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A Mobile Context-aware Framework for Managing Learning Schedules – Data Analysis from a Diary Study

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ABSTRACT

We report the results of a diary study to determine whether a diary approach could be used as a successful way of retrieving a) the user's learning contexts, b) which learning contexts are significant for consideration within an m-learning application, and c) which learning materials are appropriate for which learning situation. Analyses of data provided by 32 participants have helped us to establish the applicability of using a learning schedule for retrieving a learner's location and available time contexts. This understanding was required in order to determine the realistic usability and potential deployment of our mobile context-aware learning schedule (mCALS) framework, which uses a learner's schedule (i.e. electronic organizer) to retrieve their location and available time contexts. The purpose of this framework is to suggest appropriate learning materials to students based on the values of the proposed contexts (including learning styles, knowledge level, concentration level and frequency of interruption, at the point of usage). The study suggests that the framework should include verification methods to counter against the possibility of students not adhering precisely to their planned learning schedules. Motivation was established as a crucial learning context which should be incorporated into adaptive mobile learning applications.

Keywords

Context-aware, diary study, mobile learning

Introduction

Context-aware mobile learning (hereafter, abbreviated as m-learning) applications emphasize the use of learning contexts and the automatic retrieval of these using context-aware technologies such as location-tracking devices. Advantages include improving the learning situation and providing convenience to learners (Yau and Joy, 2009a). Learning contexts are defined by the student's situation and are used in applications in order to match, adapt or select appropriate learning content suitable for their situation and/or environment. These contexts can include the student's internal characteristics, the activities being undertaken, their location, their available time, and types of mobile device being used (Wang, 2004). Three perspectives should be considered for evaluating these applications. These are 1) *pedagogical* - how materials should be designed to enhance the learning experiences and to meet the learning requirements of students; 2) *usability* - how the user interfaces of applications on mobile devices should be designed to enhance human-computer interaction; and 3) *technological* - the physical layout of learning materials and how they can adapt to different sizes of mobile device screens (Yau and Joy, 2010).

Our mobile context-aware learning schedule (mCALS) suggestion mechanism was initially proposed as a theoretical framework in Yau and Joy (2008). The two main aspects of mCALS are 1) the context-aware suggestion mechanism, and 2) the learning schedule approach. A *context-aware suggestion mechanism* is potentially desirable for a student because the system is able to find out automatically their current learning contexts and suggest only appropriate materials to them for that situation. The intention is to create and maximize learning opportunities for learners in different m-learning situations. Other suggestion mechanisms have been proposed by Cui and Bull (2005) and Martin and Carro (2009), however, these applications require users to enter contexts information directly onto the mobile device and are not context-aware.

Our framework's *learning schedule approach* can be deployed by using electronic organizers integrated in mobile devices. This approach uses the student's study schedule (timetable) information entered in advance, to retrieve their location and available time information at moments when they may wish to study. This approach is proactive (as opposed to interactive) because it does not request users to enter information at the time of usage. The learning schedule approach removes the burden for users having to enter their location and available time information onto the device directly; and we wanted to investigate an alternative simple and effective method of retrieving contexts automatically. We also proposed this approach in order to eliminate the need for context-aware sensor technologies because these would not be necessary if learners adhered to their schedule and had kept it up-to-date (in order to retrieve location and available time information accurately). Finally, data analyses of our interview study have shown that the act of pre-planning scheduled events can be motivating for some students to carry out their studies. Therefore, this learning schedule approach can potentially provide a motivational strategy for self-regulated students (Yau and Joy, 2009a).

Five learning contexts – learning styles, knowledge level, concentration level, frequency of interruption and available time – were identified as important contexts to be considered and have been incorporated into our framework (Yau and Joy, 2009a). The framework consists of a suggestion mechanism, which selects appropriate materials (from a learning object repository) to students based on the values of the proposed contexts, at the time of usage. A learning object repository such as *www.codewitz.org* can be used for retrieving Java learning materials.

