Enhancing Science Laboratories with Technology

Design of a tablet application used

to guide the laboratory experience

By

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Abstract

This IQP report mainly focuses on the design of application for biological education on the iOS platform. Based on nearly two months of surveys and learning from the experiences of two previous IQP groups' reports[1][2], I initially designed the framework to build a suitable and user-friendly mobile application for students in the biology lab to save pre-lab study time, be more efficient in the lab and, aid in writing the report using mobile application,. In this report, I introduce and explain the design process for this application.

Table of Contents

Table of Figures

1. Introduction

During the last three years, the Biology & Biotechnology Department at Worcester Polytechnic Institute (WPI) has put Connect Lab Project into practice, which promotes application of computer technology, video and other electronic devices in the undergraduate laboratory. Students can carry out electronic data collection, preservation, sharing, and transmission.

Current Problem

Most of WPI students prefer to use mobile phones to communicate with teammates and instructor/TA. When comparing the use of an app on a mobile device to using a web browser on the same device, greatest part of students at WPI choose mobile app to take lab courses.

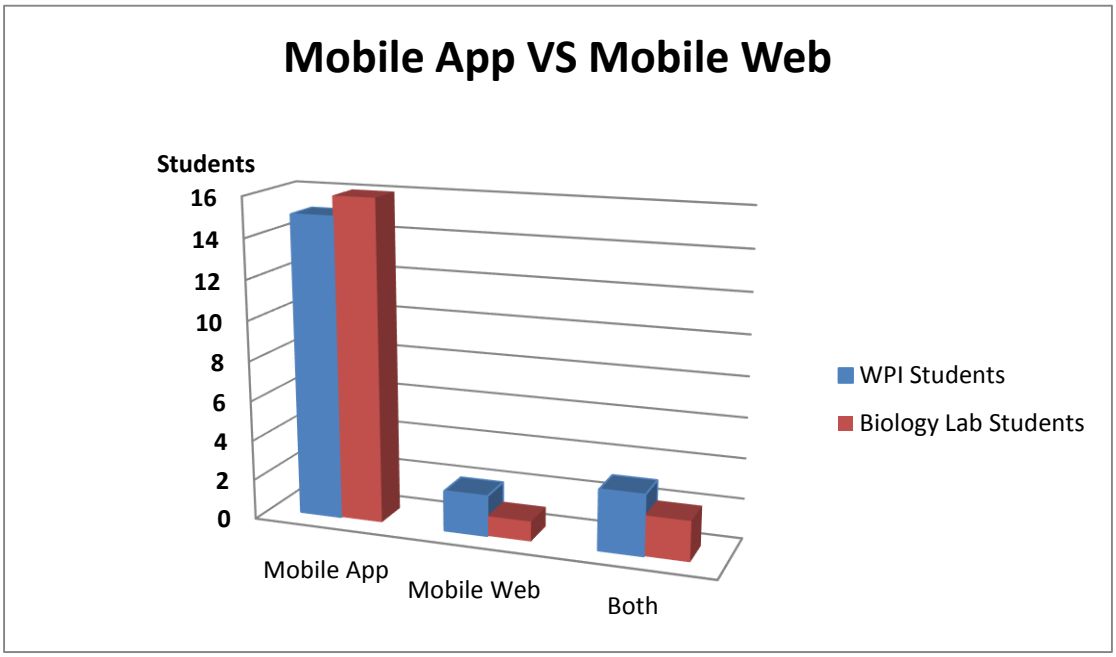

Figure 1: Survey of preference on Mobile App or Mobile Web

Figure 1 above, shows the data for 40 in-class students of BB2901 that respond to the in person question: Which do you prefer to use in your lab course: Mobile App(Using mobile application to access each course) or Mobile Web(Using mobile browser to access myWPI website)?

The first group (Blue bar labeled WPI students) includes different majors with 20 random students that I know, electronic and computer engineering, mechanical engineering, civil and environmental engineering, fire protection engineering, computer science, chemical engineering, and robotics engineering.

The second group students (red bars) are all BB2901 lab course students majoring in biology. I made the survey question to each small group in the BB2901 lab course. At least one student in each group answered the survey question.

95% students in two groups are using the “mobile web” to login to myWPI account via smartphone or tablet. They reflect that this method only works for looking for information and upload a small amount of data like course

registration.

