aspects of all situations are important, as this will change from situation to situation*” understanding if it is possible to arrange the dimensions of time and space, amongst others, in an order of importance became of interest to answering the original research query. Defining a list of preference or precedence for delivering information from a virtual learning environment to a mobile device became of relevance to this study as it allowed an insight into the importance of time and location in direct relation to other and less obvious dimensions of context. A preliminary study was carried out which observed the order of precedence when interviewing cohorts of students in three different contexts. The students were asked to arrange the five dimensions of context in order of importance to themselves in their setting. One study was carried out in the morning within a lecture theatre, the second within a designated learning environment at midday and finally, the third within student accommodation during student's free-time in the evening. Although there were slight differences between the responses within the different context-situations; a general theme emerged from the results.

The results, which can be seen in Figure 6, demonstrate the distinct differences when the same question of importance between elements of context is asked in different contexts. Another noticeable point is the lack of interest or importance for relationships to other people and objects in all three of the study exercises. The identity of the user was deemed more critical during the first two study settings, but becomes insignificant when the user is in their own time and domain. Further it emerges that time is placed as being more important than that of location consistently during this exercise. The aggregated outcome is that the order of precedence proceeds from firstly time, followed by activity, time, identity and finally relationships to other people and objects. From this preliminary insight into student's concepts of context,

temporal information is deemed to possess the highest precedence amongst other possibilities. Of course this is a theoretical evaluation and therefore any conclusion must be formed upon implementing time and location based mobile virtual learning environment applications.

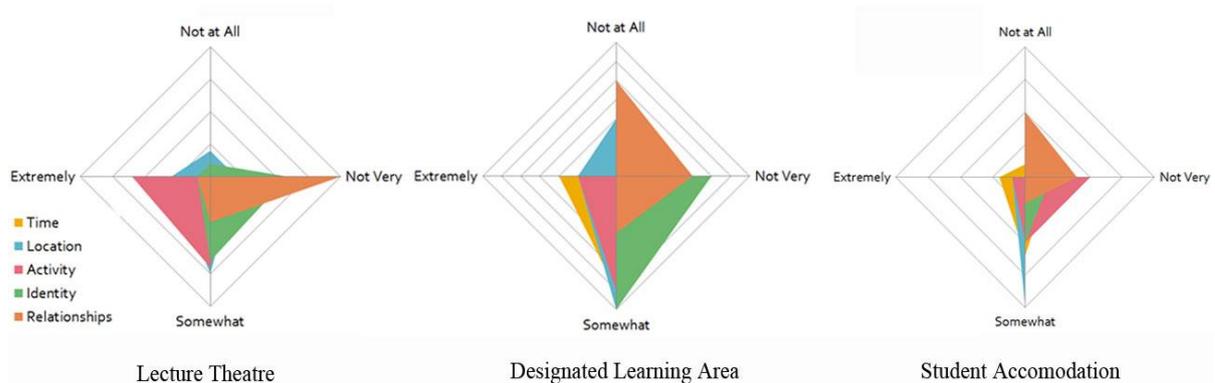


Figure 6. The three different sets of study results from the context precedence experiment

CONCLUSIONS & FUTURE DIRECTIONS

From the feedback received from the participants, location awareness does appear to be a feasible technology to be implemented into mobile virtual learning environments. Although the level of contentment of utilizing locative information does suggest a hindrance to a full immersion of context aware technology, a solution to this issue may involve including students within the design process so any inherent fears of privacy concerns may be eradicated. Although the investigation into precedence of context dimensions convey that temporal requirements were more imperative than that of location; the tangible deployment of both applications demonstrates how location can override purely temporal requirements. Further work can focus on investigating how the user can define the schedule or location updates themselves, rather than being defined by the applications functionality. The idea of ‘exit checkpoints’ or a ‘buffer zone’ for location based updates is an interesting area to explore which would be easily implemented in a campus learning environment. Again, creating an application which supports a wider range of contextual dimensions, such as activity and identity could also create an interesting insight for integration within future mobile virtual learning environments.

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