The methodology used to design our framework consists of three stages: 1) theoretical design development, 2) pedagogical, usability and technical feasibility studies, and 3) framework validation. The rationale for proposing this framework includes that students may want to make use of their idle time and/or whatever available time they have for learning/studying (Yau and Joy, 2009a; Martin and Carro, 2009). Our purpose is to support these students by providing them with appropriate study materials for the circumstances that they are situated in. In the *theoretical design development* of our framework, we incorporated self-regulated learning theory and proposed that the learning schedule approach can be a successful time-management technique and an effective self-regulated learning approach for motivated students. Results of an interview study supported this claim (Yau and Joy, 2009a). We conducted *feasibility studies* in terms of three different perspectives – *pedagogical, usability and technical* i.e. interview study, diary study and technological framework design, respectively. 37 volunteers participated in our interview study and we were able to provide an insight into the learning requirements of intended users and whether our framework can be potentially used by them. Detailed results of this study are in Yau and Joy (2009a). The *usability* diary study forms the focus of this paper. The *technological* feasibility study was conducted to determine the feasibility of implementing our framework at present with current technologies, and this forms the focus of a future paper.

This paper is structured as follows – a literature review is provided in section 2; the 'diary: diary-questionnaire' methodology we used for data collection is presented in section 3; the data analysis of our diary study is described in section 4, and finally, in section 5, we present our conclusions and future work.

Literature Review

A literature review on some of the evaluation methods deployed from the *pedagogical, usability and technological* perspectives are provided below.

Pedagogical Methods

Typical methods used for evaluating m-learning outcomes include interviews, questionnaires and diary studies; all of which require learners to give their own retrospective accounts of their learning. Limitations of these methods include (a) there may be inaccuracies in students' recall and rationalization of information, and (b) some learners may not possess the meta-cognitive skills necessary to reflect on their own accounts of learning experiences and be able to convey this information accurately (Vavoula *et al.*, 2007).

Usability Methods

A usability inspection may consist of a number of data collection and analysis methods. Its aim is to (a) identify usability problems in order to incorporate suitable usability application functions into the design of the user interface, and (b) to specify and fulfill system requirements of potential users. A *user-centered system design* usually begins with an extensive analysis of potential users, tasks and environment, where potential users are involved in the process of system design from the beginning of system development and are consulted at each incremental stage of the development and evaluations. It is completed when the system usability criteria are satisfied (Petrelli and Not, 2005).

Technological Methods

An implementation (or a prototype) of the application is usually required for a technological evaluation. The evaluation process typically involves (a) an *evaluator* who plans and conducts the evaluation, and (b) a *volunteer* who tests the implemented application on a mobile device. Depending on the nature of the evaluation, the volunteer is asked to provide information about their usage of the application before, during and/or after the hands-on experience with the device. The technological evaluation of an application can take place in either the authentic context in which it is intended to be used, known as a *real* evaluation, or in a virtual or replicated context (a *simulated* evaluation).

Research Methodology

A '*diary: diary-questionnaire*' study was chosen as the feasibility methodology for determining the usability of our mCALS framework prior to its implementation. The diary study, its advantages, reasons for deploying it, alternative usability methods, data sample and preliminary data analysis, were presented in Yau and Joy (2009b). This study offered the following advantages: (a) a more straight-forward approach for both the researcher and volunteers to conduct the study; (b) an increase in the number of potential participants; (c) simplicity for volunteers to capture their daily activities for the 2 days required for our study on paper; (d) ease of data collection; and (e) no additional necessary training time and financial resources (such as the use of mobile devices for recording data logs for students to use for two days). Such a method is especially beneficial for obtaining real-time information without the implementation of data logs to record usage of mobile devices to obtain the same information from learners (Wild *et al*., 2005).

The reason that GPS technologies are not deployed as an alternative to the diary study is that we wish to determine whether learners' location and available times can be retrieved accurately using their schedule information. Observation studies would not have been feasible in place of the diary study because learners would need to be tracked for the duration of two days, and learners may not have been comfortable being tracked, and this would affect the validity of the results (Vavoula *et al*., 2007). There would also be limitations imposed by alternative technological methods, if these were to replace the diary study. Such limitations include the amount of time necessary to implement and debug a system which would not crash for the duration of two days which students are required to use, the current inability of GPS to work effectively indoors, and resource constraints affecting the availability of sufficient suitable equipment to support the participating students. Problems experienced by students using such systems to perform evaluations have been reported, and these have deterred students from further conducting the experiments (Corlett *et al*., 2005).