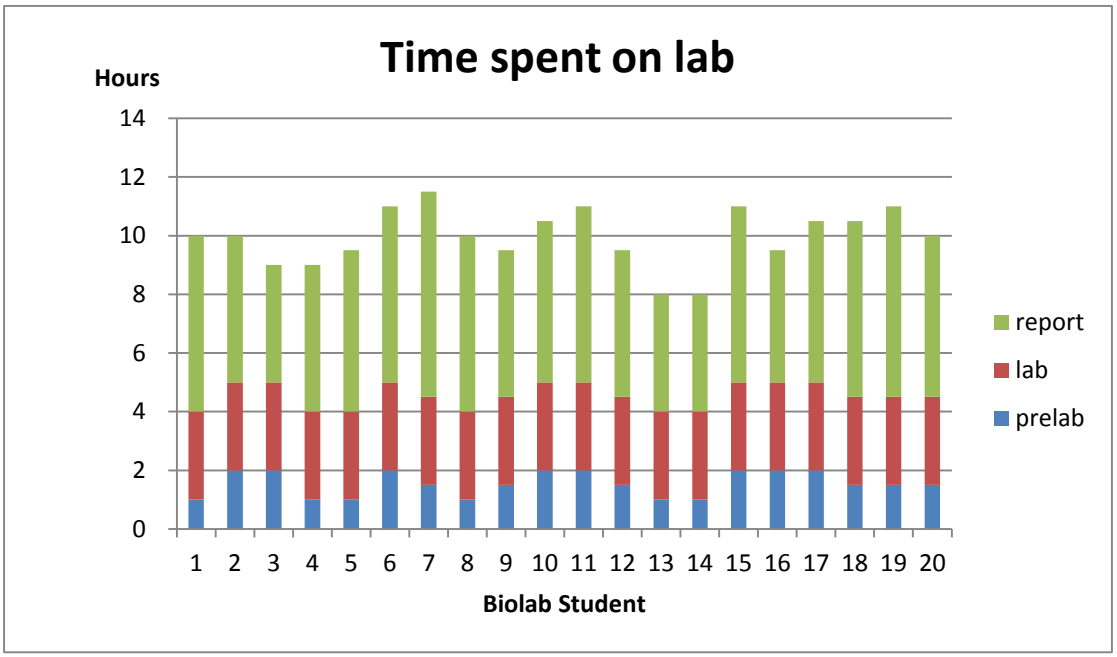

Figure 2: Time spent on lab

In Figure 2 above, 80% of the students in BB2910 lab course claimed to spend at least 10 hours for the lab part of this course, while only 10% students could finish each lab in eight hours on average.

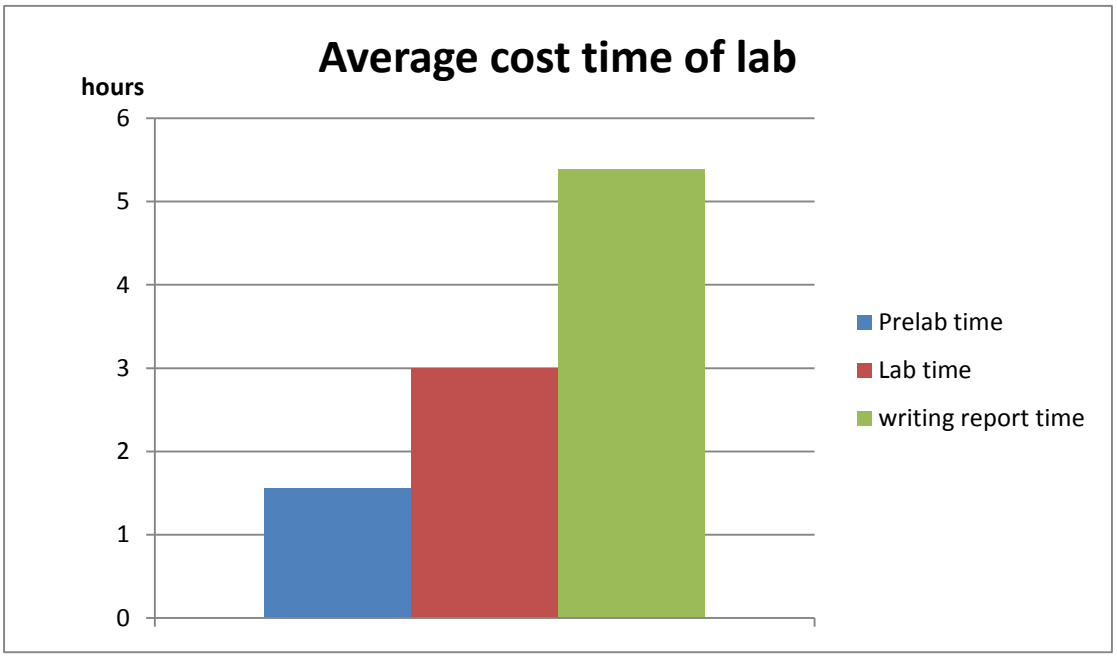

Figure 3: Average cost time of lab

Figure 3 above shows the average cost time of lab as reported by the students surveyed. The lab time is fixed to 3 hours each week, The average pre-lab time is about 1.6 hours per week, and the average report writing time is 5.4 hours per week which represents the largest time commitment in this lab course.

