
A learner-centred design of a location-aware learning reminder

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Abstract: To ensure the success of future mobile learning environments, it is essential to develop affordable and effective applications that are well matched to the characteristics of the users' (particularly, learners) learning experiences. As an early exploration of this line of study, this paper evaluates a location-aware learning organiser that can help university students to manage their learning activities through mobile devices. Empirical testing of the learning organiser revealed considerable benefits for students in the university context, and demonstrated some potential opportunities for them to be more engaged in further mobile learning activities.

Keywords: m-learning; perceived usefulness; location cues; learning experience; contextual help.

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1 Introduction

Mobile technologies are now at the heart of global society. They allow us to explore new opportunities around ‘m-’ neologisms (e.g., m-office, m-government, m-commerce, m-health, m-learning, and so on). In particular, as the cost of mobile computing devices has fallen well below that of conventional desktop machines, we have been tapping new opportunities to apply these mobile or wireless technologies to the future learning environment, enabling access to pedagogical applications anywhere, any time (Kukulska-Hulme and Traxler, 2005; Becerra-Fernandez et al., 2007; Eschenbrenner and Nah, 2007). This dominant mobile paradigm has changed the underlying pedagogical experiences of what we have hitherto taken for granted, namely traditional face-to-face or distance learning (or e-learning) experiences from educational institutions. Several researchers (e.g., Kukulska-Hulme and Traxler, 2005; Rogers et al., 2005; personal communication with Kukulska-Hume, 2007) have claimed that the most important change mobile learning (m-learning) can make, which the traditional learning experiences can not present, is that learners can be hooked into the situations where the learning actually occurs, proactively putting themselves in control of what and how they choose to learn. For instance, if you walk as a tourist around the ‘Sky Tower’ in Auckland, New Zealand, you may be interested in who designed it, how long it took to build, and so forth, but it is unlikely that you will take notes in order to undertake further research when you get home. In this type of context and situation, if there is mobile technology available, it can provide you with an opportunity to learn in ways that were not previously available from traditional learning activities.

There are, however, a number of concerns regarding the outcomes from this new way of learning. Kukulska-Hulme and Traxler (2005) maintain that m-learning alone may not find it easy to attract learners, to engage them with educational activities, and keep their motivation during learning activities, thanks to its un-intentionality (Ryu, 2007). The primary issue to be addressed in the development of future m-learning systems therefore may be how to associate these new learning experiences with more conventional ones in order to ensure their usefulness. Indeed, there have been a number of studies that have tried to bridge the gap between M-learning and conventional learning environments. One example is the Ambient Wood project, carried out by Sussex university (Rogers et al., 2005), which demonstrated a playful learning experience where primary school students could explore and reflect upon a physical environment that had been augmented with a medley of digital devices. A field trip ‘with a difference’ was created, where children discovered, hypothesised about and experimented with ecological processes taking place within a physical environment, and these experiences were discussed later back in the classroom. This project was developed with a view to creating future m-learning environments that may provide more constructive learning outcomes at the primary school level. However, while this project demonstrated a number of opportunities that we may find useful in building future m-learning applications, it is unlikely that they would have the same benefits for those (e.g., professionals or university students) whose overall motivation is the acquisition of skills linked to current or future employment. It might be argued that the learning style of the Ambient Wood project would be perceived as being less valuable for professionals or university students, and the time-consuming nature of the learning activity might be de-motivating to this audience.

This paper therefore addresses the specific context of the university learner and associated user profiles in order to explore some design features that one should pay attention to when designing an m-learning environment for this audience.

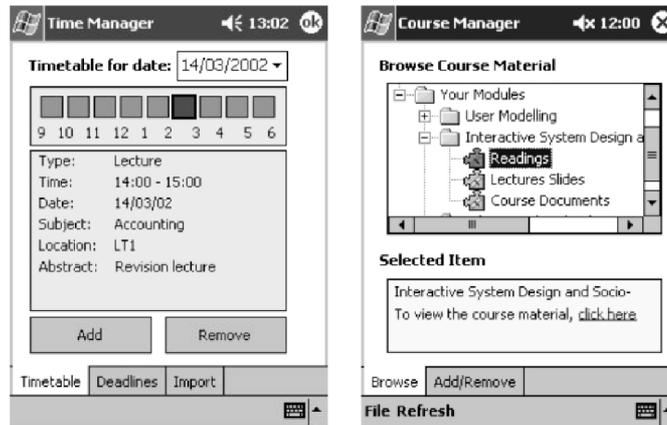
The following section begins with a brief account of which features of m-learning environments are closely related to, or different from, our understanding from early studies, so that m-learning researchers may be aware of the design issues involved in creating effective m-learning applications for university students. Section 3 covers the learner-centred design practices, and usability testing with the intended user group in their learning context is discussed in Section 4. Finally, a practical implication of this study is described in Section 5.