This usability feasibility methodology was critical to our research because of the nature of the framework which deployed a learning schedule. In order to be able to retrieve the location and available time contexts accurately, users must be able to plan their schedule in advance, conform to it and keep it up-to-date. The interview data analysis showed that many participants did make use of a diary and that they followed their events closely (Yau and Joy, 2009a). However, there may be discrepancies between what participants said they did, and what they actually did do. Therefore, this phase was important for determining (a) whether a diary approach could be used as a successful way of retrieving users' location and available time contexts, by investigating the degree of accuracy that students were able to keep to their diary, and (b) the important learning contexts that should be considered as the basis for recommending appropriate learning materials to students. A further reason that GPS (or similar) technologies were not deployed as an alternative to the diary study was that we wanted to determine whether learners' location and available time can be retrieved accurately using their schedule information alone. The study was not a burden on the participants, since they were only required to fill in their timetable at the beginning of each day, a brief 'diary-entry' form (with mainly multiple-choice questions) after each learning session, and a short 'diary-questionnaire' at the end of the study. The whole experiment should not have taken much of the learner's time.

Three parts of the 'pen and paper' diary study were specifically designed, as follows.

- Part 1 required volunteers to use '*diary schedule*' sheets to keep a chronological record of their study-related and -unrelated events for 2 days and to provide information such as location, nature of event, time (to and from), whether these were completed/attended, and a reference number of the event.

- Part 2 required volunteers to use '*diary entry*' sheets to fill out information relating to their completed study-related events including the reference numbers of the event (for cross-referencing), actual start and finish time of events (to the nearest five minutes), the location of the event, their choice for studying in that location, information about the noisiness, busyness, and temperature of the environment, how frequently they were interrupted, how motivated they were, how urgent the task was, how well they concentrated throughout the session, and if they concentrated better or worse at the beginning and end of the session. (identical sheets were given to each volunteer – one for each event – and the maximum number of recorded study-related events by any one student was 13).
- Part 3 required volunteers to fill out '*diary-questionnaires*' to provide additional information relating to diary planning, effects of different learning contexts towards their concentration level, whether they can usually concentrate at the same level throughout a learning session, whether they plan a certain activity to be completed at a certain location, and which activities they would carry out when they had different amounts of time available to them.

Volunteers were given instructions to complete each of two *'diary schedule'* sheets at the beginning of each of the two days they had chosen to carry out the diary study. They were given the flexibility to choose two days (consecutive or otherwise) where they had a sufficient number of tasks or activities. They were asked to fill out a '*diary entry'* sheet immediately after each completed study-related event to reduce the disadvantages of the 'recall' effect (Wild *et al*., 2005) i.e. students may not remember the exact settings and information that they were required to provide after some time had elapsed. Volunteers were asked to complete the '*diary-questionnaire*' sheet at the end of the diary study. An instruction sheet and a consent form for conducting the diary study accompanied the diary study sheets.

32 volunteers participated in our study and each filled in a diary for two days. This formed a total of 64 days of diary for analysis, 157 '*diary entry*' sheets were completed, and 31 (out of 32) '*diary-questionnaire*' sheets were completed. A pilot study was first carried out to ensure that (a) all parts of the study were clear, and (b) to provide an opportunity for reflection of the diary structure and the questions in light of responses from volunteers. Thereafter, 13 students participated in our main study – these students were enrolled on computer science (9), German-language students (2), law (1) and engineering (1). The data from these 13 students and the three pilot students are named *batch 1*. We also obtained 16 volunteers from the PA College in Cyprus, enrolled on Business Administration (7), Business Computing (4), Accounting (3) and Marketing (2); the data from these students are named *batch 2*. The age range of the participants was 18-30 and they were in various years of study.

Data Analysis

In this section, we present the data analysis together with the following four research questions:

- Can a diary approach be used to retrieve the *location* context?
- Can a diary approach be used to retrieve the *available time* context?
- Which learning contexts should be used for recommendation?
- Which type(s) of learning materials are appropriate for which circumstances?

Our analyses for the first two and the last (sections 4.1, 4.2 and 4.4) are necessarily descriptive, whereas we are able to apply a quantitative analysis to the third (section 4.3).

Can a diary approach be used to retrieve the location context?