When asked would you think it could save some time to build a mobile app, or an IOS app on the iPad in the lab, ninety five percent students said that they would like to use a well-designed mobile app to let them do some lab work on the go. Most of the surveyed students believed that they could watch the pre-lab video in their spare time.

When asked would you like to turn in your report via mobile app or tablet app in the lab, most students responded they did not believe so, or it would be very hard to type in text and import pictures and other data format via mobile app. They pointed out several difficulties:

- Camera focusing problem and pixel problem on mobile devices
- Import and export format problems
- Calculator
- User interface
- Account safety

2. Background

In the Pearson Student Mobile Device Survey, conducted by Harris Interactive in 2013, three of four college students own a smartphone and four of ten students own a tablet [7]. As the application and innovation of mobile application in the field of education, college students are more likely to use smartphone as a powerful complementary tool to study daily courses and even finish homework on the way. The college administrators and professors have gradually applied mobile applications to the field of education. The College of Education and Center in Florida State University had introduced a mobile application named LEAD (Lead, Engage, Apply, and Develop) to undergraduate student. Leadership-building curricula were built in the mobile app and students could improve their leadership abilities through working on some specific job under the guidance of each module on mobile app [6].

Since mobile app enhances the efficiency of teaching and learning, educators are more interested in the innovation of mobile app [8]. However, appropriate mobile app is not always well developed in each educational field. For educators with programming limitation, they could use web-based visual programming tool to develop apps that meet their corresponding needs in teaching and for students in learning [4].

Goal of the IQP

For desktop and laptops, students in biology lab courses could accomplish the basic work of each lab. The main work of my IQP is to design a mobile app that could increase interaction between students and instructor/Ta, enhance efficiency in finish the final report, make a convenient and stable access to the pre-lab demonstrative video and a powerful build-in calculator in the app.

User survey questions

The following in person questions benefits the design of a mobile app for BB2901 lab course.

1. What would the user want the iPad application to do?
2. What similar apps does the user already use?
3. What kind of calculator would the user prefer to deal with the experiment data?

These questions are most frequently asked during the talk to each student in BB2901 lab course. Most students did not use the similar app and would like to use a suitable and powerful calculator that builds in the app. Due to the memory and storage design, I understand the basic data structure, calculating method. Also, professor provided lab homework copies to help me understand he submitted data structure.

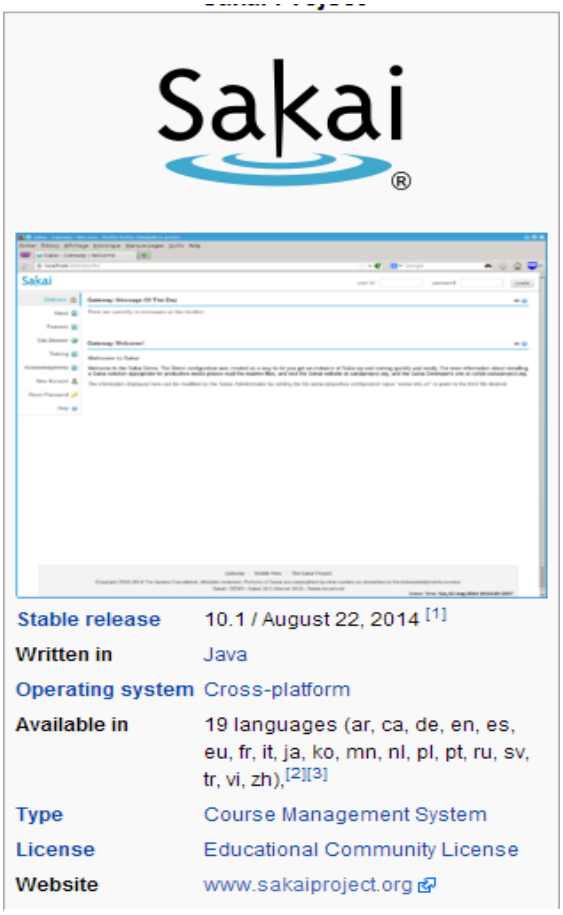

Figure 4: Sakai

Computer software analysis

Sakai is a free educational software platform for teaching and research, which is known as a course management system and/or learning management system [4]. This online learning management system can also submit E-notebook content and return graded work like Blackboard in WPI which is an alternative system.