2 Lessons learnt from early studies

One practical example to developing an m-learning environment for university students is Scornavacca et al.'s interactive Short text Messaging Service (SMS) classroom system (2007). They specifically noted a lecturing situation which involved large numbers of first-year university students in a big lecture theatre. Clearly, this situation is not easy either for the lecturer or the students. In most cases, the lecturer would like to know whether the students understand the content that they have delivered, but the students are unlikely to express themselves or ask the lecturer any questions in this context. To facilitate a certain level of engagement with the class, the students were allowed to ask any questions via SMS with their own mobile phones, so the lecturer could interactively capture important questions from the students and respond to them. Indeed, this form of educational technology is not new, but has already been commercialised, e.g., 'Clickers™' (Gilbert, 2005), but Scornavacca et al.'s SMS classroom system demonstrated that common mobile phones could be useful at the university level without the purchase of high-end devices. They found, however, that the learning outcomes had not been significantly enhanced by the system. This result takes into account that this system does not aim to bridge m-learning with other learning activities, but simply to enhance the level of engagement.

Supporting the notion of enriching the level of engagement by mobile devices, Sharples et al. (2005) developed a learning organiser on Personal Digital Assistants (PDAs) that could assist university students in some aspects of managing their studies. This was a kind of event calendar system that could present basic information about lectures (i.e., time-management) or provide access to some of the course content, as shown in Figure 1. A usability study of the system, however, provided no conclusive evidence as to its usefulness to the students' learning processes (Corlett et al., 2005), though it implied that more contextual information (e.g., reminders of course deadlines around the due dates) might be of use to the students.

Several attempts to include the student's context in m-learning applications have been made. For instance, the Portable Help Desk (PHD: Smailagic and Kogan, 2002) demonstrated the usefulness of both context and location awareness. The campus-wide sensor-based location awareness system provided some useful information (e.g., which printer has the shortest print queue or the location of their friends on the campus) to support university students' campus life. However, an early test of PHD did not show any clear benefits to the students' learning experience, illustrating only minor potential for university-based m-learning applications.

Figure 1 Learning organiser's time manager and course manager screenshots

Source: Reprinted from Corlett et al. (2005)

Having identified some areas of challenge in this line of research, what we intend to explore in this paper is how to extend the university student's learning experience with contextual help or information, by reviewing university students' contexts and requirements. We assumed that a critical success factor for an m-learning application for university students would be to provide two types of enhancements at the same time: learning experience and learning outcomes. PHD (Smailagic and Kogan, 2002) and the SMS-based classroom interaction system (Scornavacca et al., 2007) enhanced the learning experience of the university student. In contrast, the learning organiser (Corlett et al., 2005) significantly improved some learning outcomes. This paper takes account of these dual objectives, providing a location-aware learning organiser to ensure that the system meets university student's requirements within their learning contexts. Empirically, we would also like to see if this learning application enhances the learning outcomes of the university students. Usability testing was therefore undertaken to attempt to measure these factors.

3 Location-aware learning organiser

3.1 Requirements elicitation: users and contexts

There have been a wide variety of methodologies proposed for eliciting, presenting and validating requirements. Specifically, the fundamental approaches for collecting requirements are shifting away from the data to be processed by the system and moving more towards human-computer interaction or social and organisational factors. Sommerville (1996) claimed that social and organisational factors affect the requirements analysis process and proposed the use of ethnography on which social analysis must be based for examining the real everyday needs of an organisation. However, ethnography analysis requires a substantially long period of time to perform observation activities, which poses severe restrictions on performing ethnography analysis in practice.