All 32 of the participants were able to plan their study-related events ahead for the 2 days required. All of batch 1 participants noted both study-related and -unrelated events, whereas, the batch 2 participants only noted down their study-related events. A possible explanation of this was that the diary study coincided with the onset of their exam period, hence they were very busy attending revision lectures and self studies, and omitted other events which they may have felt to be less important to them at that point in time.

275 events were recorded from these students, 181 were study-related and 94 were study-unrelated. 251 of the 275 events (91%) recorded by participants went as anticipated i.e. the event was completed or appropriately attended to, χ^2 (1, N=274) =189.7, p<.001. 23 events (19 study-related and 4 study-unrelated) were indicated *not* to have gone as anticipated by 8 participants from batch 1, an average of 2.875 events by the 8 participants. Only one event was indicated by a batch 2 participant as not to have gone as anticipated and this was due to "boredom". Explanations for the events not having gone as anticipated were provided, as follows:

- Reasons concerning the study-related events included (a) their planned tasks required a longer time for completion, (b) they were interrupted often, sick, tired or had low levels of productivity and decided to either not commence or discontinue with the activity, (c) their scheduled events were cancelled, delayed, rescheduled or exceeded the scheduled time, and (d) there were transportation delays.
- Reasons concerning the study-unrelated events included (a) they changed their minds regarding their planned activities that they had wished to carry out, (b) the location of a meeting place with friends was changed, and (c) there was a lack of time.

Via the '*diary-questionnaire*', we obtained additional information regarding the diary planning of participants. 12 out of the 16 participants from batch 1 (and 2 out of 16 from batch 2) indicated that they normally kept a diary, of whom one noted that they only kept the important events in their diaries. All of the 32 participants indicated that they did not have any problems keeping and updating the diary for the two days for our diary study.

Our diary study results showed that in general students did not have any problems planning, keeping and updating their planned events, at least for the duration of two days. This was supported by our interview study results where 27 out of 37 participants (i.e. 73%) (Yau and Joy, 2009a) who had informed us of their regular paper-based or electronic-based diary usage. Of the 275 scheduled events, only 9% had not gone as anticipated, and these were affected by unforeseen circumstances. This is a clear and statistically significant difference in the frequency of which events went as anticipated compared to those which did not. That only 9% of events were not anticipated is a relatively small percentage considering the large number of events that were recorded by a total of 32 participants. Thus we conclude that our learning schedule approach for retrieving the location context can be used as a preliminary proactive source of retrieving the location, whilst noting that additional methods could be employed to verify their actual location, such as the use of GPS and WLAN technologies.

Can a diary approach be used to retrieve the available time context?

The times and locations of participants' scheduled study-related events for the two days noted in part 1 of the study were checked against the times and locations indicated on the corresponding 'diary entry' sheets in part 2. 'Diary entry' sheets were only necessary to be completed for each study-related event and not for study-unrelated events. Participants were asked to round their start and finish times to the nearest five minutes. 91% of participants' events went as anticipated (see 6.1); however, there were some discrepancies between the planned and actual start and finish times of the events, described below. For the events which went as anticipated, the actual and planned locations were consistent. Out of the total of 157 completed diary entry forms, 109 were from participants of batch 1 and 48 were from participants of batch 2.

The planned and actual start and finish times of 52 out of the 109 study-related events (47%) from batch 1 were matched. There were discrepancies between the actual and planned start and finish times of the remaining 57 events, and these events were recorded from 12 out of the 16 participants. These 57 events are classified into the following two categories of events.

1. 20 events were *scheduled classes or meetings*. These often started and finished 5 or 10 minutes earlier or later, exceptionally finishing 35 minutes earlier. Participants often rounded the start and finish times of lectures to the hour on their '*diary schedules*' sheets, when in fact, lectures at our university started at five minutes past the hour and finished at five minutes to the hour.
2. 37 events were *self-studies*. Due to the nature of these events, it was assumed that participants gave themselves the flexibility of starting and finishing at an earlier or later time, when it was convenient for them. The actual start and finish times ranged from a start of 20 minutes earlier to 95 minutes later and from a finish of 105 minutes earlier to 115 minutes later (depicted in Figures 1 and 2).

As a result, the discrepancies between the actual and planned amount of time spent on their self-study events ranged from -110 to +110 minutes, for the participants in batch 1 (depicted in Figure 3).

