Context-based recommendations of Java learning objects: a case study

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***Abstract*—In order to validate the potential deployment of the proposed learning contexts and suggestion rules of the theoretical mobile context-aware suggestion mechanism mCALS, an online case-study was conducted using Java learning objects (LOs). 14 students participated in the study, and the Java LOs used in this experiment were obtained from the Codewitz LO repository and represented a selection of procedural and object-oriented topics. Initially, participants of the study would select how much available time they had (10, 15 or 20 minutes), their current level of motivation (high, medium, low) and knowledge level of Java (high, medium or low). A choice of appropriate LOs was then presented to each participant, which they were then invited to study. This paper presents the case study, and reports that the data analysis provides interesting insights into how the proposed recommendations of context-based Java LOs are suited to students studying in various contexts.**

***Index Terms*—case study, context-based recommendations.**

I. INTRODUCTION

CONTEXT-BASED/AWARE m-learning applications are recent innovative applications which deploy learning contexts (such as location, learning styles and knowledge level), and recommend/supply appropriate learning activities/materials to learners based on their current contexts. These groups of applications are categorized in Yau and Joy's [1] third and final m-learning generations respectively. At the time of writing, only a small number of context-based/aware suggestion mechanism applications have been developed and evaluated. These applications/frameworks include CoMoLE [2], TenseITS [3], and the didactic profiling framework of Becking *et al*. [4].

We have developed a mobile context-aware learning schedule *mCALS* framework [5]. This framework aims to recommend Java learning objects to learners that are appropriate for their current learning situation. The data analyses of our previous qualitative interview and quantitative diary studies [1, 6] have informed us of three significant learning contexts that should be deployed. These are the learner's knowledge level of the proposed topic, their available time for study, and their current level of motivation. A set of suggestion rules based on Cui and Bull's [3] to be deployed in our framework are also presented in Yau and Joy [6]. The formed general suggestion rules are as follows. 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 mins then easy tasks are selected.

This paper presents a case study used to validate the learning contexts and suggestion rules deployed in the mCALS framework. It is structured as follows – a literature review is provided in section 2, our case study research methodology is presented in section 3, the data analysis of the case study is described in section 4, and finally, in section 5, we present our conclusions and future work.

II. LITERATURE REVIEW

We provide a literature review on the following – context-based suggestion mechanisms/frameworks, Java and Java-learning applications, and learning objects.

Context-based suggestion mechanisms/frameworks

There are three context-based suggestion mechanisms/ frameworks that are most related to our work. These are CoMoLE [2], TenseITS [3] and the didactic profiling framework of Becking *et al*. [4]. CoMoLE [2] has been evaluated by students based on materials from two subjects – data structures and operating systems. Different types of learning activities related to these subjects were included. Students could use different devices such as PCs, laptops, or PDAs to access and perform these learning activities. Their learning styles, knowledge level, available time, and type of device used are taken into consideration when the system recommended materials for them to study. Results of their case study are discussed together with our results in section 4, where appropriate.

The TenseITS [3] system selects appropriate English-learning materials to students based on their available time, concentration level and frequency of interruption at their current location. This system had not yet been evaluated.

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The didactic profiling framework of Becking *et al*. [4] defines a set of contexts that should be used for determining the types of learning materials/activities for learners in different situations. It is centered on an inference engine and contains a set of filtering rules, which are based on learner profiles and the characterization of learning objects. The learning contexts used within this mechanism are classified into four categories - *situation*, *learner*, *learning objects*, and *participation*. This framework has not yet been evaluated.

Java and Java-learning applications

The majority of software applications for learning the Java programming language are still web-based and have not been made specifically available for use on mobile devices. Example Java e-learning applications include those of Sykes [7], Ab Hamid and Fung [8], Mungusukh and Cheng [9].

In order to assign particular Java topics to students based upon their proficiency level of Java for our case study, we needed to first determine an order of difficulty of Java topics. We were not aware of any previous work that had been completed on this at the time, so we conducted two experiments – 1) a literature review of currently deployed Java textbooks at our university, and 2) a questionnaire completed by students to indicate their perceived difficulty levels of Java topics. The results of these experiments are in Yau and Joy [10], and the topics and their levels of difficulty (in brackets) were established as follows – assignment (1), expressions (2), output (3), input (4), if-statements (5), for-loops (6), arrays (7), methods (8), classes (9).

