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Enhancing Course Timetable Management in Science Classrooms with User-oriented Mobile Application: Analysis and Prototype Development on KMUTT-ESC Case Study

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Abstract: In Science schools, one of the challenging issues in learning management is course timetable for both learners and teachers. Unlike regular schools, most Science courses are provided in topic/module-based; that is the topics among courses are associated to each other, managed by several teachers simultaneously, learned by different groups of students, and altered frequently without notice. This causes a crisis for teachers who teach on the same topics being not aware of that changes leading to miss teaching management, while students could not prepare themselves for learning materials, reviews, assignments, etc. accordingly. As technology advances, mobile application has widely been accepted as an effective means to cope various management problems in the real time. Therefore, in this study, we proposed a design of mobile application prototype with user-oriented design to tackle such common problems in Science schools. A case of an Engineering Science School in central Bangkok, Thailand was studied for the actual problems and for the requirement analysis. The application was designed based on users' UX/UI concepts and mobile platforms; whereas a prototype was developed with xCode based on MVC strategy. This application could help students and teachers to access the real-time changes of the timetable information, including notifications and history revisions; meanwhile, it helps them get ready for the class and finally would enhance more effective learning and teaching in science classrooms. In addition to that, an experiment has been conducted with users to examine the effectiveness of the application, while the feedback has been collected and analyzed for further development. The findings of this study not only showed that the proposed application was more effective than the conventional approach, but also provides any Science schools with similar contexts a practical guideline to cope with such complexity in timetable management of science classrooms.

Keywords: Science classroom, mobile application, course timetable management, user-oriented design

1. Introduction

In Science learning nowadays, many schools employ a variety of effective teaching approaches to enhance the quality and the performance of their classrooms and students, respectively. To reach the effective science learning, all science schools have set their goals for students. After learning, students should be able to construct their knowledge from the experiences within the context of narratives or stories, to merge their knowledge of Social Studies with Science and Mathematics, and to apply the solving skills to address scientific problems, social problems, including problems in their real lives. These approaches function differently in different environment of science classrooms. For example, Problem-based learning and Project-based learning (PBL) functions based on the problem and project set upon the learning topic; while Story-based learning (SBL) requires students to construct their knowledge by integrating related disciplines. To say, these approaches have their own outstanding features to help students to learn science more effectively and meaningfully under authentic problems (Du, Su & Liu, 2013; McQuiggan, Rowe, Lee & Lester, 2008; Story-Based Learning, 2016).

Although these features most of the time operate outside of the classrooms, Almeida and team reported that it is necessary to spend classroom time efficiently since both teachers and learners are located in the same physical learning environment as face-to-face learning (Almeida, Medeiros & Oliveira, 2015). During the classroom time, they are engaged to learn, share, and discuss newly-introduced or misunderstood topics; moreover, hands-on activities take place during this time with teacher facilitation.

Considering classroom management on these mentioned approaches, different schools are confronting different complex situations. These include handling limited resources of learning and teaching materials, classrooms, facilitation under time, program requirement constraints. For example, Du, Su and Liu (2013) reported that PBL can successfully facilitate participative learning, critical reflection, systemic thinking, creativity, and cultural awareness, which are the core values of sustainability in teaching and learning; therefore, these methods provided materials and activities for students. Furthermore, SBL focuses on training students to link their knowledge to real life; while requires students to prepare themselves for experiences in the classrooms (Ruiz-Gallardo, González-Geraldo & Castaño, 2016).

In past decades, technology has become more significant in terms of supporting management problems in various areas, including business (Chen & Popovich, 2003) medicine (Clifford & Clifton, 2012) and education (DiGiano & Patton, 2002; Treepuech, 2011). Meanwhile, mobile applications have been widely developed for its handy access and usage anytime anywhere in various context and applications (Holzer & Ondrus, 2011; Rana, Dwivedi & Al-Khowaiter, 2016; Zydney & Warner, 2016). In addition to that, mobile applications have been employed to support management for automation (Das, Chita, Peterson, Shirazi & Bhadkamkar, 2011; Kirubakaran & Karthikeyani, 2013) and for collaboration (Connolly, Cosgrave, & Krkoska, 2010; Hakkila & Mantyjarvi, 2005). Consequently, users found more convenient and productive in their working processes.