We attempted, instead, to collect the university students' learning experiences by using the Critical Incident Method (CIM: Flannigan, 1954, 1962) which is used to identify critical elements from previous experience. We collected as many critical incidents as possible from 20 university students, asking what types of contexts, tasks, information and design features would suit a university student's expectations. The interview questions used were as follows:

- Tell me about an incident that you remember which was an example of an ineffective learning experience.
- What were the general circumstances leading up to the incident?
- Tell me exactly what it was about the learning experience that was so ineffective at the time.
- When did the incident occur?

The 20 interviewees were all Massey University students, aged between 18 and 32, randomly selected from the User-Centred Design course that the first author was teaching in 2007. Twelve of them were male, and eight of them were first-year students. Eleven of them were international students. Each interview took around 15 min.

After transcribing the interview data, we decided upon a coding scheme containing two categories for handling the interview data: *mobility issues* and *learning issues*, as depicted in Table 1. In the first category, the interviewees presented some requirements relating to location issues around the campus. In the second category, the interviewees presented several ineffective learning experiences that they had at university. The frequency column in Table 1 gives the number of interviewees who contributed to each category. Note that one asterisk (*) indicates excerpts from the first-year students, and two asterisks (**) indicates excerpts from those who are senior students (i.e., second and third year students).

Interestingly, the frequencies in Table 1, as derived from the protocols, appeared to show certain differences between the user profiles (new students vs. senior students). That is, the senior students had more concerns about learning issues, whereas the new students reported more mobility issues.

These interview data served to specifically identify the design requirements of the m-learning application that we were developing in terms of three perspectives. Firstly, the interview data revealed that most of the new students (seven out of eight students) had little idea of where the classrooms and laboratory facilities were located in a widely distributed campus (in fact there are three separate precincts at Massey University in Auckland). Because of this, new students are often unsure of where their next meeting or lecture is to take place. In contrast, many of the senior students seem to be already aware of this type of information, but require more in-depth information about their personal studies (learning issues). Their concerns during 'campus life' revolve around the organisation of their studies, such as being aware of assessments, while also being up to date with messages and resources from lecturers and/or other students involved in their programme of study, which were given little consideration in Corlett et al.'s (2005) learning organiser. The new students' contexts and requirements were thus relevant to aspects of interface design, such as map support, while the requirements of the senior students related to the personalisation of their learning environment.

Table 1 Interview data summaries. Frequency indicates the number of interviewees from each user profile which gave the incidents for each category

Category	Frequency		Sample excerpts
	New students (8)	Senior students (12)	
Mobility (or location) issues	7	1	<p>*I am a new student, so sometimes..., I have no idea of where QA2 is, I do not even know what QA2 means. That means I missed the first lecture in my first ever school life</p> <p>*The lecturers never told us where to go for the tutorials and lab sessions. I was looking for the labs immediately after the lecture, but it was not so easy to find the place which is in the other precinct in five minutes</p> <p>**This ... course has changed the lecture room in Week 5. But I have not got any notice of this room change (<i>interviewer asked why</i>) Actually, I missed the Week 4 lecture, so I also missed the Week 5 lecture</p>
Learning (or contents) issues	2	10	<p>*I want the university to help me easily find assignments, examinations, library information, room changes, and so on, because the lecturers never kept the course outlines, so I have some difficulties to find the correct information</p> <p>**When I arrived to the campus in the morning, I liked to set up today's itinerary, says where I have to get now, and then, and then, when or where I can have a lunch and so on. Also, if I have some time off between lectures, I want to stay at the library to read some books and do some assignments. However, sometimes, the library is full of students, so I cannot find a place to study</p> <p>**The lecturer told us that we had quizzes next week, but I did not know what I had to prepare for this, so I had been to his office, but he was not in the office. And then I found his telephone number from my mobile phone, and left a message in his voice mailbox. But he never returned me at all</p> <p>**I requested an inter-library loan book. ... I did not collect this book for some time, because I did not know I could. I had no calls or emails from the library, and they charged me \$2 fine</p>

*The excerpts from new students.