Learning Objects

Learning objects (LOs) are reusable online learning materials each of which contains a rich set of metadata for describing which learners and/or learning purposes is appropriate for. They are usually stored in global learning object repositories such as Codewitz (contains programming LOs), MERLOT (contains materials from disciplines including biology, business, engineering, history etc.), CAREO and Telecampus. Applications which allow mobile learning objects to be viewed on mobile devices have been created by Smith [11] and Bradley *et al*. [12].

III. RESEARCH METHODOLOGY

Our case study has been an attempt as a means to validate the deployed learning contexts and suggestion rules in our proposed mCALS framework [5]. We were constrained by both time and financial resources – a) of developing the framework as a working prototype and b) of owning a number of mobile devices which students can use for the experiment, respectively. We therefore constructed an online experiment, for which participants could choose freely the time, location and the device with which to carry it out. We describe two parts of our research methodology – a) how we set up our online experiment and b) the recruitment and participation process.

The online experiment

We had chosen learning objects which were of tutorial type from the Codewitz learning object repository. The experiment was set up to allow participants to first select their available time (10, 15, or 20 minutes), followed by their current motivation level (high, medium, low), followed by their knowledge level of Java (high, medium or low). A choice of a few LOs that are appropriate for that context appears for the participant to select to learn/study. These suggestions are based on our general suggestion rules presented in section 1, as well as the established proficiency levels of Java, presented in section 2.

For example, when participants have a lower level of motivation, they will be suggested easier LOs to study, and vice versa. The proficiency level of the learning object and the length of time it requires to be completed are matched with the knowledge level of the student and the amount of available time that they have.

Recruitment and participation process

Participants were recruited via lectures and emails within our university as well as in other universities via HEA-ICS. 14 university students had participated in our study – Warwick (6), Nottingham Trent (2), Coventry (2), Greenwich (2), Bradford (1) and Dundee (1). Gender and age information were not necessary to be recorded.

Participants were asked to complete an online feedback form after they had finished studying/learning an LO. Feedback required from participants primarily related to 1) how useful they had found the study of the LO in the contexts, 2) whether their learning experiences of using the LO was more enjoyable as a result of studying it in those contexts, and 3) whether the suggestion rules were appropriate in the recommendation of LOs. Our online experiment can be viewed in [13].

IV. DATA ANALYSIS

In this section, we present the results of the data analysis of our case study. In particular, it is divided into seven parts – overview, followed by 5 parts where we address each of our research questions, followed by a summary of the results. The five research questions are as follows:

1. How useful had participants found the study of LOs in appropriate learning contexts?
2. How enjoyable had participants found the study of LOs in appropriate learning contexts?
3. How appropriate were the deployed suggestion rules for recommending Java LOs to students?
4. What were the reasons that students chose particular time slots to study in?
5. What overall feedback can be deduced from the case study which relates to the mCALS framework?

1. Overview

Here, we provide the reader with an overview of the quantitative data results, shown in table 1, concerning research questions 1, 2 and 3. The results showed that 11 out of 14

participants had found it very useful or useful studying the LOs in the particular contexts. 8 out of 14 participants found it enjoyable studying the LOs, and 11 out of 14 participants had it more enjoyable studying the LOs in the particular contexts. 12 out of 14 participants noted that the LOs were recommended appropriately to them in their situation. 12 out of 14 participants noted that the recommended LOs would also be feasible for studying in other contexts.

Table 1 - Overview of quantitative data results

1	How usefulness had participants found the study of LOs in appropriate learning contexts?	Very useful (3)	Useful (8)	Not useful (3)
2	How enjoyable had participants found the study of LOs in appropriate learning contexts?	Very enjoyable (2)	Enjoyable (6)	Not enjoyable (6)
	Whether participants found the study of LOs more enjoyable in contexts?	More enjoyable (11)		Not more enjoyable (3)
3	How appropriate were the suggestion rules for recommending Java LOs?	Appropriate (12)		Not appropriate (2)
	How feasible can the recommended LOs be studied in other contexts?	Very feasible (1)	Feasible (11)	Not feasible (2)

2. Usefulness of learning contexts

Here, we answer the research question – "How useful had participants found the study of LOs in appropriate learning contexts?" We examine whether in practical terms, participants had found the deployment of the proposed learning contexts in the recommendation of LOs useful. 3 out of the 14 participants of the experiment informed that they had found the LOs to be very useful in the particular learning contexts, whereas 8 had found them useful and 3 had found them not useful. Some of the feedback given by participants informed us that the usefulness was related to the particular contexts that they had found it useful studying in, whereas other feedback was related to the learning content and/or the user interface of the LOs and learning environment respectively.

