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Dissertation Title
Efficient Object-structure-based E-learning IOS App

Submitted in partial fulfillment of the requirements for the admission to the degree of
Master of Science in Computer Science

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ABSTRACT

This project aims to build an E-learning IOS app based on the requirement offered by a president of a college in Hong Kong. Target users of the app are primary school students and teachers. The destination of the app is to help them with math-learning and teaching efficiency both in and after class. Besides, interaction pattern are considered during the design phase of the app. The tasks of building the app are separated into 3 parts: 1) Math-learning; 2) SVG controller; 3) Mind-map. I am responsible for the first part about math-learning. And I will also give a brief introduction about the other two parts. Therefore, I was involved in the phase of design, implementation, UI design and icons collection, testing, user research and feedbacks. Finally, our first version product called Skyapp 1.0 has been on the Apple store. And we are doing pilot tests in two primary schools in Hong Kong.

Keywords: E-learning app, Interaction, Whiteboard, Primary school teachers and students

DECLARATION

I hereby declare that that project work entitled " Efficient object-structure-based E-learning IOS app" submitted to the MSc office is a record of an original work done by me under the guidance of Dr. Lucas C.K. Hui. And this project work is submitted in the partial fulfillment of the requirements for the award of the degree of Master of Technology in Computer Science. The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree or diploma.

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I acknowledge with gratitude to the outside supervisor of this project Dr.Shum, who gives me the chance to do the user research of the application and have interviews with local primary schools in Hong Kong. What's more, many thanks to my teammates who share the same resources, either software, hardware or documents with me.

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1.Introduction

How cool would it have been to be able to draw, write and learn directly onto my own computer? As the years went on, people theorized that laptops would take over the classroom, but the price of these devices was too high for a 1 to 1 ratio. It never quite caught on in lower grade schools.

Now, it is the age of the tablet. We have affordable high-powered computers that can provide all sorts of enrichment through an intuitive touch screen interface and the education world is taking notice. More and more classrooms are imaging the curriculum in the context of each child having his or her own tablet. Yet, some educators are still skeptical. How can a piece of technology truly enhance the learning process, without causing distraction?

The answer is yes with our e-learning application. Tablets are more efficient. Teachers can pre-list assignments for the day and student's can see the schedule before even arriving. Communication is fast and instant between the teacher and child as well. There is less time grading, sorting, and filing.

Besides, the testing methods with our application may be efficient. Teachers can use all sorts of innovative ways to gauge how well their students are learning the material. Charts, graphs, and classroom analysis is easy when test scores are already digitized.

And do you have one student that learns better when they listen to a lecture rather than read? With a tablet, you can teach the same information in different ways to different students. A history lesson might work better for some to read, some to listen to the audio, and still some to interact with a game that tests them on important points along the way. It is impossible for a teacher to cater to each individual student's learning style, but the tablet can help with this immensely.

As our application uses “gamification”, psychologically, children do better when they are offered choices. Students that are labeled with ADHD or other behavioral problems may benefit when a teacher is able to say, “Okay, today we are learning our multiplication facts. There are several games you can choose from.” This way, the student feels a sense of empowerment in his own learning and the teacher is able to give autonomy to the child.

1.1Math-Learning

iPads are becoming more prevalent in classrooms because of the rapid uptake of tablet devices by schools. These mobile devices enable students to access the Internet easily and have a range of apps available for educational purposes. As students and teachers become familiar with using iPads, new ways of using this technology for teaching and learning can be explored.

Nowadays, as the Internet and electronic devices spread widely and fast all over the world, people in various fields begin to use them as tools to enhance their work and learning ability, particularly in some developed countries and regions. In Hong Kong, there are some primary schools that would like to use iPads as learning devices for teachers and students to enhance math learning. And this is where the product idea comes from or we would say that this is where the custom requirements come from.

From a research [1], “students saw learning gains after as little as 20 minutes of study on the iPad, the research found, and if supported with guidance from an instructor their improvement may have been even more pronounced, the scientists suggest. ‘The bottom line is that these iPads and similar tools actually do make a difference,’ said physicist Matthew Schneps, a founding member of the Science Education Department at the Harvard-Smithsonian Center for Astrophysics in Massachusetts.”

“The research suggests that tablets could aid the study of many scientific concepts that are difficult to grasp, such as distance, time, and other large-scale subjects, said Schneps. ‘These

occur in the study of geologic time; the size and age of the universe; the timeframe of biological mutation and evolution; the mass, size, and speed of subatomic, atomic, and molecular particles; and so on,' the study noted."

Indeed, there are already some excellent products about E-learning in the market. In mathematics, there is an extensive range of iPad apps available. These apps can be loosely categorized into four types: Internet; encyclopedic (e.g., Wolfram Alpha); single use (e.g., Math Bingo); and general classroom use (e.g., Notability). They are summarized and recommended by American primary schools about iPad apps in sorted ways. After doing some research about these, I finally come to the idea of the "Whiteboard" element in our app. Thus, our app is based on the whiteboard to enhance learning and teaching efficiency. And our focus is on:

1. "Whiteboard" as a tool or interaction pattern for teachers and students; and users could use their hand to write on the board. "Whiteboard" is the core element and the basis of the actions performed by users.
2. The application could recognize handwriting symbols automatically and transform them to electronic version.
3. The application could recognize some answers automatically and give hints to students.
4. The application could record the steps or footprints automatically of students using the iPad.
5. The application could visualize the data or steps and organize the data automatically to show students' learning process, which is called "Mind-Map" in pedagogics domain.