In the article *An inquiry-based biochemistry laboratory structure emphasizing competency in the scientific process: A guided approach with an electronic notebook format* [5], the author states that using the inquiry-based approach templates to guide the four stages of lab work: pre-lab work, an in-lab discussion, in-lab work, and a post-lab. By using the learning management system like Sakai or Blackboard, students could transfer each stage template, arrange sequential structure and finally form the final lab report that could be submitted online in this system. Also, students could send feedback and satisfaction to teammates and instructors/Ta.

Similar smartphone applications analysis

1. New England Biolabs

In the field of molecular microbiology, the New England Biolabs application can

Figure 5: Home of New England Biolabs

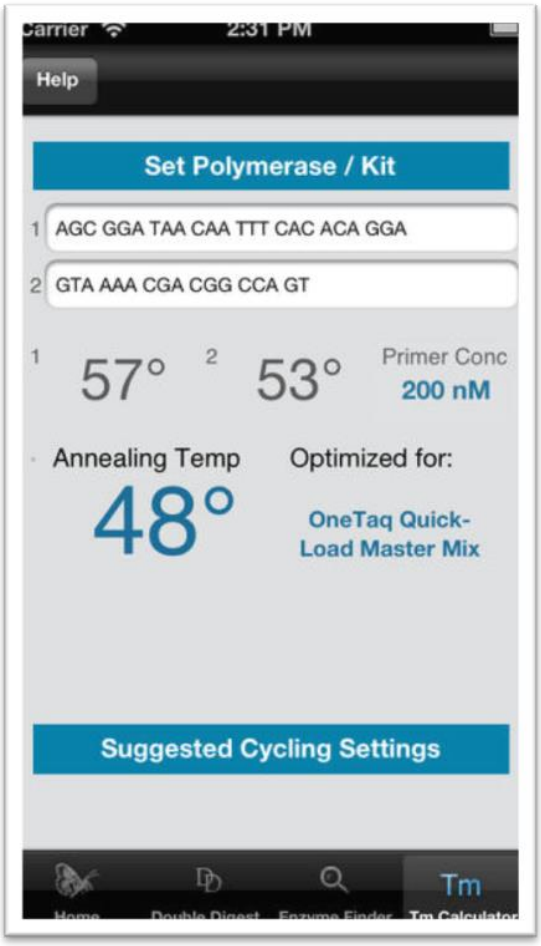

Figure 6: Tm Calculator of New England Biolabs

serve as a “mobile dictionary” to help user find out more fitting buffer and enzyme combinations in double digestion. Also, the functionalities include enzyme finder and Tm calculator. If the database of the dictionary is well-deigned users can easily to find out their needs using New England Biolab.in a short time [10].

To design this kind of dictionary-based mobile app, several steps are required as follows:

1. Create data files.
   According to the user’s needs, database design should be considered to suite to the configuration of mobile hardware and software.

2. Build a dictionary file.
   Use software tool to aggregate the created data files to form a package file format which is an executable file (like jar file on java platform) on the corresponding developing platform.

3. Store the dictionary on the device
   The dictionary file can be stored on the database management systems. Take android developing platform as an example, files can be stored in SQLite which is a relational database management system.
   Also, the dictionary file can be stored online. The advantage is the extra option to store the data. However, network transmission and security problem should be taken into account.

The New England Biolabs provides a build-in calculator using a jar file on the platform which serves as a guidance of the design of our mobile app.

2. Promega

Promega can provide reference information in the field of microbiology and cell biology. Also, it has a build-in calculator shown in Figure 7 and can provide multiple protocols shown in Figure 8.

The main features include:

Biomath calculator: DNA and protein concentration conversion, temperature and other conversion like dilution, molarity and transformation efficiency calculator.

Restriction enzyme tool: search for restriction enzymes by name, recognition sequence or overhang, enzymes compatibility in double digestions. [11]