**The excerpts from senior students.

The next consideration was the students' learning context, which emphasises the needs and intended outcomes of specific learning activities. In particular, the interview found that spatial awareness is very important for the junior students, but temporal issues were

more relevant to the senior students, for example relating the time of day to their study schedules. One of the interview data showed that when a senior student arrives on the University campus, the contextual information that they are searching for may be related to their course schedule for the day, room changes or important messages (e.g., assessment information, library records, and so forth). These different activities define different design requirements. As noted above, the junior students want more navigational support on the campus, but the senior students require more contextual knowledge and social interaction with lecturers or tutors.

The key point to note from this requirement elicitation process is that the success of any m-learning application relies on taking into account different contexts of use for different learner groups, who may have different expected learning experiences, as we have identified from the responses above.

3.2 Design of a location-based learning reminder

To address these design requirements, location support was thought to be an essential function to be implemented, with contextual information linked to the location-aware service. Indeed, the location in everyday life regularly tends to present a particular circumstance or stimulus of our activity. According to Suchman (1987), the nature of our activities or plans of actions would be highly associated with particular social and physical circumstances pertaining at the time. As an example of this in the university context, for instance, as a student is passing by the library, she or he may think about something that is related to the place (e.g., returning an overdue book or collecting an inter-library loan). Likewise, the lecture room where the student is present would be likely to make them think about course-related information (e.g., assessments or assignment due dates and so on). This location-based reminder, which was not considered in Corlett et al.'s (2005) learning organiser, would be central to the m-learning application that was developed in this paper.

We developed this location-aware learning organiser with a PDA phone (HP IPAQ 6700) with a separate Bluetooth GPS device (GlobalSat BT-338). It is able to locate the current position of each learner on the university map, and to access the server using a mobile network (Vodafone New Zealand). The aerial photos of the campus were obtained from the North Shore City Council, and calibrated for use with a GPS device by constructing software for the task. Microsoft SQL server was used to relate the contextual information and the location data. Each component of the software was built using Microsoft Visual Studio 2005.

The assumptions of typical users and the physical environment for the development of this application were that a student was concurrently studying four or more courses and that activities related to their daily study routine included accessing learning content and returning books to the library. In terms of their coursework, most courses include lectures, tutorials, and/or laboratory sessions. In terms of the physical environment, the Massey University campus consists of three separate areas, presenting spatial-temporal issues related to a student's locational context. For instance, most lectures take place in theatres in the upper precinct of the campus, while many of the tutorials and laboratory sessions are some distance away in the lower precincts. Therefore, students need to be constantly aware of the spatial contexts of their learning activities. Figure 2 shows a screenshot from the location-aware system. There are indicators representing the user's current position, and a path to their selected location. The map is synchronised with the

users' location, moving and rotating in line with their movements. This type of feedback provides the user with the necessary navigational information. In addition, the user can select their next destination from the course calendar, and the path to the location appears on the map.

Figure 2 Screenshot of navigation software for a user who wants to get to the Quadrangle building for her or his next lecture



Figure 3(a) shows the location-aware learning organiser's system architecture. It automatically sends the user's current location to the PDA server. The server builds the query for the SQL server database (as shown in Figure 3(b)), which retrieves the client's information. The PDA server returns the information to the user's PDA. As users move through an area, the PDA server delivers contextual information relating the current position based on the predefined user's profile. Therefore the user can request information to provide new knowledge and assist their activities related to study at the University. The major challenge was the data set we should put into the database, because of the privacy protocols that the university applies. We therefore used the student records of course enrolments with the consent of each student and the lecturers' voluntary support for each class.

In terms of user-driven information, a user could utilise this system to find what books have been placed on reference in relation to their course of study. As the user walks past the library, they can automatically see this type of contextual information. Figure 4 demonstrates some contextual information a user may receive while walking close to a lecture theatre. In addition, if the user clicks the 'Assignment 1 available' link to their learning environment, they can see what the assignment is. In addition, they can access the whole M-learning module as shown in Figure 5.

Central to this research was to explore whether this location-aware learning organiser could effectively support tertiary students' learning experiences without any significant difficulty-performance tradeoffs. To do this we examined the perceived usefulness of the location-aware learning organiser, which we describe in Section 4.