1.2 SVG Controller

Though this part is not done by me, I need to do a little research on why we use SVG for E-learning? SVG is well suited to play a major role in E-learning environments. The visualization options available in SVG graphics go beyond competing file formats. Any

attribute can be animated and the available interactivity options and script bindings allow the building of fully interactive applications that do not need to hide from stand-alone offline multimedia applications. It is important to note that SVG should be used as a complementary technology and in conjunction with other established web-technologies, such as XML, XHTML, static raster graphics and movies. SVG is primarily a presentation and exchange format that can and should be generated out of other storage formats, databases, and XML sources. Specifically, it is recommended that one uses SVG in connection with other XML based e-learning markup languages, such as ELML. SVG should be used for static illustrations, animations and interactive applications.

It is a fact that interactive applications can motivate students. Interactivity can involve and immerse students compared to a dry verbal and static presentation. Benjamin Franklin said "*Tell me and I forget. Teach me and I remember. Involve me and I learn."* One can let the student solve the problem himself, directly with an interactive SVG application. Specific learning goals can be isolated and students can concentrate on the essential tasks rather than first having to learn complex applications. Besides, when using SVG to teach or illustrate phenomena, one can involve students in different levels of integration.

SVG is also particularly useful for data driven visualization of learning data, charts, maps and technical drawings, as it can be generated using XSLT conversion or any scripting or programming language the developer is familiar with. Developers are therefore not limited to a specific server-side framework and there aren't any vendor lock-ins. Futhermore, many spatial databases already support SVG generation. Having defined conversion rules, updating the SVG presentation is easy and can be automated.

1.3 Mind-map

The question involved in this part is "How mind maps can be used as an effective tool for E-learning?" First of all, mind maps are the perfect tool for creating a learning plan; whether it's

planning your curriculum, breaking down a particular subject or simply to map out an essay or exam answer. Visual learners will especially appreciate the structure and layout of information on a mind map which are appealing and easy-to-understand. Online mind maps have an added advantage in that they can be accessed from anywhere at any time, meaning peace of mind if you've forgotten what topic you had planned to focus on.

Secondly, mind maps can be used as interactive resources which can transform a classroom or a discussion. As discussed above, Mind Maps can be used as a brainstorming tool for both individuals and groups through the sharing of new ideas which can ignite sparks of possibilities. This enhances the e-learning experience by providing a unique resource to unlock creativity and express ideas intuitively and quickly.

Third, mind maps, and in particular online Mind Maps, have the potential to improve learning and contribute to exam success. Seth Godin wrote in his book Stop Stealing Dreams, "The magic of connecting dots is that, once you learn the technique, the dots can change but you'll still be good at connecting them." Mind Maps provide the ideal opportunity to identify these connections and give a deeper understanding.

1.4 Workflow of the application

The workflow of the application is showed in following steps:

1. Teachers choose language mode and log in;
2. Teachers create a new whiteboard on the main view;
3. Teachers edit the whiteboard and assign it to the students;
4. Students choose language mode and log in;
5. Students see the assigned work on main view;
6. Students open it and answer the question;
7. Students submit the work to teachers;
8. Teachers could see the recording and the results of students' work;
9. Students get praise according to their answers.

Besides these basic steps, there are more detailed functions within the app, for instance, on whiteboard page, teachers could hide the answers using answer box, and decide the questions are only exercises or a test for students. What's more, teachers could import pdf or word files to show students. Further more, an embed browser in in the app.

2. Analysis of Problem

The main problem of the project done by me is "How to enhance math-learning using ipad?" From a research done by a teacher, the teachers recognized that iPads hold the potential to enhance mathematics teaching and learning due to their wide range of affordances that include a vast variety of application, ease of use, and their ubiquitous nature. However, they found it challenging to incorporate creative iPad use into mathematics lessons when compared to their integration into other subject areas such as English and science. During the course of the two studies, the teachers tended to rely on apps that are specifically designed for mathematics, but focused on a drill and practice approach that simply replaced the repetition of a standard worksheet or textbook page with some added animation and color. Sometimes the apps that were used in the observed mathematics lessons were based on games, with little or no opportunity for students to develop their problem solving skills or being able to reflect on their learning, and limited opportunities for the teachers to capture evidence of learning.

Studies have long shown that teaching mathematics is becoming more and more difficult. The challenge is to catch student's attention and interest in the subject. Obviously, there is a crucial need to incorporate new tools into the classroom to preserve the relevance of the educational institution. Recently, there has been a growing interest in the use of tablets and more specifically iPads as a tool of promoting learning and teaching of mathematics. In fact, iPad creates an environment that facilitates students' learning processes. It also provides an interactive classroom with real-time feedback.

To design a good application, we need to do some research on the emerging products and do some comparison between them. So here we adopt a method called comparative analysis which also includes the summarization of the products.