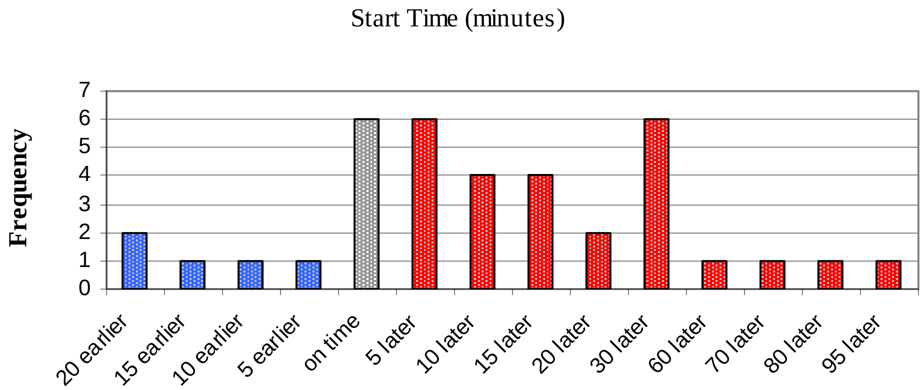

Figure 1: Actual start times of self-study events

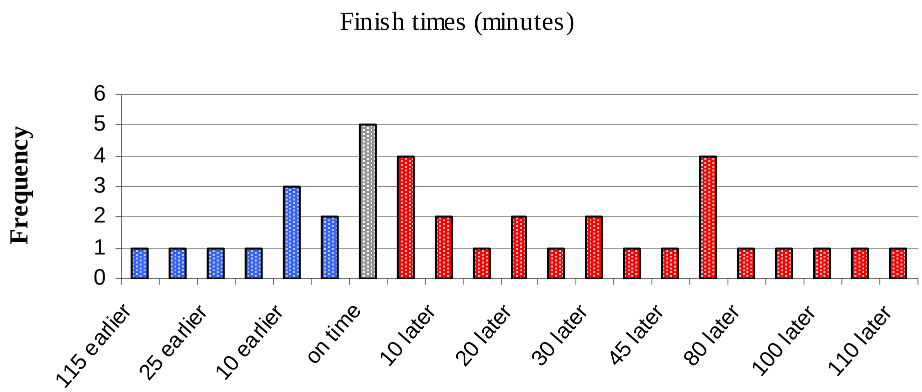

Figure 2: Actual finish times of self-study events

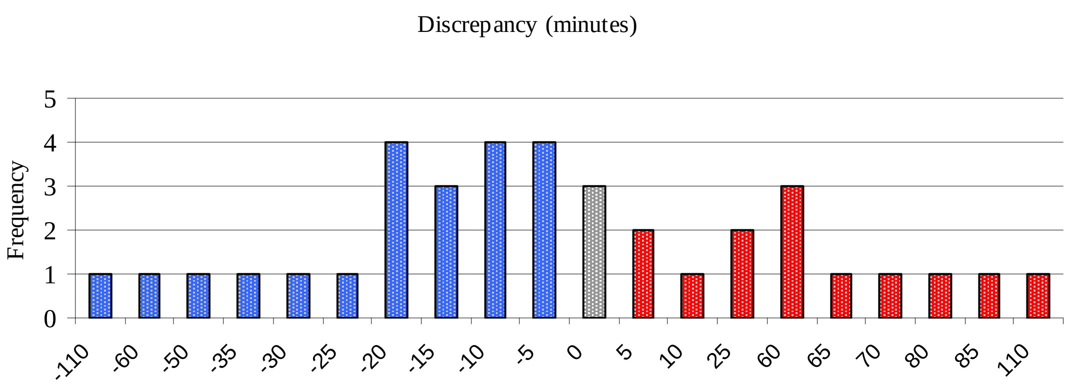

Figure 3: Discrepancies between the actual and planned amount of time for self-study (batch 1)

Regarding the data from batch 2, the actual and planned start and finish times of 44 out of 48 study-related events were matched and were recorded by 9 participants; whereas the remaining 4 study-related events were not. One of the four events that were not matched was a scheduled class and the remaining 3 events were self-study events; these were recorded by 2 participants from the batch. 5 participants did not note down the actual start and finish times of their events on the diary entry forms; however common amongst the batch 2 participants were 2 daily laboratory revision exercises classes, in preparation for their exams. We presumed that due to the importance and urgency of these events, these participants had attended these events from start to finish.