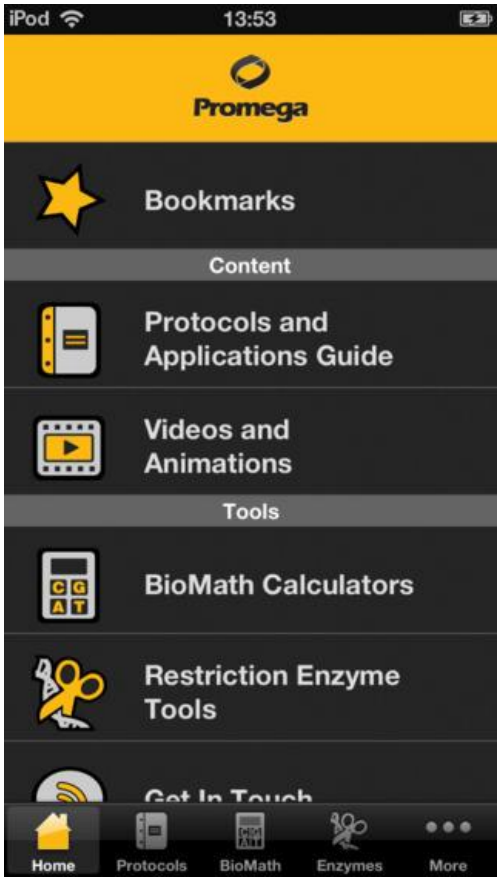

Figure 7: UI of Promega

Design patterns of mobile calculators can be divided into two categories due to the hardware. The main advantage of calculator in tablet applications is the larger display compared to smartphone applications. Memory and processor should also be considered between tablet and smartphone since hardware performance affects the compatibility and accuracy of mobile application.

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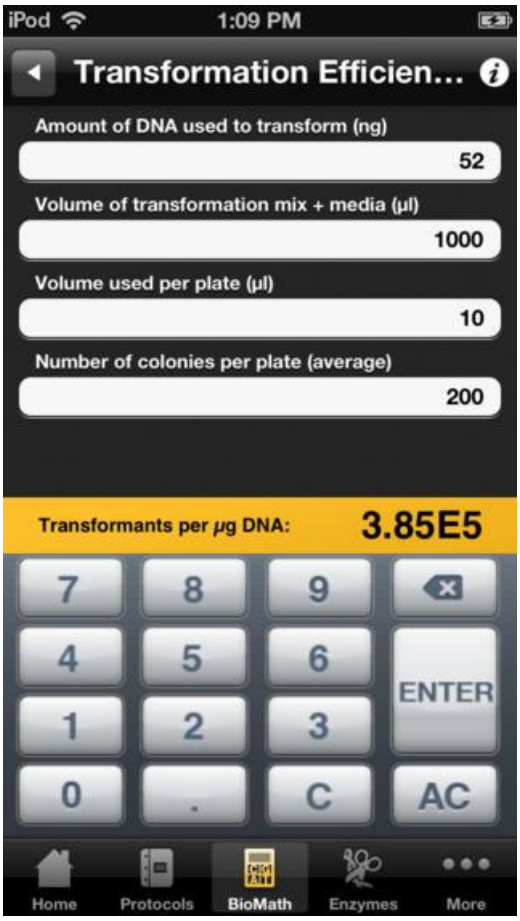

Figure 8: Calculator of Promega

3. Methodology

I began this project by reviewing research reports of two former IQP groups which designed and implemented the first generation IOS applications. Through the study of similar applications, I understood how the workflow related to application and user feedback. Also, I found new features on related similar applications, user satisfaction, user feedback, especially the architecture of design. Meanwhile, , I surveyed 20 of theBB2901 students who might use the future lab application, made an in-depth assessment of the students' use of the myWPI platform, pre-lab data type and lab report format. Based on my surveys and the suggestions of professors in Biology and Biotechnology department, I analyzed how to design our tablet application. I knew that an in-depth study and design would contribute to the development for a future IQP team or MQP team. The educational design goal of, our tablet application is designed to provide more interaction among students and professors and TA, enhance customer satisfaction, save students pre-lab time, add more option to finishing pre-lab work and is user friendly.

My goal then is to design a mobile application specifically an iPad application for biology laboratory usage.

The basic steps are:

- Understand the problem
- Create the storyboard
- Define the objects
- Define the connections between the screens the users will see
- Plan the logic

Technology of application design and development

1. Event-driven programming

Event-driven programming is a computer program deign module. The flow of running program of this module is determined by users actions and the order from other program.

2. Objective-C

Objective-C is an object-oriented programming language for iOS and OS X operating system. The most recent version is Objective-C 2.0 with new added "garbage collector" like Java.

3. Xcode

Xcode is an integrated development environment developed by Apple.Inc for developing on iOS platform. The most recent version is 7.x series allows developing on iOS devices without apple developing licence.

4. The Unified Modeling Language

The Unified Modeling Language (UML) is a standard modeling language which is also a general-language that pictures a system's architecture in a diagram, including elements such as:

- Each job user participated in
- Each entity in the system including any subsystems
- Interaction with other systems.
- What is the workflow in the system
- Interactions among each entity
- Interactions with external user interface

UML diagrams include many types which can be divided into two categories. As seen in Figure 9, left branch represent structural diagram, and the right branch represent basic behavior diagram, including most important interactive UML diagrams like Activity diagram and Use case diagram. UML diagrams shown in Figure 9 can be considered hierarchically.