2.1 Generality:

1) **Keynote**-easy to do presentations, animated charts and transitions;
2) **iMovie** - create high-quality videos anywhere, anytime , in iPhone, iPod touch, iPad 2 can be used
3) **Pages**-production, editing, viewing file
4) **Numbers**-like Excel Spreadsheet Application
5) **BrainPoP Featured Movie**-Tim and Mobi humorous dialogue and animations mathematics, English, social, scientific and other knowledge, there are more than 750 movies, each movie has ended quiz (Quizzes), all have a complete dialogue English subtitles, but also there ESL (English as Second Language) content.
6) **Non-free Whiteboard Lite**-On-line real-time interactive whiteboard, iPhone, iPod touch, iPad can be used.
7) **iBooks**-interactive classroom software, teachers can in class for students to answer the question, the statistical results immediately, master degree students to understand
8) **Comic Life**- produced cartoons (Comic) Tools
9) **TypeDrawing**-Creation TYPOGRAPY ART and add the photo WATERMARK artistic creation.
10) **Animoto Videos**- will the iPhone photo you add music into a professional a type of film, just a few minutes, you can share with your friends
11) **Discovery Education**-Educational videos
12) **Mobile Mouse**-Your iPad into a wireless mouse computer
13) **Professor Garfield Cyberbullying**-Garfield teach children how to safely use the Internet to determine the credibility of information, to avoid cyberbulling.

14) **Sundry Notes**- a full-featured notebook software. Face the audience when the iPad VGA cable connected projector or television screen on the iPad up on the projector, you punctuate briefing on filling iPad, synchronous display, and let you do the briefing- Blackboard Presenter
15) **Little artist HD**-with finger drawing tool
16) **Templates for Elementary Students**- 15 file format to enable students to make a report or homework, finishing news.
17) **Notability**- will turn into a spoken text or take notes
18) **TeachMe**: for the kindergarten level, teach spelling, addition and subtraction within 10, so that children learn side collecting stickers, wall stickers can show and share.

2.2 Math

For math, especially for math-learning, is temporarily the most part of observation and research. The result is, the interests and the results of learning math will definitely enhanced using iPad applications. So we have summarized the emerging product below:

1) **MathBoard** – Learning Math (Add, Subtraction, Multiply, Division)
2) **MATHsKOOL 1**- 12 games to learn math skills, high grades suitable for primary school
3) **Free Graphing Symbolic Calculator** – Math Plots calculator Ruler-instant measurement plot size.
4) **Math Quizzer**- Interactive fun way to reinforce arithmetic skills
5) **Ace Kids Math Games**-animation to each children to count, add and subtract, there are incentives to enhance learning motivation
6) **Math Bingo**-bingo game will be fun to join mathematical exercise
7) **iFactor quadratics**- learn decomposition binary simple equation
8) **eSolver HD**- teach you the solution of binary linear equations
9) **Math Flash Cards**-the same as the conventional memory and lets you repeat enhance learning

10) **Numerate: Count, Add and Subtract**-interactive games teach you to learn to recognize numbers as well as simple addition and subtraction
11) **MakeChange**- practice counting and addition
12) **Equation** – quick and easy tool for the solution of binary linear quations
13) **Park math**- teaching preschool children to mathematical
14) **Motion Math**-you can guess from the name, it is in motion control iPad App, familiar concepts and estimation scores
15) **Math Ninja Lite**- learn and apply addition, subtraction and mixed computing tasks to achieve Ninja
16) **Math Ninja HD**- Another similar games, applications, addition, subtraction and mixing operations to reach ninja mission, to protect the tree house.
17) **Motion Math Zoom**-learning to count line (Number Line) and set up a numerical concepts.
18) **Pizza Fractions**-Pizza as an example to practice the concept of fractions.

2.3 Certain apps downloaded

The forestall summarization gives us a very clear view of how our application should be designed. For better solution, I downloaded the following apps to my iPad:

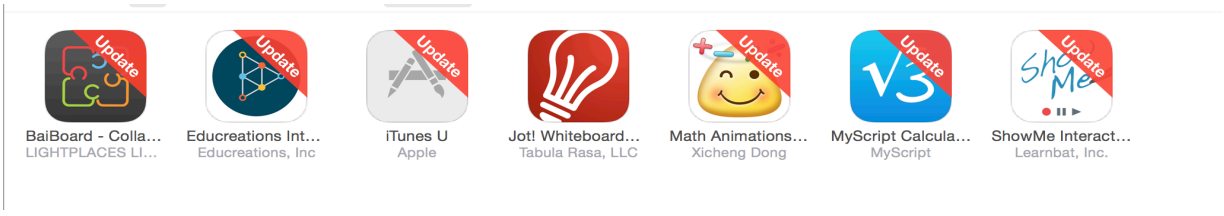


Diagram 1

These certain applications conform to some described characteristics in our apps. For example myscript calculator could recognize handwriting lines automatically and transform them to the electronic format. Besides, some of them include the recording function inside the apps.

In this report, I will elaborate every stage during the project: design, implementation, testing and user research for every part.

3. Theoretical Principles

3.1 Design

3.1.1 General

During the design process, it includes the user-interface design, icons collection, and the human-computer interaction design.

Before designing the application, we need to repeat the target functions of our apps. And in our case, we would like to help (1) teaching in the classroom and (2) self-directed learning at home. But no matter what we design, we follow the following design principles in our app.

1. More pupil-friendly interface: colorful and animation but learning than playing.
2. Control functions of the application makes the app much more usable for teachers to lock the students' actions.

Diagram 2

3. Simple and clear
4. Modularity: for example, we may have calendar, play, course review, worksheets, testing

for students, communications with teachers and some other useful modules for the user interface.