Results from the '*diary-questionnaire*' showed that 10 out of 15 participants from batch 1 indicated that they had always carried out the activities that they had planned at the specified location. One participant indicated that they usually did, and another participant indicated they sometimes did and the remaining 3 indicated that they did not always carry out the activities that they had planned at the location. Most of the batch 1 participants indicated that they were always in the location that they had planned, except for two participants who noted that they occasionally would complete their previous studying activities together with their current one in the same location. 11 participants from batch 2 noted that they had always carried out the activities that they had planned at the specified location, one noted that they had sometimes done so, and 4 that they did not carry out the activities that they had planned at the location. Out of the batch 2 participants, 8, 2 and 5 indicated that they were *always, sometimes* and *not* in the location that they had planned respectively.

The results showed that the actual locations of participants were consistent with their planned locations of events. In the case of the actual start and finish times of scheduled classes events in comparison with the planned times, there were small discrepancies of 5 or 10 minutes earlier or later than planned, with occasionally a larger discrepancy. For self-study events, participants were also in the same locations as planned, however there were more and larger discrepancies between the planned and actual start and finish times. Our conclusion is that the retrieved available time of a learner from the learner schedule can be used as the default values of their available time at a certain point in time. An additional user verification method may be required to enable users to verify the amount of available time retrieved, and change this, as necessary.

Which learning contexts should be used for recommendation?

In this section, we present a quantitative analysis of the learning contexts and identify correlations with the other factors we have measured which affect a student's study activity.

Correlations between the attributes and the learners' level of concentration

The qualitative data analysis from our interview study has demonstrated relationships, either positive or negative, between *busyness of environment, noise, temperature, motivation, frequency of task, frequency of interruption* and the concentration level of a learner (Yau and Joy, 2009a). Therefore, we require further quantitative analyses to establish the relationships between these attributes and the concentration level of a learner. 157 completed '*diary entry*' sheets were obtained, and each recorded a learner's levels of concentration and the values of the various attributes in each learning session. We make the assumption that each set of responses obtained from the 'diary-entry' sheets, with attributes coded on a parametric scale of 1 through 5, is normally distributed, each having a mean and a standard deviation (N=157) as follows:

- *Noise* – mean = 2.16, SD = 1.03
- *Busyness of environment* – mean = 2.2, SD = 1.07
- *Temperature* – mean = 3.0, SD = 0.50
- *Frequency of interruption* – mean = 2.13, SD = 1.05
- *Motivation* – mean = 3.56, SD = 0.94
- *Urgency of task* – mean = 3.29, SD = 1.03
- *Concentration level* – mean = 3.44, SD = 0.94

Table 1 shows the correlation matrix where correlations between each of the attributes and participants' concentration level throughout a session were calculated. We calculated the zero-order correlations and subsequently the partial correlations, where other factors were controlled to ensure that the other attributes in the observations were not affecting the outcomes of the correlations. The significances of the normal and partial correlations of each factor are also displayed in this table.

Table 1: Normal and partial correlations between concentration level and factors

	Factors	Normal*	Partial*
1	*Noise*	-.271	-.310
	Significance (2-tailed)	.001	.000
2	*Busyness of environment*	-.029	.183
	Significance (2-tailed)	.721	.024
3	*Temperature*	-.020	-.064
	Significance (2-tailed)	.806	.434
4	*Frequency of Interruption*	-.205	-.051
	Significance (2-tailed)	.010	.535
5	*Motivation*	.445	.425
	Significance (2-tailed)	.000	.000
6	*Urgency of Task*	.101	-.063
	Significance (2-tailed)	.208	.441

*Note: The number of degrees of freedom is 155 for zero-order correlations and 150 for partial correlations.

When we correlated the noise level normally with the concentration level, the result was a statistically significant negative correlation (r = -.271, p<.001), suggesting that the higher the participants had found the noise level to be, the lower their average concentration level. The partial correlation between noise level and concentration level was even higher than the zero-order correlation (r = -.310), and the correlations became stronger after controlling for the other factors.

Negative zero-order correlations were found between the *busyness of environment*, *temperature* and *the frequency of interruption* in relation to the concentration level. Of these, the zero-order correlation between the frequency of interruption and the concentration level was statistically significant (r = -.205, p = .010), indicating that the higher frequencies of interruption coincided with lower levels of concentration. However, after controlling for the other factors, this correlation was no longer significant (partial r = -.051, p = .535).