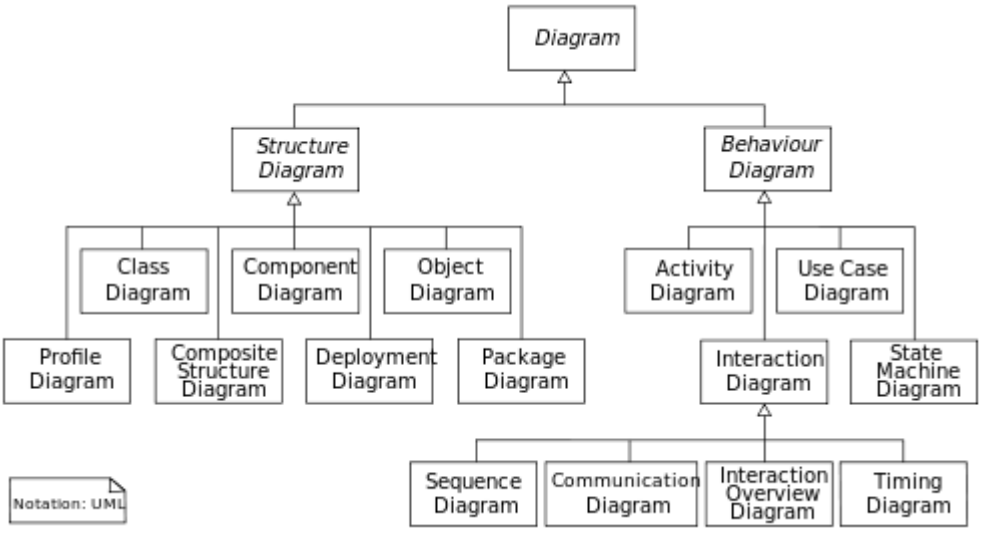

Figure 9: Types of UML Diagrams

4. Conclusion

The following Use Case Diagram Figure 10 at its simplest is a representation of lecturers, students, teaching assistants and senior assistants that interact with the account system. Each line between students, TA, SA, lecturers and entities in the account system means the person has the authority to manage and maintain the entity in the account system. For example, students that registered in BB2901 can login and logout their account. They can only maintain the student account information and cannot access the database of scores and course information in this system.