5. Diagnostic test: The teacher gives the students tests to see their strong as well as week section of the math subject.
6. Navigation patterns: colorful right or left side navigation to browse subject in easy mode. (Equation, inequation, formula, variables, constants, numbers, functions, logarithms, integration, square,)
7. Main Content
8. Test
9. Report

For example, we have the application called XClass which has the control function. The main issue our application needs to solve is the interaction between teachers and students. So the whiteboard is to show some calculations to students in the projector and we would like to make the content in a modular manner and different modules have different shape and color to draw students' attention. We can classify the modules by "Time", "Content", etc. Besides, we could include IT resource library in our application.

What's more, we need to support learning at home for students to finish homework, reviewing lessons, doing tests and for teachers assign assignments, producing report and assessment about students.

So, finally the basic function is settled down to design a whiteboard for teachers to teach in class and save the notes for students to review after class.

And for user interaction design in our application, we follow the design tips for a great flexible user experience:

1. Progress message and indicator shows while the application loads;
2. A feedback message is displayed when an action is performed;

3. Match between system and the real world. The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order;
4. Organized as a library that contains your media library: music, movies, shows, audibooks. Beneath the library is the store where you can buy more media to put in your library;
5. The branches and hierarchy of a mind map can be easily reorganized visually in a non-linear manner. An outline would never works, but this matches the paradigm exactly;
6. User control and freedom (NAVIGATION);
7. Users often choose system functions by mistake and will need a clearly marked "emergency exit" to leave the unwanted state without having to go through an extended dialogue. Supports undo and redo and a clear way to navigate;
8. Search is easy to open, enter info, execute or cancel;
9. Clearly marks where the person is and where they can go by showing the section in each menu;
10. Cell editing shows row and column IDs, and the cells used in the equation. The equations could be saved and canceled;
11. Undo and redo buttons are available in the toolbar, and can also be accessed with the standard keyboard shortcuts;
12. Users should not have to wonder whether different words, situations, or actions mean the same thing. Follow platform conventions.

3.1.2 Gamification

How can gamification improve E-learning? What is the future of gamification in E-learning industry? We have data to explain why we use gamification in our application especially for primary school students.

Over 75% people are games. Learners recall just 10% of what they read and 20% of what they hear. If there are visuals accompanying an oral presentation, the number rises to 30%, and if

they observe someone carrying out an action while explaining it, 50%. But learners remember 90% if they do the job themselves, even if only a simulation.

Almost 80% of the learners say that they would be more productive if their institution or work was more game-like. Over 60% of learners would be motivated by leader boards and increased competition between students. 89% would be more engaged win an e-learning application if it had point system.

Besides the data, we have some gamification techniques to illustrate. 1) Progressing to different levels; 2) Scores; 3) Avatars; 4) Virtual Currencies; 5) Competition with friends; 6) Virtual gifts; 7) Being part of a narrative; 8) Real time performance feedback and activity feeds. The most effective uses of gamification in learning: 1) Illustrating progress; 2) Increase engagement; 3) Creating challenges; 4) Instilling a sense of accomplishment.

According to all these data and technique, I decide to use "gamification" in our app to enhance math learning.

3.1.3 Whiteboard

There are 5 benefits of whiteboard in corporate learning for teachers and students:

1. They can be a great marketing tool for primary schools. If you are introducing a new process in the classroom, your greatest worry is to change management. Whiteboard can generate interests in a new process or tool within the classroom. They are short and crisp – taking up very little time of the viewer. They are also informal, encouraging the viewers to 'try and see'.

2. They can also provide suitable refreshers to accompany text-heavy courses. Encapsulating the crux of the course, they can help the learner revise and refresh as per need. This makes the information more palatable and easier to consume as well as retain.

3. Complex processes (like the working of machinery, assembling of parts, and so on) can be broken down and illustrated with the help of whiteboards. Unlike static images, these ‘how-to’ whiteboards help the learners ‘see’ how things work and understand the processes better.

4. For products that are being built, whiteboards can be utilized to create impactful demos. When real pictures are difficult to get, illustrations or drawings can suitably represent the products to the learners through animation.

5. Whiteboards are ‘in’ and quite the flavor of the times! So they also help in differentiating your course from the run-of-the- mill variety. A short whiteboard before the beginning of a course can instill curiosity for the learner to know more.

3.2 Implementation

According to the ideas from design phase, we also have some implementation principles to illustrate.

For implementing better interaction results, we need a server to connect teachers and students and the application together. Special database needs to be designed during the implementation process.

According to the e-Learning book by Ruth Clark and Richard Mayer, there are six fundamental principles for implementing and designing e-Learning application.

1) The multimedia principle

   Solution: create content using smaller chunks of text; Use images with popups; limit scrolling to the very minimum.

2) The modality principle

   Solution: use words as audio instead of text, whenever possible; keep narration short to ease-up on download time; and provide headsets to your users.

3) The contiguity principle

Solution: use flash lite or similar technologies to implement popup text over images; and keep feedback with the question. Do not separate naturally linked content.

4) The redundancy principle

   Solution: do not duplicate information; use duplicate narration for language learning.

5) The coherence principle

   Solution: do not use any type of information that is not related to content and context. Do not add illustrations, music, or environmental noises.