Based on the significance of classroom management in science school and benefits of mobile applications, the objectives of this study includes:

1) Problems and requirement analysis for classroom timetable management;

2) Design and development of mobile application prototype, hereinafter called MASCAA;

3) Experimental study and results for the effectiveness of the proposed application.

In particular, a case of an Engineering Science Classroom, King Mongkut's University of Technology Thonburi (KMUTT-ESC) was later introduced and employed in this study. The originality of this study not only enhances the understanding of mobile development for management in practice, but also provides school administrators a possible solution to handle with the complexity in timetable management for science classrooms.

2. Related Studies

2.1 Effective Classroom Timetable Management

Classroom timetable is used to provide the information for students and teachers by presenting course name, classroom, course corresponding teachers, students group, and time. Teachers and students can prepare themselves for the class and manage their learning and teaching appropriately. Managing classroom timetable has been improved for decades, most of the time happen on a basic spreadsheet done by manual effort which is considered time-consuming (Padmini & Athre, 2010).

Later, technology has been adopted to better manage classroom timetable in offline mode, resulting in less time and less effort consumed. However, it still could not change any information after publishing to a hard copy timetable (Burke, Elliman, Ford, & Weare, 1995; Dorneles, de Araújo & Buriol, 2014; van den Broek, Hurkens, & Woeginger, 2006). In addition, the administrative staff in regular schools arranged the timetable only once a semester before the school begins, then students and teachers just used that fixed timetable along the semester (Babaei, Karimpour, & Hadidi, 2015). In science schools, the administrative staffs have to always follow-up and adjust the timetable to be corresponding with students' learning progress which is more complex than the timetable of regular school as it always changes to reflect the students or teachers' requirements.

Therefore, the effective classroom timetable management need to be responded to teachers and students, which requires user-friendly interaction in real-time, convenience to use anywhere and notification. It should make possible for students or teachers to update their schedule to help them eliminate the problems and get more effective learning (Amaral & Pais, 2016; Cavus & Alhih, 2014; Vermuyten, Lemmens, Marques & Beliën, 2016).

Consequently, the science school timetable should be developed in consideration of above mentioned points to enhance better learning and to reduce possible mistakes that usually occur and affect to learning duration, material preparation, appointment management, homework and assignment management, class absence etc. (Burke & Petrovic, 2002; Kwok, Kong & Kam, 1997).

2.2 Design and Development of Mobile Application

Recently, mobile application has become popular and important in various applications (Böhmer, Hecht, Schöning, Krüger & Bauer, 2011). For example, instructors use iTunes U to assign homework and share the materials with students, online banking is used to transfer and deposit money, and Scribd is a digital online library that users can read books. However, to make such mobile applications more human-oriented; in other words, to make it easier to use. Such that, it is important to concern many factors during design and develop the mobile applications.

In designing mobile applications, there are 2 key factors that should be considered, particularly User Interface (UI) and User Experience (UX). UI is any objects that is visible to users on mobile screen in which users can interact with, e.g. button, hypertext, text box. UI can make users interest and impress the application, while UX is what make feel when they use the application. UX will make them want to use the application again. That is, if they feel the application used is not user-friendly, they are not likely to continue using it anymore. In order to do that, a prototype is needed to be initially developed to collect users' initial feedback, hence the developer can then improve it accordingly.