Figure 3 (a) System architecture and (b) the system receives the user's query and matches it to an appropriate contextual help, accessing the SQL server database

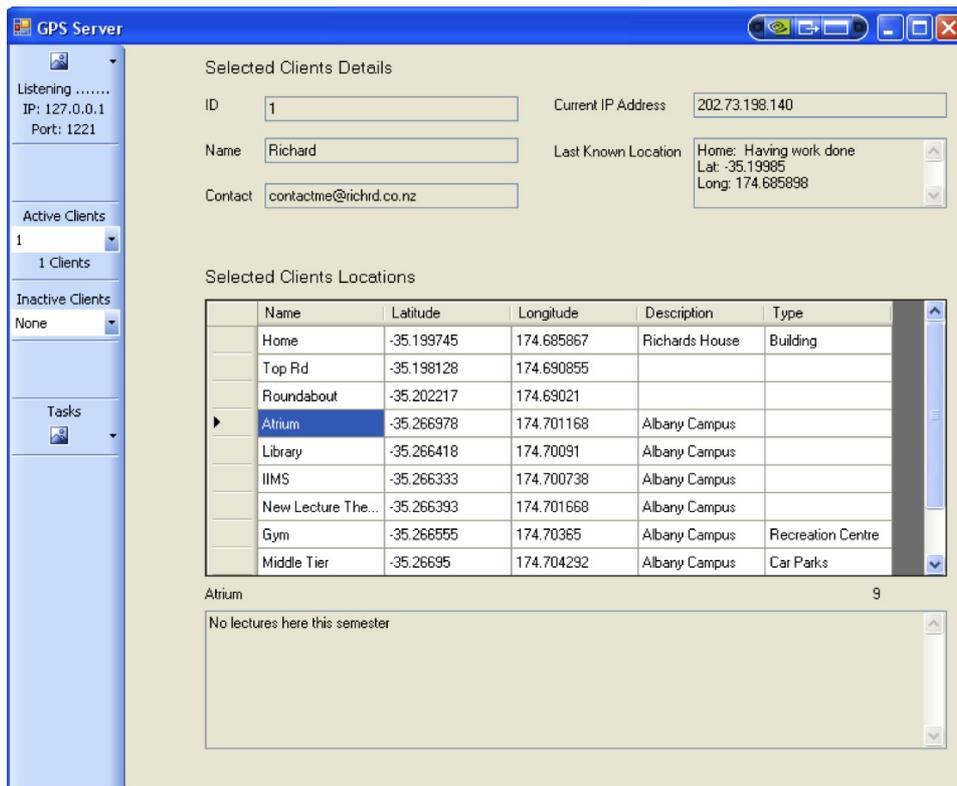
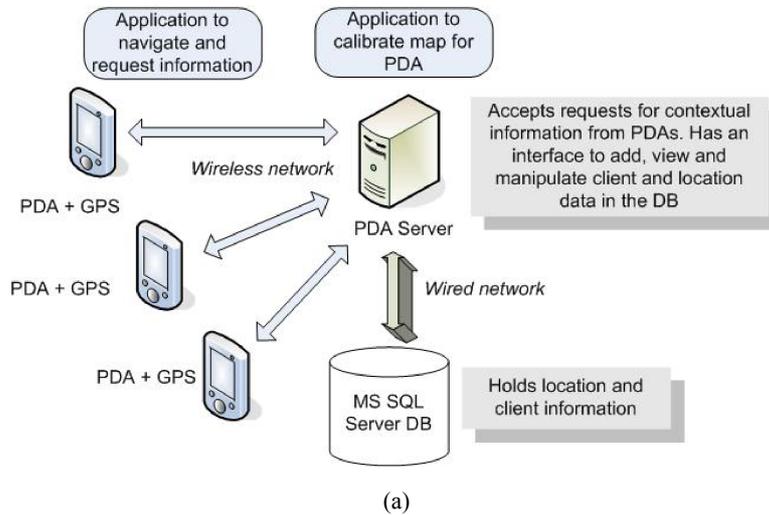


Figure 4 Contextual information presented to the user. If a user clicks ‘Assignment 1 available’ on the system, they can access the m-learning module