Feedback related to the usefulness of the LOs in the learning contexts includes "being able to follow the object without too much effort". Although, not many participants had given comments regarding why it had been useful studying the LOs in the learning contexts, 11 of the 14 participants had found it to be either very useful or useful. Hence, we can deduce from that that the choosing of the LOs according to which learning contexts the LOs should be studied under were mostly appropriate.

The obtained feedback from participants related to the usefulness of the learning content and/or the user interface of the LOs and learning environment include 1) finding "the step-by-step explanations of the LOs to be good"; 2) finding "the visual display of code statements made it easy to understand and follow"; and 3) finding "the program clear, well laid out and the LO gave a very coherent explanation, much more effective than lecture slides." The amount of feedback we received from participants was quite limited; this is often the case with online questionnaires. Martin and Carro [2] had also noted that many of their participants had selected the "I do not know" option, and this was particularly true in the days prior to the participants' exams. Some of the later participants of our case study had also forthcoming exams.

On the negative note, the following was noted from participants – 1) "there could have been a lot more information on each line of code explaining things a bit better as, for example, there was no explanation/definition of what an exception actually is"; 2) finding the content to be very simple and did not learn anything from it, and therefore had found it not useful; and 3) finding "the code examples to be a little too simple, despite choosing a high level of knowledge, it still seemed very rudimentary".

Regarding 1), this is insofar related to the learning content, and not the learning contexts. We were attempting to provide evaluations of the learning contexts in the experiment rather than the learning content. Regarding 2) and 3), these were related to the difficulty level of the topic, not exactly appropriate for the knowledge level of the participants. Although, we did attempt to assign most appropriate LOs according to their difficulty level for the proficiency levels of students, it is perhaps not in every case that we can precisely match them. This is because of a two possible reasons – 1) the participants might have over- or under-estimated their proficiency level in Java and/or have selected an inappropriate or incorrect level for them; 2) the LOs were not exactly in the range of the proficiency level of an average student with that knowledge level. Or if there was a particular topic that has been over- or under-studied by a student, then the LO could be more or less difficult than anticipated.

The chosen learning contexts used for recommendation of LOs were available time, knowledge level and motivation level. Cui and Bull [3] and Martin and Carro [2] noted that these first two contexts were very important when recommending materials to learners 'on the move' when they have limited time until their next scheduled task. Whereas Cui and Bull [3] had used 'concentration level' and 'frequency of interruption' contexts for their recommendations, we had alternative introduced a third context – 'motivation level' of the learner, to replace the former two contexts. This was a result of our earlier study which established that there was a high positive correlation between a learner's motivation level and their concentration level. The results obtained from participants regarding the usefulness of these learning contexts prove that they are indeed useful when studying online materials. All of the participants had either studied at home or at the university.

To conclude, the majority of participants had found the LOs to be useful for learning/studying Java. Most of the LOs selected for their current learning contexts were appropriate for them and they had found that to be useful. A small amount of feedback indicated that participants had not found the LOs to be useful because they were too simple for them.

3. More enjoyable studying different LOs in different situations

Here, we answer the research question "How enjoyable had participants found the study of LOs in appropriate learning contexts?" We first discuss whether participants had found the

study of LOs enjoyable, and whether they had found the study of LOs more enjoyable in their learning contexts.

Whether participants found the study of LOs enjoyable

2 students had found the experience of learning with the LOs very enjoyable, 6 students had found it enjoyable and 6 had found it not enjoyable. The feedback obtained relating to this research question were also more directed to the learning content or the user interface, rather than the learning contexts itself. We presume that this is because participants were less aware and knowledgeable of what learning contexts actually were, even though we had described these to them explicitly.

Positive feedback given by participants relating to how enjoyable the study of LOs was in their current learning contexts includes 1) they had found it comforting given "the ability to follow easily the LOs and having the ability to click on each step in order to go to the next one"; 2) they had found it convenient having "the ability to skip forward and backwards at will"; 3) they had "found it easy to understand and follow when inspecting the code as it was being processed, and it was a good way to illustrate program flow; 4) they had "found the interactive LOs very appealing even though they were not motivated to concentrate on learning".

Suggestions to improve the user interface to make it look more professional and exciting were made by a participant and they noted that this may help potentially encourage a larger set of audiences to participate in learning the LOs and also spend longer studying them. One participant suggested that the "representing memory & variables LO was very intuitive and would be very useful for beginners".