Although mobile application has been carefully designed, development phase is also considered to be more essential. The platform of mobile application is what the developer should keep in mind as a heart of the application. For example, Android Studio should be employed when developing applications for Android devices, while xCode should be implemented when developing applications for iOS devices (Hussin et al., 2014). To make the application more stabilized, right platform is required in development. Moreover, Model View Controller (MVC) is a development strategy that the developer should implement on as it views application into 3 separate components: Model (M) contains all of the data in the application, View (V) interacts with users, and Controller (C) makes control of everything in the application. This strategy has been widely accepted in developing mobile applications nowadays (Lossius et al., 2014). Finally, as a Service (aaS) is necessary when developing the application since it provide cloud-based services to manage incoming and outgoing data of the application in the cloud, which could save developer much time and effort (Sviridova, Sviridova & Tymoshenko, 2011).

3. Problems and Requirement Analysis

3.1 Case Study of KMUTT-ESC

In this study, Engineering Science Classroom, King Mongkut's University of Technology Thonburi in Thailand (KMUTT-ESC) was used as a case study. At KMUTT-ESC, each year there are about 80 students qualified to study in this higher secondary program (grade 10-12) under its science classroom-based curriculum design, called Story-based learning (SBL). Being expected to be young scientists, students are closely facilitated by 10 to 20 science teachers approximately. There is only 1 class for each grade.

SBL has been employed to make their science learning more meaningful by integrating multiple subjects together in order to learn the content based on the world history timeline as a story. This learning approach could help students better understand how everything in the world has happened in a meaningful, scientific way; besides, the students can see any phenomena happened in the world in different aspects.

Regarding the classroom timetable management at KMUTT-ESC, teachers presently post the learning topics relevant to any learning story on Google Sheets and Facebook Group. The post information includes topic name, time and date, materials to bring, other advanced preparation for the class. However, students are facing a serious situation in which they miss prepare for the class, which are mainly caused by the changes of classroom timetable happening anytime. This makes a negative impact on students' learning during the class; in addition, students tend to avoid following changes in the timetable since it is difficult to use and not user-friendly.

3.2 Problems and Requirement Analysis

In order to understand all the problems occurred at KMUTT-ESC, we conducted an interview with 22 students and 6 teachers. They were asked to feedback their feeling on using the current classroom timetable management in Google Sheets, particularly the difficulty and problems. Moreover, they were required to provide opinion on the preferred classroom timetable management.

Based on the interview analysis, we found that 2 key issues to be addressed including: 1. Google Sheets is not convenient for our SBL program since the timetable information can be changed anytime. Google Sheets makes students confused and misunderstood the information. Consequently, they don't want to use it, and 2. Frequent changes without notification and multiple modes of communication lead to failed usage. It makes students wouldn't know which information is the latest , resulting in miss preparation for the class that decreases efficient learning.

Nevertheless, interviewees are looking for a more effective classroom timetable management approach with following requirements: 1. User-friendly interface on the timetable, 2. Information presentation relevant to the selection of the topic, classroom, activities, etc., 3. Shorten time to get the latest information for right preparation in advance of the class time, and 4. Reduction in miss communication caused by the changes of the class/topic information.

4. Design and Prototype Development

In addition to the problems and requirement analysis results, the context of KMUTT-ESC was considered. This school program loans iPads for all students and teachers to use on- and off- school time. Therefore, mobile application is considered to be developed to cope with the mentioned issues.

The mobile application, hereinafter called MASCAA, has been developed by the authors who have background in Science-engineering pedagogy, Computer Science and information technology for years. The idea of UI and UX was carefully adopted to make the application more user-friendly. For example, clear color contrast for each day, each class of timetable, bigger button for easier access, real-time display of any class information changes, etc. During the prototype development, MVC strategy was employed for more effective development for mobile application, xCode was used to program this native mobile application for iOS, while Parse (https://parse.com) is used as a service (aaS) to provide two-way synchronization with the app whenever Internet is connected. As shown in Figure 1, the system structure of this mobile application prototype is depicted, while the examples of application screenshots are shown in Figure 2.