6) The personalization principle

   Solution: Use an audio coach or place a small icon on screen to gain access to the coach; create a conversation with the user; use the first or second person in your narration or text.

In a word, all implementation steps need to conform to the design phases.

3.3 Testing

As testing is an imperative part of the agile development process, I've also been involved in the testing phase. We have a programmer who mainly writes codes for the application so that it will has high efficiency to separate the programming and testing apart, which means that testing and programming are done by two people.

In testing phase, I adopt a way called Unified Modeling Language concept. Though the Unified Modeling Language is a general-purpose modeling language in the field of software engineering, which is designed to prove a standard way to visualize the design of a system. The document included in it could be a better way to represent clear use cases, scenarios, steps in the testing document.

4. Method of Investigation

In agile software development, user research is also a critical part during the process. User research basics focus on understanding user behaviors, needs, and motivations through

observation techniques, task analysis, and other feedback methodologies. Mike Kuniaysky further notes that it is “the process of understanding the impact of design on an audience.”

The types of user research you can or should perform will depend on the type of site system or app you are developing, your timeline and your environment.

Guided by the user-centered design process, we have following user research methods: card sorting, contextual interviews, first click testing, focus groups, Heuristic evaluation/expert review, individual interviews, parallel design, personas, prototyping, surveys, system usability scale, task analysis, usability testing, use cases.

In our whole process, we adopt use cases, usability testing, task analysis, personas, parallel design and focus groups.

Use cases: provide a description of how users use a particular feature of our application. They provide a detailed look at how users interact with the app, including the steps users take to accomplish each task, which we mainly use in our testing phase.

Usability testing: identifiers user frustrations and problems with our applications through one-on-one sessions where a “real-life” user performs tasks on our app.

Task analysis-Involves learning about user goals, including what users want to do on our application, and helps us understand the tasks that users will perform on our app. We mainly do this in the design phase.

Personas-The creation of a representative user based on available data and user interviews. Though the personal details of the persona may be fiction, the information used to create the user type is not.

Parallel design- A design methodology that involves several designers pursuing the same effort simultaneously, but independently, with the intention to combine the best aspects of each for the ultimate solution.

Individual interviews: One-on-one discussions with users show you how a particular user works. They enable you to get detailed information about a user's attitudes, desires, and experiences.

Focus groups-Moderated discussion with a group of users, allow you to learn about user attitudes, ideas, and desires.

5. Design and construction of software system

Below is the use case designed for the application:

5.1 Use case

Table 1

Use case	Actor(s)	Description	Interaction Pattern
A math teacher is **preparing** class work for Class 4A using SkyApp	Teacher	Teacher could use the app to prepare the content before the class	Teacher
A math teacher is **teaching** in class	Teacher	Teacher could use white board to teach in class and save the notes of the class.	Teacher->Class
The math teacher is **delivering** the classwork during/after class	Teacher Students	Teacher uses the whiteboard to give questions and distribute them to students	Teacher->Class/ Student
Answer Questions	Students	Student use whiteboards to answer questions and submit it to the teacher	Student->Teacher
Praise Students	Teacher/Students	Teacher could give icons to students by their performance on tests.	Teacher->Students
Faciliating **sharing** in the classroom	Teacher Student	Teacher uses the control panel to change the project to show students' work	Teacher->Class Student->Class
Presentation of the students' data objects	Teacher Students	Students use mindmap to find the reviewing classes	Students
Game	Teacher Student	Teacher assigns students to play a game	Complex and multiple

5.2 Scenarios for each use case

5.2.1 Prepare Class Work

Table 2

Use Case Name	A math teacher is preparing class work for Class 4A using SkyApp	
Actor(s):	Teacher	
Description:	Teacher could use white board to prepare notes for the class	
Reference:	SkyApp	
Typical Course of Events (Scenarios):	**Actor Action**	**System response:**
	Step 1: Initiate this use case when the teacher logs in. Teacher inputs account and password that have been stored in the database, chooses language mode and clicks login button.	
		Step 2: The app goes to the "Main View" page.
	Step 3: Teacher clicks the "add" button to add a new whiteboard.	
		Step 4: The app shows a whiteboard on the left top corner.
	Step 5: Teacher clicks the whiteboard.	
		Step 6: The app goes to the "Note View".
	Step 7: Teacher clicks the "draw" button and draw on the whiteboard and clicks "finish".	
		Step 8: The app shows the drawing on the whiteboard.
	Step 9: Teacher clicks the "add picture" button to add a picture from the gallery.	
		Step 10: The app shows the picture on the left top corner on the whiteboard.
	Step 11: Teacher clicks "add text" button and inputs the text and clicks "Done" to add a text.	
		Step 12: The app shows the text on the left top corner
	Step 13: Teacher clicks "internet" button to use the internet.	
	Step 14: Teacher clicks the "camera" button to take a picture of the	

	document. **Step 16**: Teacher clicks "save" to save the notes to database. **Step 18**: Teacher clicks "back" button to go back to the "Main View"	**Step 15**: The app shows the picture of the document on the left top corner. **Step 17:** The app shows the success message.
Alternative courses	None	
Pre-conditions:	The teacher logs in successfully.	
Post-condition:	Teacher has successfully created new note.	
Assumptions:	None	
Remarks:	For every object the teacher adds on the whiteboard, he/she could single click or "long press" it to edit.	