A few students who did not find the study of LOs enjoyable had stated that it was because the content was too simple for them (as mentioned in the previous section), and therefore it was boring and not enjoyable. Some participants had found them to be too precise and it took longer than necessary to explain some concepts, and they had already previously understood the contents of the objects. Hence, they had found the study of LOs less enjoyable, due to these reasons.

Whether participants found the study of LOs more enjoyable in their current contexts

In terms of whether the participants had found it more enjoyable studying the LOs in their current learning contexts, 11 participants found their learning experience to be more enjoyable and 3 participants had found it not more enjoyable.

Positive reasons include 1) being in the "comfortable environmental surroundings of where they had conducted their learning"; 2) the study of LOs approach was "more enjoyable as it was a fresh approach to teaching that is more involving than a whiteboard". However, regarding 2), this does not directly answer our research question. Another participant noted that "if [their] motivation was lower, then it is unlikely that [they] would have continued through the object". A further participant noted **"**what mattered was the thorough explanation". Some of these feedback obtained for this research question were directly related to how the learning contexts can be used to adjust LOs that are selected to higher- or lower-motivated students. For example, the participant who noted that they would not have continued with the LO, if there motivation was lower. This implies that the LO had been selected appropriately given their level of motivation and hence lower-motivated students can be accommodated as well as medium or higher-motivated students. On the other hand, some of the feedback was concerning the quality and the content of the LO such as the detailed explanations provided. One participant had felt that using LOs was an innovative way of learning, rather than other means such as teaching using whiteboards.

In Martin and Carro's [2] case study, 78% of their participants had preferred learning activities to be recommended to them based on their learning contexts and preferences. This implies that they had also had an enjoyable learning experience with learning in the online environment. In particular, some of the noted comments on the usefulness of the learning environment by their participants include – 1) "these systems guide one over the whole set of activities and help to decide the starting point (what are the best activities to be done according to one's personal needs and learning process); 2) "it helps to know which topics have been wrongly learned, and it proposes review activities for consolidating these concepts"; 3) "it includes many exercises and [they] can train for the final exam since teachers do only a few exercises in class" - many of our participants had noted this similar comment; 4) "these environments are more attractive because they allow [them] to do many types of activities, not only study theory from a book or [their] personal notes"; and 5) "this type of learning environment helps to organize one's free time, so they are very useful when one has only a few minutes available" [2].

Similarly, insights gained through this case study suggest that by giving participants the options to inform the online learning system their situation i.e. available time, knowledge level of Java and current motivation level, they are able to choose from a recommended list of LOs materials that should be appropriate for them under those circumstances. This case study has confirmed that participants had enjoyed learning those LOs which had been recommended to them appropriately, based on their circumstances.

We have described whether our participants had enjoyed a) the study of LOs in general and b) the study of LOs in the participants' current learning contexts. 8 out of 14 students had found it very enjoyable or enjoyable for part a); and 11 out of 14 participants had found their learning experience to be more enjoyable for part b). The feedback obtained was limited as is often the case with online feedback questionnaires. We also described some of the feedback obtained from Martin and Carro's [2] case study, their results of which had shown that their participants had found their online environment very useful and hence potentially very enjoyable, too.

4. Appropriateness of suggestion rules

Here, we answer the research question – "How appropriate were the deployed suggestion rules for recommending Java

LOs to students?" We discuss the results obtained from participants for the following – a) whether the recommended LO that they had studied had been appropriate for their current learning contexts, b) how feasible can the recommended LOs be studied in other contexts, according to the participants' opinions, c) other appropriate activities that can be recommended in the same contexts, and d) inappropriate activities that should not be recommended in the same contexts.

Whether the recommended LO had been appropriate for their current contexts

12 participants noted that the recommended LOs were appropriate for them to study in their current contexts, whereas 2 participants noted that the recommended LOs were not appropriate for them to study in their current contexts. Positive feedback includes "the learning materials or code was relevant to the topic being explained and for [their] knowledge level and available time". Negative feedback includes 1) the LO was short in time duration and it did not require much time or effort to understand; and 2) the LO was too easy for the level of knowledge that they had selected.