There are 2 databases in the system, one for class data and another one for revision history data. In the meantime, updated data from Parse is retrieved when any changes made and downloaded to the local data stores to save loading time and is available in offline mode. Regarding the timetable features, the system is responsible by 3 main modules. First, 'Class information presentation' module, the application displays class information, e.g. date, time, subjects, etc. retrieved from the local data store. As presented in Figure 2(a), students can view timetable in any particular week; moreover, they can click on any teacher name or topic to see more related information, as shown in Figure 2(b). Class changes, addition and cancellation features are enabled for teachers. The first module works in corresponding with 'Showing classes' module, as users have options to view timetable by selection of teacher name or subject code. With the subject code selected, students can have a long-term preparation before coming to the class of that subject, as it usually involves multiple topics and is taught by several teachers, as displayed in Figure 2(c). By selecting the teacher name, as shown in Figure 2(d), students can see all subjects taught by that particular teacher. This would also be a great benefit for teachers to set their lesson plans and make their teaching preparation on SBL program. In the last module, ‘modification and revision history’, teachers can make changes on class information, as shown in Figure 2(e), while relevant users get notified once it is updated. Moreover, users can see revision history to trace back who made modification onto the timetable, as shown in Figure 2(f).

In summary, this mobile prototype, MASCAA, can handle the problems of frequent changes of information and help students and teachers better plan their lessons and works. While, notification and UI/UX can reduce the confusing and misunderstanding of the information. The classrooms availability and materials needed for class activities are considered when providing class information. The teacher’s interface provides the ability to handle the class, while the student’s interface is limited to access such information. For these reasons, the teachers’ view and the students’ view are different on user interface see Figure 2(b). Importantly, this mobile application can work in offline mode, students will be more likely to use the application that decrease mistakes from current timetable management and finally increase efficient learning.

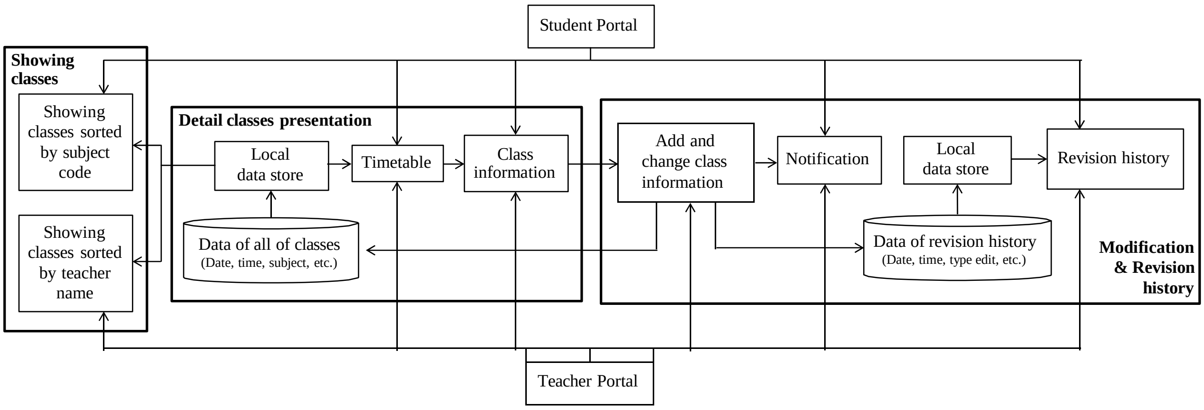


Figure 1. System Structure of Mobile Application Prototype

5. Experiment and Results

After the prototype development of proposed mobile application was done, the experiment has been conducted with 41 students and 7 teachers of KMUTT-ESC, in total of 48 participants in order to examine the prototype effectiveness. The experiment began by asking them to study a brief instruction of the application, for 2 minutes. After that, they experienced MASCAA by following the hands-on tasks for 10 minutes. At the end of the experiment, they completed a questionnaire for 10 minutes. The experiment was conducted at convenience of participants.