5.2.2 Teach In Class

Table 3

Use Case Name	A math teacher is teaching in class	
Actor(s):	Teacher	
Description:	Teacher could use white board and the projector to show the notes and teach in class as a real-life blackboard.	
Reference:	SkyApp	
Typical Course of Events (Scenarios):	Actor Action 1. Teacher connects the ipad with the projecter. 2. The following steps are the same with the use case "prepare class work"	System response: The steps are the same with the use case "prepare class work"
Alternative courses	In step 16, teacher could choose not to save the note for class, and clicks "back button. The app will show a	

	message, teacher clicks "yes" and goes back to the "Main View" page.
Pre-conditions:	The teacher finished the use case "prepare for the class"
Post-condition:	Teacher has successfully taught the class using the whiteboard the projecter.
Assumptions:	None
Remarks:	For every object the teacher adds on the whiteboard, he/she could single click or "long press" it to edit.

5.2.3 Delivering Class Work In/After Class

Table 4

Use Case Name	A math teacher is teaching in class	
Actor(s):	Teacher & Students	
Description:	Teacher assigns exercise and tests in class.	
Reference:	SkyApp	
Typical Course of Events (Scenarios):	**Actor Action**	**System response:**
	Step 1: Teacher finished the steps in the use case "Prepare for the class".	
	Step 2: Teacher clicks the "draw" button to give questions to students.	
	Step 3: Teacher clicks "teacher mode" button to choose "Open answer" and then clicks "OK".	
		Step 4: The app shows a successful message. The "teacher mode" button changes into "distribute" button and is in gray. At the bottom, the tool bar shows "answers" button in gray.
	Step 5: Teacher clicks the "answer box" button in red and put it to cover the text.	
	Step 6: Teacher clicks the answer box to give answer	
	Step 7: Teacher clicks "hide all answers"	
		Step 8: The answer box shows the "lock"
	Step 9: Teacher clicks	

	"distribute" and choose a group, then clicks "distribute" at the bottom.	**Step 10**: The app shows a successful message.
Alternative courses	In **Step 2**, teacher could also 1) Clicks "text" button to type something on the whiteboard; 2) Clicks "gallery" button to choose a picture from the iPad; 3) Clicks "camera" button to take a picture. In **Step 6**, if the teacher forgets to give the answer in the answer box, clicks the "hide all answers" button and clicks "distribute", the app will show a alert message. And the locked answer box will become editable. In **Step 9,** if the teacher forgets to choose a group, and clicks "distribute", the app will show an alert message "Please choose a group."	
Pre-conditions:	The teacher goes through the steps he/she needs in the use case "prepare for the class".	
Post-condition:	Teacher has successfully distribute the exercise/test to the target students.	
Assumptions:	Followed by the use case **"Students answer questions."**	
Remarks:	For every object the teacher adds on the whiteboard, he/she could single click, double click or "long press" it to edit.	

5.2.4 Student Answer Questions

Table 5

Use Case Name	The students do the exercise/tests given by their teacher.
Actor(s):	Students
Description:	In students mode, students could do the exercise and tests given by teachers.
Reference:	SkyApp

Typical Course of Events (Scenarios):	**Actor Action** **Step 1:** Student-Tansy logs in and enters to the "Main View" page. **Step 3**: Tansy clicks on a whiteboard to open the exercise. **Step 4**: Tansy double clicks the answer box and type in the answer. **Step 5**: Tansy clicks "save" button to save the answer. **Step 6**: Tansy clicks "back" button to go to the "Main View" page.	**System response:** **Step 2**: The app shows the exercise with a tag on the left top corner of the whiteboards. **Step 7**: The app changes the "question" tab to "answered already".
Alternative courses	In the use case "**prepare for the class**", **Step 3**, if teacher chooses the answer to be "fill in the blanks", in **this use case, step 2**, the app will show the "question" and "testing" tab on the whiteboard. Still, in **Step 5**, if students clicks "submit", and typed in the right answer, the app will show a message "You're right." But if the answer is wrong, the message will show you are wrong and let you try it again.	
Pre-conditions:	The teacher distributes the questions to students successfully.	
Post-condition:	Students finish the questions given by teachers.	
Assumptions:	Followed by the use case "**Praise Students**".	
Remarks:	For every object the teacher adds on the whiteboard, he/she could single click or "long press" it to edit.	

5.2.5 Give Praise to Students

Table 6

Use Case Name	A math teacher gives praise to students
Actor(s):	Teacher Students
Description:	Teacher could give students praise by looking at their performance on tests.
Reference:	SkyApp

Typical Course of Events (Scenarios):	**Actor Action** **Step 1**: Teacher goes to the "Note View" page. **Step 2**: Teacher clicks "Performance" icon. **Step 4**: Teacher clicks "view" button to see the students' answers. **Step 5**: Teacher clicks the "back" button to go to the "Note View" page. **Step 6**: Teacher clicks "distribute" and choose a group and a gift, then clicks "OK".	**System response:** **Step 3**: The app could calculate the marks, trials, and time automatically and show the results on the window. **Step 7**: The app shows a success message.
Alternative courses	None	
Pre-conditions:	Students have already submitted the answers to teachers.	
Post-condition:	Students receive the icons teachers send to them.	
Assumptions:	None	
Remarks:	For every object the teacher adds on the whiteboard, he/she could single click or "long press" it to edit. I think this kind of user experience is a little bit uncomfortable.	