How feasible can the recommended LOs be studied in other contexts

1 participant noted that it would be very feasible to study the LO in other contexts, 11 participants stated that it would be feasible, and 2 stated that it would not be feasible. Positive feedback include 1) "it doesn't matter where or when I study the LO, if I'm just reading a bit of code in front of me"; 2) "some LOs could be completed when [they] had a lower level of motivation"; and 3) "people's learning capabilities are different so it is good to recommend different LOs based on these". There were limited responses to this. We had explained the question well and had described clearly what we had meant by contexts. However, participants might still not have understood the question fully, in the intended way, or had felt that there were not many inappropriate activities for different situations/contexts.

Other appropriate activities that can be recommended in the same contexts

We asked participants to indicate other learning activities that may also be appropriate in their opinion in the same contexts. 10 participants had noted that 'answering multiple-choice questions' would be appropriate; 2 participants had noted that 'revising learning materials' would be appropriate and 2 participants had noted that 'practicing tests' would be appropriate.

Inappropriate activities that should not be recommended in the same contexts

We also asked participants to indicate other learning activities that would be inappropriate in their opinion to learn in the same contexts. 'Learning theoretical concepts' was indicated by 2 participants as inappropriate; 'answering multiple-choice questions' was indicated by 3 participants as inappropriate; 'revising learning materials' was indicated by 1 participant as inappropriate; 'Answering open-ended questions' was indicated by 3 participants as inappropriate. Reasons given include that 1) it would take too long to write essay answers to open-ended questions; however one word answers would be desirable in such a short time-frame; 2) open- ended questions and learning new concepts also would require more concentration and would not be appropriate for learning/studying in short available times. In Martin and Carro's [2] study, learning activities which required theoretical explanations were the type of learning activities that were most frequently noted by their participants as inappropriate/unsuitable.

To summarize, the data results suggest that the suggestion rules are appropriate for recommending materials to participants, using the proposed learning contexts. We had carefully selected those LOs which should be appropriate for learners under certain circumstances, based on the suggestion rules presented in section 1. After the participants had studied the LOs, the majority of them had noted that the LOs had been appropriate, and therefore we can validate that both our suggestion rules and the established Java proficiency levels had been constructed accurately and appropriately.

5. Why particular time slots were chosen for studying

Here, we answer the research question "What were the reasons that students chose particular time slots to study in?" We are interested in this question because we want to find out for our mCALS framework [5] or any other mobile context-based suggestion mechanisms, which time slots and the reasons for choosing these time slots to study in. This is so that we can gain more understanding about how, when and why particular learners perform mobile learning and/or use mobile devices for learning.

11 participants noted their reasons to be having spare available time; 2 participants noted that they had interest in learning and in Java respectively; 1 participant noted that it was due to convenience. Additionally, 13 participants noted that it had been a good time slot for studying in – one participant had noted that "[they] were relaxed at home and so could absorb information easier". The remaining participant noted that it had not been a good time slot for studying in, primarily because he was revising for his forthcoming exams at that point in time and should be concentrating on his revision instead.

Positive feedback obtained from participants in Martin and Carro's [2] case study include "this type of learning environments helps to organize one's free time, so they are very useful when one has only a few minutes to spare". Negative feedback obtained includes that students might have "preferred to choose the activities to be performed at each time"; this is also supported by the results obtained in our interview study. Some participants said they could not concentrate because they were tired.

We can conclude that there is a need for mobile learning and the need of mobile devices for learning for students. This is because they may in any time, or any location, want or choose

to perform some learning materials and may not always have sufficient paper-based materials at hand. The time slots participants chose to perform in inform us that convenience and comfort are major factors in influencing whether and where they study. Portable mobile devices can provide the convenience as they are small in physical size. By recommending suitable materials to learners under different circumstances can help them to make use of different situations to make their learning more productive and more enjoyable.

6. Any other and overall feedback

Here, we answer the research question "What overall feedback can be deduced from the case study which relates to the mCALS framework?" Additional data obtained from participants included a) whether they were aware of their learning styles, b) whether they feel that they would benefit from studying LOs that are appropriately recommended based on their learning styles, c) the quality of the learning content; d) whether they would use the LO again; and e) any other comments provided by participants.

Relating to learning styles

Learning styles has been a topic subject to much controversy. Some authors suggested that students should be open to learn using several different learning styles [14], whilst other researchers have continued to use learning styles in their learning systems such as [15,16]. Results from our previous interview study [1] informed us that participants are aware of their learning styles and often would prefer to study using their particular style. We omitted the use of learning styles in this experiment for reasons of simplicity, as participants only spent a short amount of time studying the LOs. However, we gained further insight from participants regarding their views of the use of learning styles.