The questionnaire used in this experiment was adapted from Wongwatkit, Tekaew, Kanjana & Khrutthaka (2015) and Wongwatkit, Meekeaw, Lati, Tungpantong, Saitum & Atanan (2015), and designed and validated by the authors in order to examine users’ attitude and feedback towards MASCAA. There are 10 Likert-scale items including 4 items for performance (PER), 4 items for design (DES) and 2 items for usefulness (UFS) dimensions, as shown in Table 5 in Appendix. The participants were asked to rate their attitude for each item ranging from “1” for lowest satisfaction to “5” for highest satisfaction. Moreover, there is another open-ended question asking for their feedback towards MASCAA at the end of the questionnaire. The Cronbach’s alpha of the questionnaire was 0.78, indicating its good reliability; while the composite reliability ranged between 0.75 and 0.89, indicating its internal consistency on each dimension.

5.1 Effectiveness of The Proposed Mobile Application Prototype

Based on the questionnaire results, the effectiveness of MASCAA was analyzed by comparing students’ attitude towards Google Sheets and MASCAA of their classroom timetable management. After the test of data normality, parametric paired sample *t*-test was used. As shown in Table 1, it was found that students revealed significant better attitude on design ($t = -4.021$, $p = 0.000$) and usefulness ($t = -1.795$, $p = 0.049$) dimensions, indicating that MASCAA was more effective than the existing timetable management approach. Moreover, the relationship among 3 dimensions was verified, as shown in Table 2. This indicates that students who revealed positive attitudes on the prototype's performance and design were more likely to perceive that the proposed approach was useful for them.

However, from the teachers' results, it was found that they revealed similar attitude towards both proposed application and the existing approach, indicating that the current version of prototype needed to be further improved for teachers' use.

Table 1. A comparison of students' attitude towards Google Sheets and MASCAA for timetable management

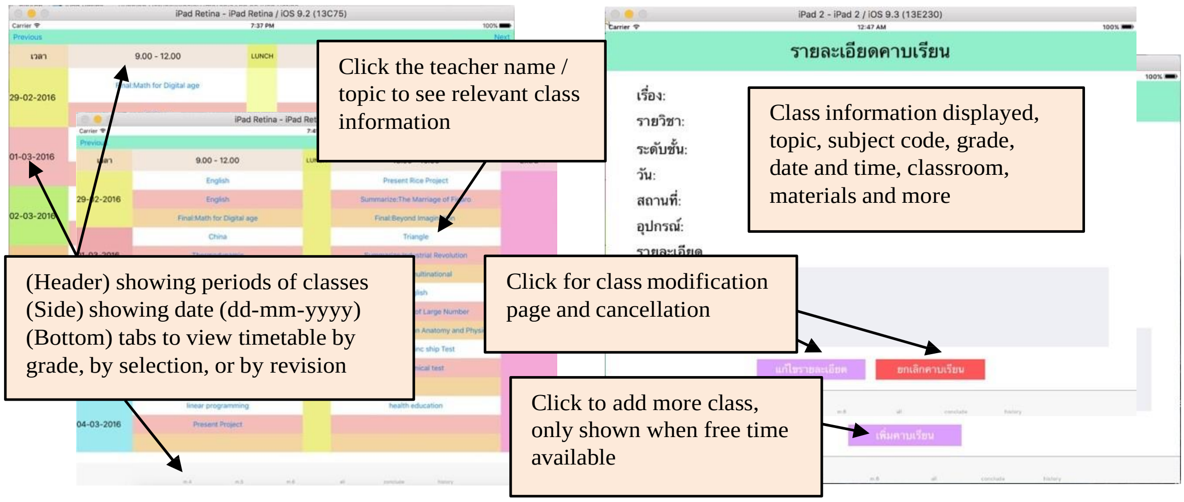
Dimensions	Google Sheets ($M \pm SD$)	MASCAA ($M \pm SD$)	t	p
PER	2.62 ± 1.07	2.82 ± 1.17	-1.091	0.282
DES	2.67 ± 1.05	3.55 ± 1.07	-4.021	0.000***
UFS	3.06 ± 0.74	3.38 ± 0.90	-1.795	0.049*