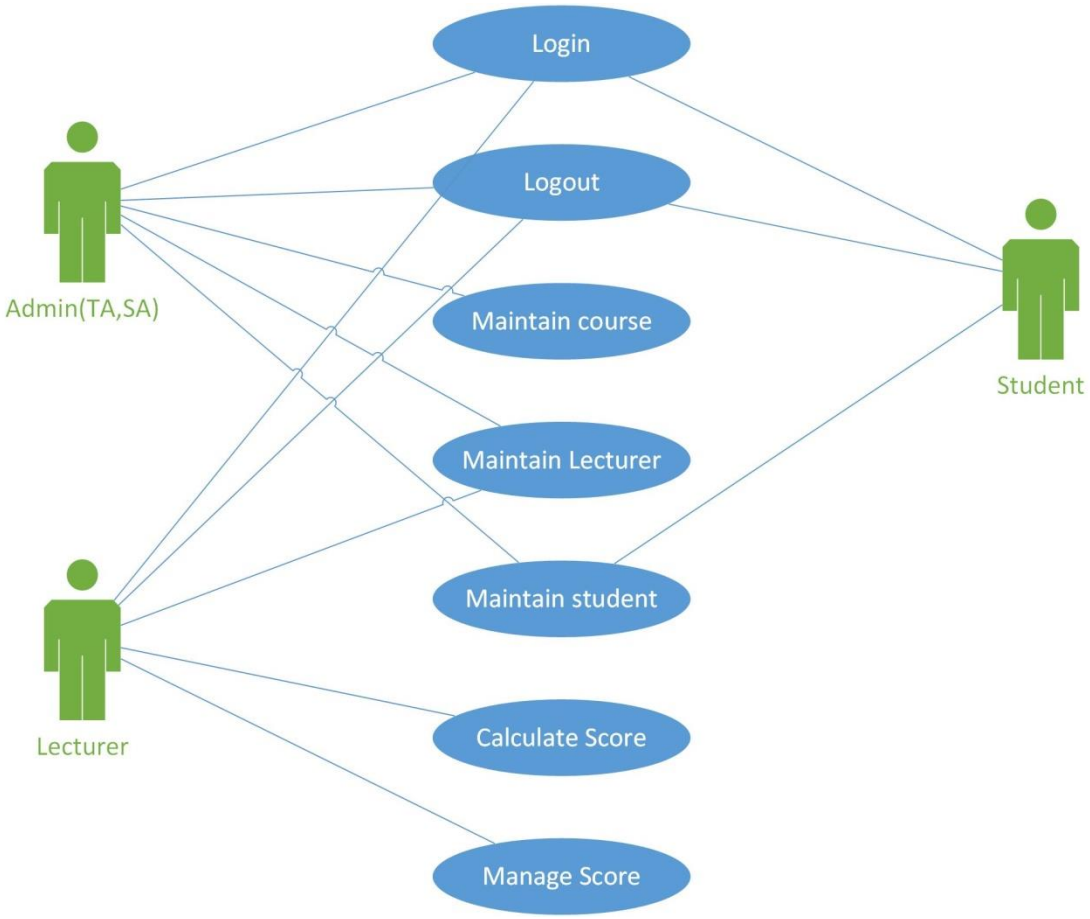

Figure 10: Design of Use Case Diagram

The following Use Case Diagram (Figure 11) describes the behavior of a tablet application system from BB2901 students' point of view.

In this UML diagram, "include" shown between two use cases is a directed including relationship. The included use case is inserted into the including use case (the base). The including relationship could be used to split a large and complicated use case in to several simple use cases. It could be also used to extract common features of two or more use cases according to the principle of object-oriented analysis and design. The main purpose of include relationship is make the whole system more manageable.

While, "extend" shown between two use cases is a directed extend dependency relationship. The extending use case, which could be used as a supplementary part,

can be inserted into the behavior defined in the extended use case. The extending use case is always working with extended use case. The extending use case is not meaningful by itself; however, it can be extended by other use cases. The same extending use case can extend more than one use case even if the use case is not in the same system. For example, student needs to provide his ID and password to login into the mobile application. The login use case is the extended use case which needs supplementary information ID and password. If the account password can be used with other entities in the system, it could be extended to the corresponding use cases.

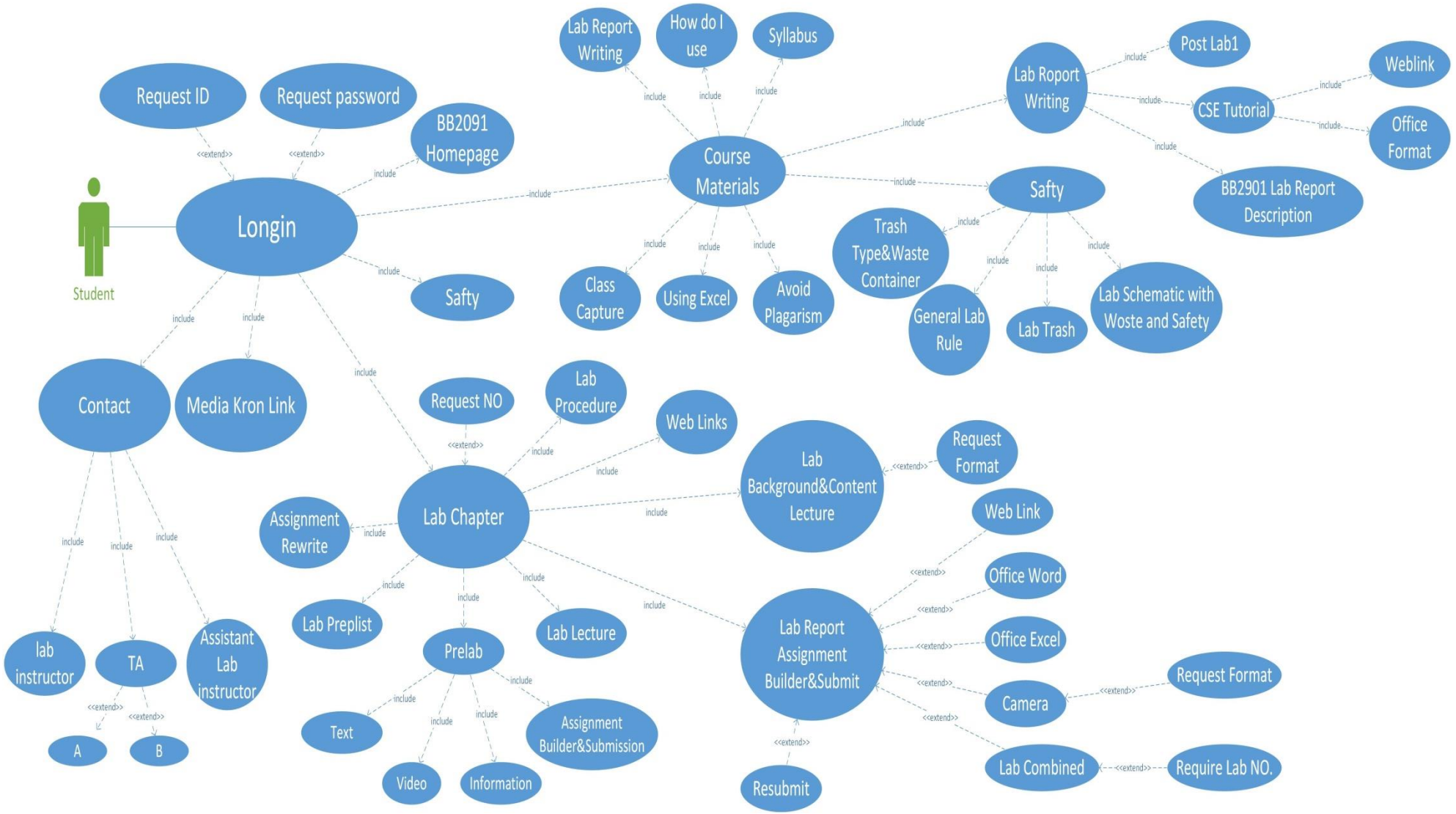
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Figure 11: Design of UML Diagram