13 participants had noted that they were aware of their learning styles (hereafter, abbreviated as LS) and were able to locate their learning style on the spectrum of the Felder and Silverman model [17]. 5 participants noted that they had sequential LS, 1 student noted that they had active LS, 2 participants noted that they had visual LS, 4 participants noted that they had intuitive LS and 1 participant noted that they had reflective LS. The remaining participant was not aware or did not have a LS.

13 participants noted that they think that they would benefit from studying LOs that are suitable for their LS and 1 participant noted that they would not necessarily. Our interview results support these results. Positive feedback by participants includes that 1) "this will provide a different way of learning the various Java concepts"; 2) they find "interactive diagrams fantastic for [their] style of learning and therefore would be great to use these for learning"; and 3) "it would make it more interesting to learn".

Relating to quality of the learning content

In terms of the learning content, 2 participants had found the LOs to be very useful, and 9 students had found them useful, and 3 students found them not useful. Positive feedback includes 1) "[even though they] already had a firm understanding of basic java, but [they still] found it would be very helpful for beginners"; 2) "some of the Java principle are fairly important to know and are well-developed". Negative feedback includes 1) a participant felt that "there was nothing new or novel in the learning materials"; 2) the learning materials were "not useful in the sense that I did not learn anything new from the learning experience", because they were already familiar with the topic.

8 participants noted that they would use the LOs again, 5 participants stated that they would not, and 1 participant did not provide any answers. Negative reasons provided include that 1) "[they already] knew the material covered in it"; and 2) "the content was well below my current knowledge level of Java so it was too simplistic".

Any other comments

Further suggested comments by participants include 1) "different levels of code for different levels of learners would be good"; 2) "nice way to teach, [they] could see this being useful for those students with no prior knowledge of computing, and are struggling with basics of programs, memory and logic flow."; 3) "[they] particularly liked the "memory" display, but [they] think that it should have more detail, such as having additional arrows to show where the variables would be stored in memory and to show it the source code.

Participants from Martin and Carro's [2] case study noted the following: 1) "these systems guide one over the whole set of activities and help to decide the starting point (what are the best activities to be done according to one's personal needs and learning process)", 2) "these environments are more attractive because they allow [them] to do many types of activities, not only study theory from a book or personal notes". They also considered the learning contexts slightly less important than the learning styles. 81.5% of their student participants had considered the online learning environment to be useful for learning because "they were able to support content adaptation according to the user context (available time and device used) at each time". Participants had noted that this had contributed to their learning processes, and the environment guided them well through topics of a given subject and had helped them to approach the subject in a new way, and visualise it as "an incentive to study more in less time" [2].

7. Summary of data results

Our case study has provided us with a large amount of qualitative data results concerning the learning contexts and suggestion rules to be deployed in our proposed mCALS framework [5]. The results showed that participants found the LOs to be useful in the situations that they were studying under. They had an enjoyable learning experience whilst studying these and their learning experiences were enhanced because the LOs had been chosen selectively to be studied under different circumstances based on the suggestion rules presented in section 1. The case study has validated our proposed learning contexts – available time, knowledge level and motivation level – to be appropriate for using in a context-based learning environment. The Java LOs used in this experiment were taken

from the Codewitz LO repository (www.codewitz.org) and participants have found them to be of high-quality. Participants also noted that the use of learning styles for the recommendation of LOs might be beneficial for them.

V. CONCLUSION AND FUTURE WORK

In this paper, we have described our case study which was an online experiment for learning Java. Participants were required to indicate their available time (10, 15 or 20 minutes), their current motivation level for learning (high, medium or low) and their knowledge level of Java (high, medium or low). Appropriate Java LOs would then be presented to them to select for studying. These had been pre-determined based on our suggestion rules presented in section 1. After participants had studied the LO, they were asked to complete a questionnaire to provide information regarding a) usefulness of the LOs studied in those contexts, b) whether they had enjoyed studying the LOs, c) whether the selected LO was appropriate for that context, d) why they had chosen that particular time slot for studying in, and e) any other comments.

This case study has been conducted to validate the learning contexts and suggestion rules of our mCALS framework [5]. A qualitative data analysis concerning these is presented in this paper, validating the deployed learning contexts and suggestion rules for the case study (and subsequently for our mCALS framework). We are currently developing a software design of the framework. Our future work includes developing a working prototype of this framework for students to learn with anytime anywhere.

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