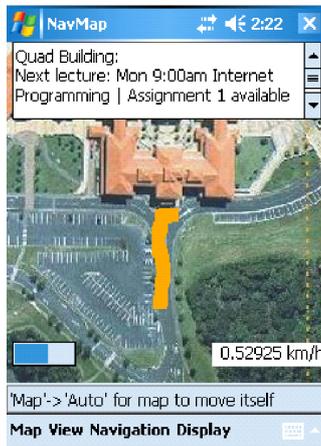


Figure 5 Learning module design for the learning organiser. It provides their current location and additional learning modules that students can download



4 Usability testing with targeted users

To explore the perceived usefulness of the location-aware learning organiser, we obtained the participants’ perceptions of their experience of the system. This approach has been validated through many usability studies for predicting user acceptance and explaining the use of newly developing systems (Davis, 1989; Dadayan and Ferro, 2005, Mathieson, 1991).

The usability testing involved exposing 20 participants (ten new students and ten senior students) to the system, and then asking them to give seven ratings on four questions. All the participants (18 males and two females) were Massey University students who had enrolled in the first author’s undergraduate course in 2007. For the contextual help information, participants’ profiles such as their interests, coursework, and library information were collected before the evaluation. Based on these profiles, contextual information for each participant was added to the system database.

To evaluate the system in use, the participants roamed the campus for 15 minutes, where they experienced the two major functions of the location-aware learning organiser,

- finding the location of their classrooms
- contextual help.

Each user was first asked to find the location of their next lecture with this system, and then get to that location. As they approached the location, relevant contextual information appeared. For instance, if the students were passing the library, the system proactively displayed their library information, for example if there was a new book based on their interests or books due for return. After using each function, they were asked to rate the usefulness of the system using a seven-point Likert scale. In this way, we were able to examine how much the system was perceived to be useful and useable by the different user groups, simulating a realistic learning context at university level.

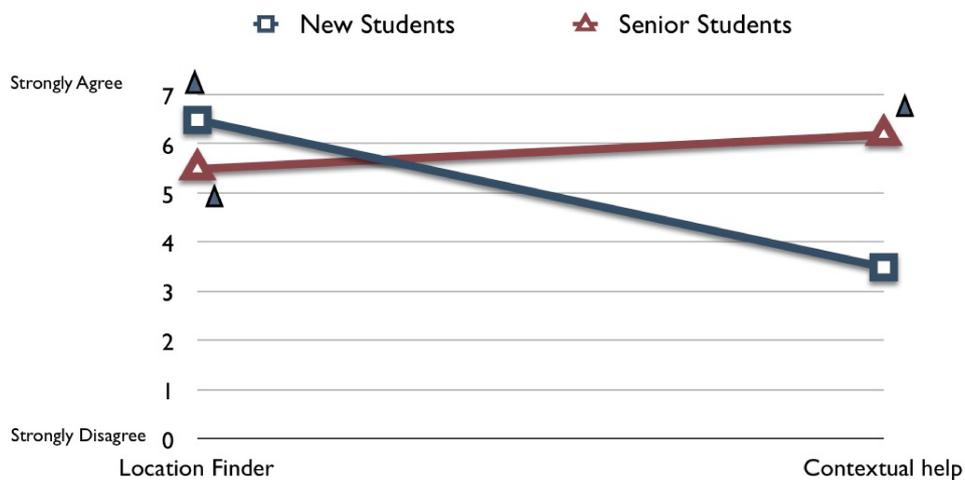
Figure 6 depicts the questions used in this usability study. The purpose of this evaluation was to determine if this sample of participants (ten first year students and ten second or third year students) found the system useful. To answer this question the ratings were analysed in terms of their absolute level, i.e., whether the mean rating was significantly higher (agreement) or lower (disagreement) than the neutral value 4.00.

Figure 6 The questionnaire about perceived usefulness and ease-of-use

1. I think this device would be very useful in my university life
2. The system made me more organised in my campus life
3. I would like to use this system again
4. The system made me more engaged with my studies

Figure 7 gives mean ratings for Scale 1 “I think the device would be very useful in my university life”. A rating of 1 indicates that the participant strongly disagrees with the statement, a rating of seven that they strongly agree. Arrows indicate that a mean is significantly different from 4, at 0.05 level, by one sample *t*-tests.