5. Recommendations for Future Work

I listed most of the features of our lab application for BB2901 in the two UML diagrams Figure 10 and Figure 11 in the conclusion. Below I have listed some potential improvements, guidance on development of the mobile application, several recommendations, and difficulties that may occur in the following work.

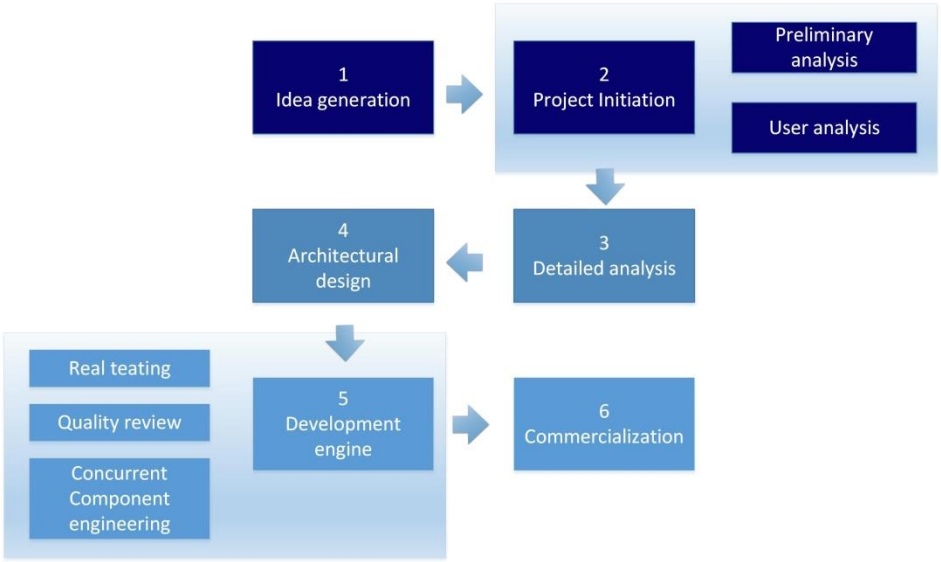

Figure 12: General workflow

As shown on the above Figure 12, this is a general workflow from the idea of the application to the final tablet application that we could use in our BB2901 biology lab.

The design of the mobile application could be developed on different kinds of software developing platform for any operating system tablets. However, the main task for future work is to build an iOS application especially for the iPad 2 in our biology lab.

Three aspects have been taken into account:

On the one hand, as the iOS 8 operating system has been published in 2014, some new features are able to help Apple products achieve greater success in the field of education [9].

One of the most important features in iOS 8 is the extensibility. Take iOS 7 as an example, it is not allowable to save a webpage in Evernote on iPad, as Safari and Evernote do not have the same interface and cannot directly communicate with each other. As a third-party application if we will build an iOS application, we could add this new feature into our application to achieve a more efficient form of operation. It meets the need for a lot of access, preservation of information for students and

teachers.

Figure 13 iCloud Drive in iOS devices

Another feature is iCloud Drive, although there is nothing unique. Because similar services like Dropbox have been around for a long time. Of course, from a platform perspective, iCloud Drive opened the barrier between iOS and Mac, and it is still very convenient for students who often interactive between Mac and iOS device. For our biology lab application, developers could make use of iCloud APIs to enable our apps to store app data in iCloud synchronously. In addition, iCloud Drive reduced the price of iCloud usage space, which is a positive impact. But generally speaking, we are still looking forward that iCloud Drive can do more than just a cloud space. [12]

One the other hand, we have enough iPad 2 used in our biology lab. The most important is that iOS 8 still supports iPad 2 and iPhone 4s and other early A5 devices. We could take advantage of some of tablet only features like displaying and annotating PDF, DOC and text files, processing graphs and charts.

What's more, we need to build our mobile application to satisfy different kinds of operating system tablets for the convenience for every BB2910 students.

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