Positive correlations were found between the *motivation* and *urgency of task* (zero-order only) in relation to the concentration level, of which the correlation between motivation and concentration level was significant (r = .445, p < .001). The results showed that the most significant factors affecting participants' concentration levels positively and negatively were *motivation* and *noise* respectively.

Regression analysis, t-test and analysis of variance

A regression analysis was performed to show the correlation between the concentration level and all the other attributes in order to predict changes in the concentration level. The regression model significantly predicted changes in concentration level, $F(6, 150) = 10.889$, $p < .001$, adjusted $R^2 = .276$. This revealed that the motivation was the most important factor in determining participants' concentration levels, such that higher motivation led to higher concentration levels after controlling for the effects of all other variables. Moreover, *noise* also independently predicted changes in concentration level, such that more *noise* decreased concentration level.

Two statistical tests were employed to investigate whether there were any consistencies in the levels of concentration of participants throughout a learning session. On the '*diary-entry*' sheets, participants selected what they regarded as their concentration (a) *throughout the session*, (b) *at the start of the session*, and (c) *at the end of the session*.

1. A t-test was applied to compare the means of two values – the concentration level at the start and end of the session. The mean of the end concentration levels was 3.08, which was lower than the start concentration 3.44. To test that this lower level at the end of the session was not due to chance, the observed difference (3.4 - 3.1 = 0.3) was tested against an underlying distribution based on the degrees of freedom (df), which was 159. We obtained $t(159) = 3.579$ and $p < 0.001$, showing that the difference in concentration level from start to finish decreased significantly.
2. An analysis of variance for comparing the means of three concentration values mentioned above. Our results showed that concentration peaked during a learning session and then fell steadily towards the end. Concentration

level depended significantly on the time it was measured (Start vs. Throughout vs. Finish), $F(2, 316) = 10.58$, $p<.001$, $\eta^2 = .063$. Polynomial contrasts were run to explore how concentration level decreased over time. Results showed a significant linear trend, $F(1,158) = 12.066$, $p=.001$, $\eta^2 = .071$, in addition to a significant quadratic trend, $F(1,158) = 8.130$, $p=.005$, $\eta^2 = .049$. These linear and quadratic trends suggested that while concentration level decreased over time, it actually peaked during the study session.

Results from the 'diary-questionnaire'

Results from the '*diary-questionnaire*' relate to the effects of the various factors on the 31 learners' concentration for studying:

- *Noise* had an effect on 25 participants, but for 19 participants this was a lesser effect when they were completing an urgent task and 12 participants noted that there are not usually any times when noises did not affect them.
- *Busyness of an environment* had an effect on 21 participants.
- *Temperature* had an effect on 18 participants and not on the remaining 13 participants.
- *Motivation* had an effect on 27 participants. The effect was significant (a) on 24 participants in determining whether they would study at a particular location, and (b) on 26 participants in determining whether they would study a particular topic.
- *Internal distractions* had an occasional effect on 25 participants.
- *Urgency of task* had a significant effect of eliminating (a) general distractions for 19 participants, and b) noise distractions for 20 participants.
- 23 participants had *discontinued with their studies* due to distractions (such as noises, heat, phone ringing, fire alarm, busyness of environment, tiredness, motivation, mood, hunger, and talked to others instead). The 8 participants who not discontinued with their studies despite distraction gave as the main reason determination to finish their study activities.

Results from the '*diary-questionnaire*' also show that 15 participants from batch 1 had the opinion that there were normally changes in their concentration level within a learning session. Reasons included (a) becoming tired or bored, (b) the difficulty of the work was, (c) potentially better motivation or mood at the start of the session, (d) interruptions/distractions, and (e) how well their work was going. 13 out of the 16 participants from batch 2 indicated that there were usually changes in their concentration level within a session, whereas 3 indicated that they could concentrate at the same level throughout a session.