*$p < 0.05$; ***$p < 0.01$

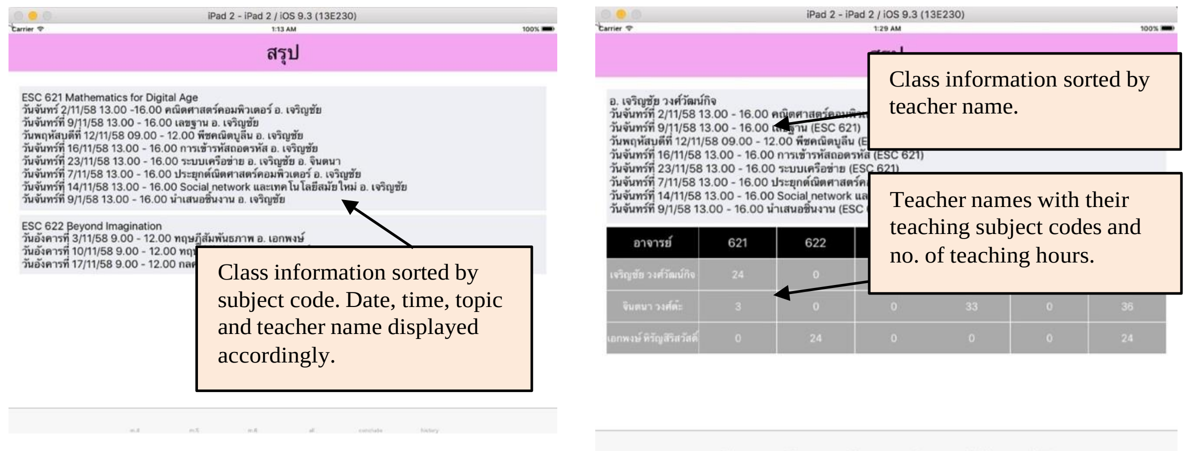
Table 2. Pearson's correlation coefficient among dimensions (PER, DES, UFS)

Dimensions	PER	DES	UFS
PER	1		
DES	0.835*	1	
UFS	0.861*	0.841*	1

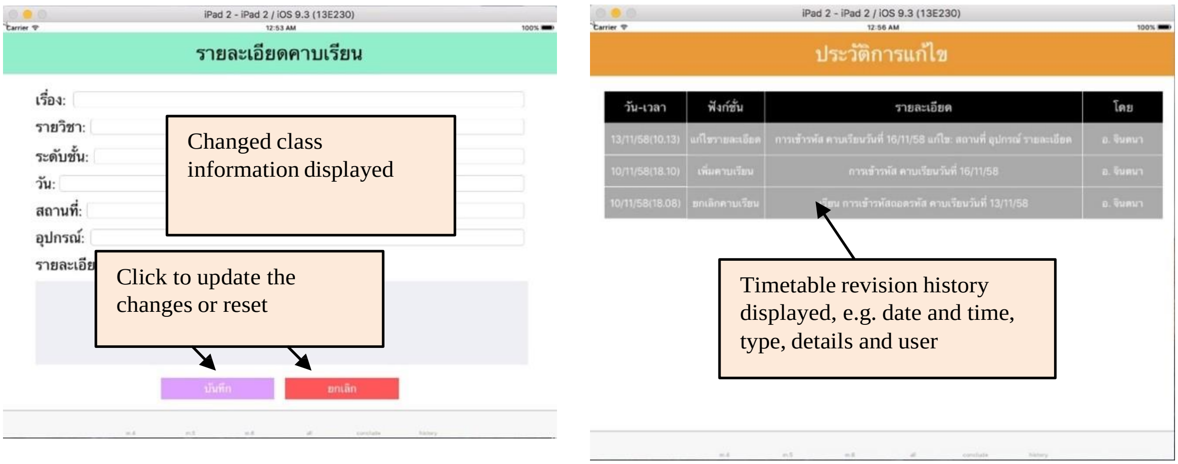
*Correlation is significant at 0.05



(a) Weekly Timetable (b) Class Information (Teacher Page)