Figure 7 Mean ratings for Scale 1 “I think this device would be very useful in my university life”



Looking at the separate lines in Figure 7, it can be seen that there is a reverse effect of the functions. The location finder functions were perceived as being very useful by new students, while in contrast, senior students gave a higher rating to the contextual help than new students. This tells us that the expected learning experiences from the learning organiser vary. One-sample two-tailed t-tests against the neutral value 4.00 showed that the new students efficiently utilised the system to discover new locations while feeling confident in themselves in using the system. The senior students, however, were attracted to the contextual information.

The ratings for Scales 2 and 3 were around 7.00, indicating that most of the participants gave the maximum rating for both functions (so the ratings of both functions were averaged out, see Table 2). This results in no variance for these scales. Because of this overall ceiling effect, the small differences between means are not interpretable, so they made it hard to identify any behavioural differences between the new students and the senior students. However, the face values of Table 2 were broadly in support of the usefulness of the location-aware learning organiser in the university context.

Table 2 Mean ratings for Scales 2 and 3. Scale 2 “The system made me more organised in my campus life”; Scale 3 “I would like to use this system again” (mean/sd)

	<i>New students</i>	<i>Senior students</i>
Scale 2	6.60 (0.84)	6.40 (0.97)
Scale 3	7.00 (0)	6.80 (0.63)

Finally, for Scale 4, the ratings for the location finder function were uniformly low, but the ratings for the contextual help were relatively high, even though they were not statistically different between the new students and the senior students (see Table 3).

Table 3 Mean ratings for Scale 4 “The system made me more engaged with my studies” (mean/sd)

	<i>New students</i>	<i>Senior students</i>
Location finder	1.30 (0.48)	1.50 (0.71)
Contextual help	3.90 (1.20)	3.70 (2.00)

There are a number of possible explanations for these results. One is the novelty of the technology. The participants who use this location-aware learning organiser might have been attracted by the new technology, and enjoyed it more as a result.

To explicitly see how the students would interact with the system, we further assessed the system using the think-aloud technique. Three students (one new student and two senior students) were further recruited from the campus, and the same task procedure was applied. Verbal protocol results concurred with the usability study described above, placing emphasis on ease of use and the ability to learn from contextual information. All the participants were able to complete the tasks in a straightforward manner. They would create an objective to either find a location, acquire some contextual information while moving around, or a combination of the two. In each occurrence the participants interpreted new contextual information, assisting in their purpose of studying at Massey. Also, they appeared to find the contextual information both useful and informative in relation to their goals of being at the location, such as ‘library books due’

messages when they were near the library. The participants with specific information appeared to feel more satisfied with the system, and its abilities. Therefore they were more likely to have a positive attitude to, and respect for, the system, gaining and learning more.

5 Conclusions and future work

There have been a number of repeated questions raised about the usefulness of m-learning from a pedagogical perspective, such as; is it really possible to learn with such small handheld devices? What kinds of people would use mobile devices for teaching and learning? What sorts of subjects and situations are appropriate for mobile learning?

Following from these concerns, we assumed that relatively informal learning activity support, such as the location-aware learning organiser described in this paper, can be more situated, experienced, and contextualised within specific domains.

5.1 Limitations of the study

Though this study seems to provide us with some guidance for the potential of future m-learning applications within the university context, it would be difficult to say whether this location-aware learning organiser would encourage the uptake of m-learning. Most importantly, we did not directly assess the most important function, i.e., the content of the course, which can bridge the M-learning application with the conventional learning experiences. Indeed, we did implement this function, but the very slow connection to the content through the GPRS wireless network did not allow us to continue this functional test with our participants. Future studies will therefore need to use the faster HSDPA network.

5.2 Summaries and future work

This study was designed to discover whether university students would gain significant benefits from contextual help, and how m-learning processes might be integrated with current learning experiences. We partially reached these objectives, identifying the importance of the contextual help. However, there is no conclusive evidence regarding integration of current learning activities, though the location-aware learning organiser was perceived as being useful.

The results of this study suggest several opportunities that could be pursued in future research, in particular, we found that the location-based reminder would be a useful function to support students' learning activities, which has not been demonstrated empirically before.

Indeed, this paper is not the final result of this activity; the main objective here is to foster a wider discussion of m-learning design practices, based on an analysis of current research and future challenges.

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