5.3 Application work flow

Then the following images show the pages of the application: the login page for both teachers and students. Teachers' and students' accounts have been stored in the database. There are 2 language modes: Complex Chinese and English for users to choose.

Diagram 3

The following image shows the main page of the application. It includes the “logout” the button, the user’s name, the “add board” button, the “refresh” button, and the “achievement” button.

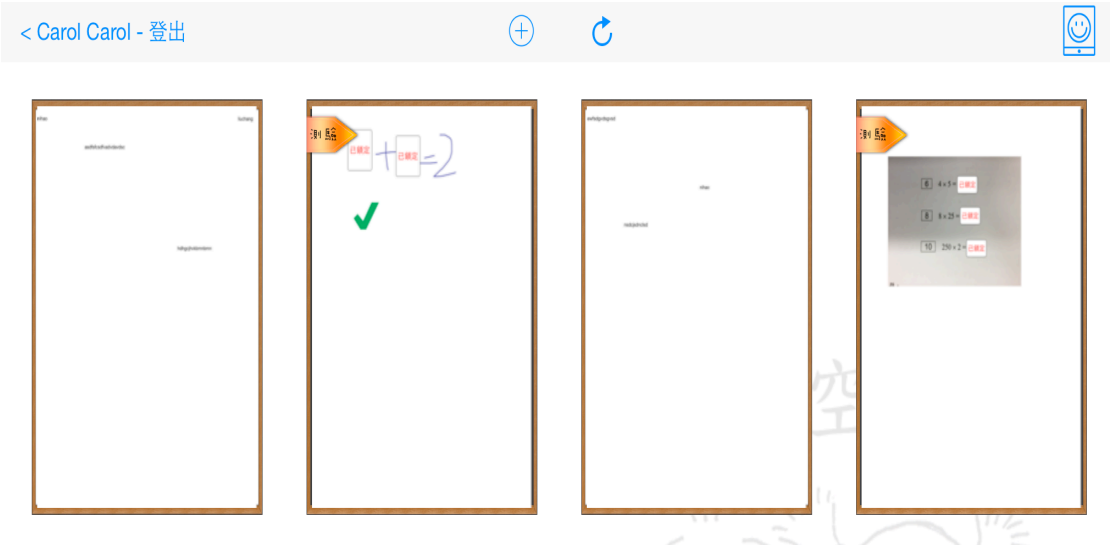


Diagram 4

From above picture, we could see that there are tags on the left top corner of the “whiteboard” button, which are decided by teachers when teachers assign tests or exercises to students.

Then, after clicking on the “whiteboard” button, the following page will show up which is called “whiteboard” page. On this page, you could do any operations you want on it by

choosing “draw”, “add text”, take a picture” or choose pictures from gallery” buttons. Besides, on the right bottom corner, there is an inside-app browser for users to search for useful information. This page shows only the teacher-mode whiteboard, because on the right top corner of this page, there is only “point-to-point” transformation and “save” function which means teacher could choose to save the note or not and assign the note to individual student.