Discussion

A participant's high level of motivation during a learning session was shown to have a positive impact on how well they could concentrate throughout that session. Similarly, a high noise level in an environment had a negative impact on student concentration. Statistically insignificant negative correlations between the *busyness of environment*, *temperature* and *frequency of interruption* were found in relation with the concentration level of a student, and a statistically insignificant positive correlation was found between the *urgency of task* factor and the concentration level of a student. We conclude that the two variables – *motivation of a learner* and *noise in the environment* – are two necessary variables that should be taken into consideration in the selection of appropriate learning materials for students in different situations.

Which type(s) of learning materials are appropriate for which circumstances?

Via the completed '*data-entry*' sheets, reasons for participants' chosen types of locations for performing their study activities were obtained, as follows:

- Coursework assignments (as well as writing/updating reports, making notes, and reading) were completed in *department office, library, home (bedroom, dining room, study), train and student union building*. The main reasons given for studying in these locations included that the location was quiet or relaxing, it being their preferred study location, the availability of academic help and resources, as well as the urgency of the task. The main reasons for studying in the two latter locations included maximizing productivity and not wasting idle time whilst travelling or waiting.

- Hands-on programming (as well as learning how to program and programming exercises and projects) was completed in *computer laboratory, library and home (bedroom)*. The main reasons were the same as the ones stated above.
- Making a presentation was completed at home (kitchen).
- Lectures and classes were completed in lecture theatres or classrooms due to the scheduled locations.

14 participants indicated that they did normally plan a certain study activity to be completed at a particular location. Reasons for this included that some places were better for them to concentrate and they had a higher level of productivity there as well as due to the requirement to use certain resources (such as books or computers). The remaining 17 participants indicated that they did not plan a certain study activity to be completed at a particular location because they were able to perform them in any location.

In the '*diary-questionnaire*', participants were asked to name the study activities that they would perform when they had a) *less than 15 minutes,* b) *15-30 minutes,* c) *30 minutes to an hour, and* d) *over an hour*, respectively. The results revealed that participants would choose shorter and easier learning/studying activities such as *planning, brainstorming, reading*, or none at all (because the time available was too short), when they had a shorter time for example 15 minutes or less. When they had more time available for example half an hour or more, they would carry out more difficult tasks requiring more concentration such as *writing coursework assignments,* and *programming* etc. This suggests that there is a relationship between the time available to a student and their motivation for carrying out a particular learning/studying task.

General suggestion rules can be formed considering the motivation level of the learner and the types of materials suitable for different values of these. We established the following suggestion rules for students to perform their self-study events. Note that the difficult, medium and easy levels of tasks are in terms of cognition:
- If motivation = high and available time > 30 mins then difficult tasks are selected.
- If motivation = medium and available time > 30 mins then medium tasks are selected.
- If motivation = low and available time > 30 mins then easy tasks are selected.
- If available time < 30 then easy tasks are selected.

For the selection of Java materials to students, we used a simplified version of Cui and Bull's (2005) suggestion rules for recommendation, and the choice of time durations is also consistent with theirs. Instead of considering the student's concentration level and frequency of interruption, the student's motivation level and their available time is to be considered. The full set of modified suggestion rules can be found in (Yau and Joy, 2010). An example is given, as follows.

1. Tutorials, exercises and revision materials are selected
    - If motivation = any level and available time > 30 mins.

Lastly, the learner's learning styles and knowledge level were also to be considered. This can be done by matching the learner's learning styles and knowledge level with the learning object metadata containing information relating to these attributes.

Conclusions and Future Work

In this paper, we have described our diary study for data collection and analysis in relation to our mCALS framework which uses a learning schedule as a proactive approach in retrieving the learner's location and available time contexts. Data analysis shows that the planned and actual locations of learners were entirely adhered to, and 47% of the planned and actual start and finish times were precisely matched. Although, evidence suggests that the planned location of a learner can be relied upon as the actual location, there may always be unforeseen circumstances when the learner is not adhering to their schedule. We propose that our learning schedule approach can be used as a default method of retrieving the learner's location and their available time. Thereafter, verification methods are to be put in place to verify the location, using GPS technologies outdoors and wireless LAN indoors, together with a user interactive method to request users to confirm their available time. Four learning contexts –learning styles, knowledge level, motivation, and available time – are to be incorporated into our framework for the suggestion of

Java learning objects to students. Motivation and available time are considered when selecting students' own learning/studying materials to them in different situations. Future work includes a technical implementation of our framework on a mobile device with a built-in learning schedule and context-aware technologies.

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