(c) Class Information Sorted by Subject Code (d) Class Information Sorted by Teacher Name



(e) Changes of Class Information (f) Revision History

Figure 2. Example Screenshots of the Application

5.2 Qualitative Feedback towards The Proposed Application

In order to further investigate users' feedback provided in the questionnaire, students and teachers, qualitative analysis was conducted. Feedbacks were analyzed into 2 themes on superiority of MASCAA over Google Sheets, as shown in Table 3 (3 categorizations of access and convenience, real time and logging, and relevant data presentation) and useful suggestion/comments to improve MASCAA, as shown in Table 4 (3 categorizations of user analysis, system and performance, and engagement).

Table 3. Feedback showing MASCAA superior to Google Sheets

Category	Feedback
Access and convenience	1. I can get needed information in shorter time and less steps. 2. It is convenient to make application purposely for timetable management in our school which employs a non-regular curriculum.
Real time and logging	1. Data changes were automatically updated. 2. I can see who update information from History view. 3. I can easily identify what to prepare for the classes.
Relevant data presentation	1. Data is presented in timetable manner, e.g. by grade, by teachers. 2. I can view class information more meaningfully.

Table 4. Feedback showing useful suggestion/comments to improve MASCAA

Category	Feedback
User analysis	1. It is good to collect more requirement for in-depth system analysis. 2. Try to have an open discussion with all users and bring to talk with all teachers.
System and performance	1. Be aware of misunderstanding when presenting data. 2. Sometimes, it is slow and delayed to retrieve or change information. 3. Search function should be implemented. 4. Calendar view is needed for easy access.
Engagement	1. Make the application more user-friendly with users, including students and teachers. 2. Highlight or contrast where it needs more attention to interact with. 3. Simplify data presentation in more meaningful manners.

According to users' feedback, it was helpful for developers to further improve the mobile application for actual implementation by strengthening the satisfied points and considering their comments.

6. Conclusion and Discussion

This study proposes a mobile application prototype, namely MASCAA to help solve the problems and inconvenience in science classrooms timetable management. The development of application was made based upon users' analyzed data collecting from students and teachers at KMUTT-ESC who involved in the classrooms timetable management. Moreover, we employed user-oriented strategies, including UX and UI, and considered effective mobile development factors, including platform and system performance to make the application more effective.

Based on findings of this study, users found the proposed application better than the current platform of Google Sheets in design and usefulness dimensions. This was because in the requirement collection phase, users raised more points regarding these issues; moreover, we collected those opinions in the analysis phase together with the approaches suggested by other studies. This result was consisted with Marciniak, Zabierowski & Napieralski (2009) that requirement analysis was essential for system development.

However, due to the limited time of this study and as of the prototype phase, there are several points to be addressed. First, more functionalities can be further integrated into the app, e.g. the compatibility with Google Calendar import/export features including private events, and the synchronization with relevant systems to enhance the workflow automation like the availability of teachers and classrooms. Second, this version of prototype is limited to use on iPad device only due to the availability of the devices used at school; however, the next version of application will be further developed to work across major devices of users. Finally, native notification and alert will be considered in the next version as it would provide a great benefit to users in preparing for the class in advance. In addition to the samples used in this study, generalization of the findings would not be possible beyond similar context of the science classrooms and schools.

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Appendix

Table 5. Questionnaire items

Dimension	Items
PER	1. I am certain that the application responds fast and accurate. 2. The overall performance is appropriate to use in our school context. 3. It is appropriate to use the application in off-line mode. 4. Data shown on the application is updated correctly when Internet connected.
DES	1. I like the composition of graphics and text used in the application. 3. The size of the graphics, text and pictures is appropriate with the screen size. 4. I find the application is user-friendly. 5. I am certain that I am not confusing to work on the application.
UFS	1. I am certain that I will use this application in the future. 2. I find the application is useful for timetable management.

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