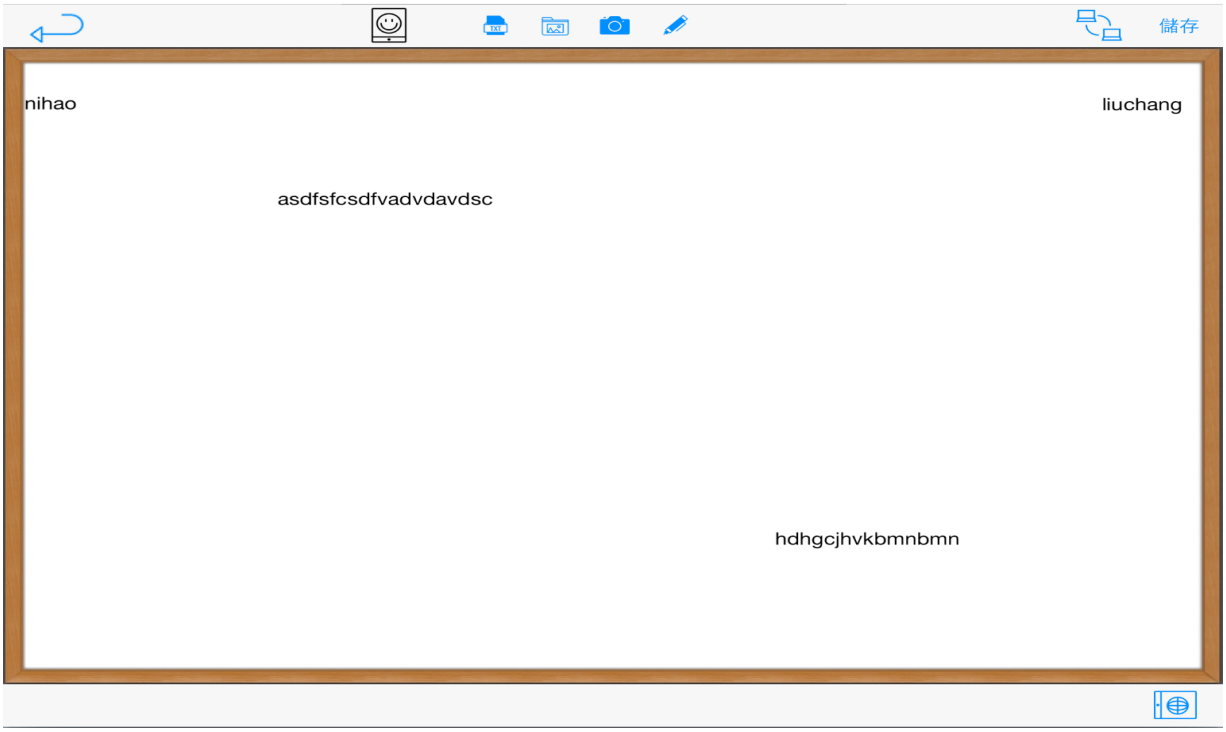


Diagram 5

And after saving the notes to the database, and then come back, teachers could modify the questions on the whiteboard like shown below. There is a small answer box to hide the answer and lock the answer for students to think about. Then there is a “distribute” button for teachers to assign the work to target learning groups.

Diagram 6

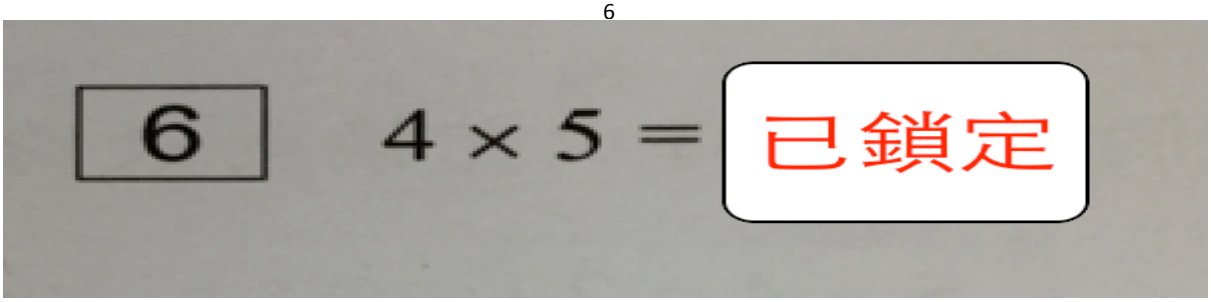
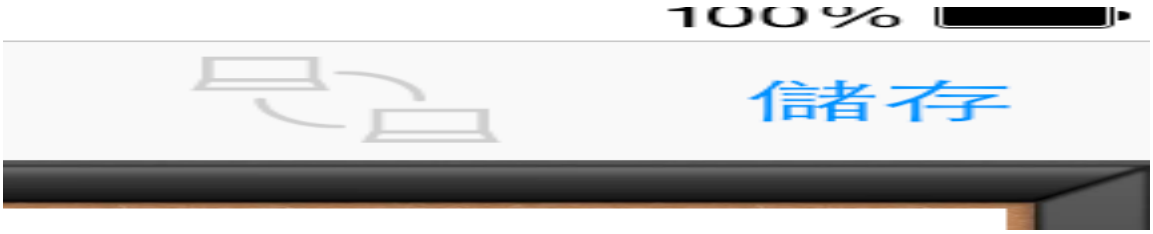
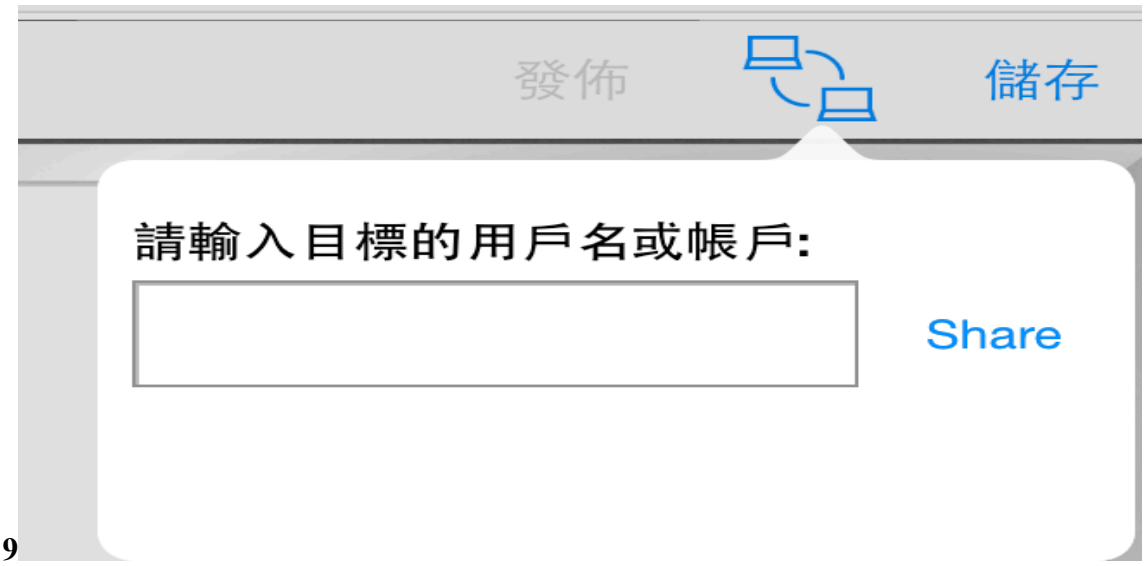


Diagram 7

Diagram 8



Diagram



9

Diagram 10

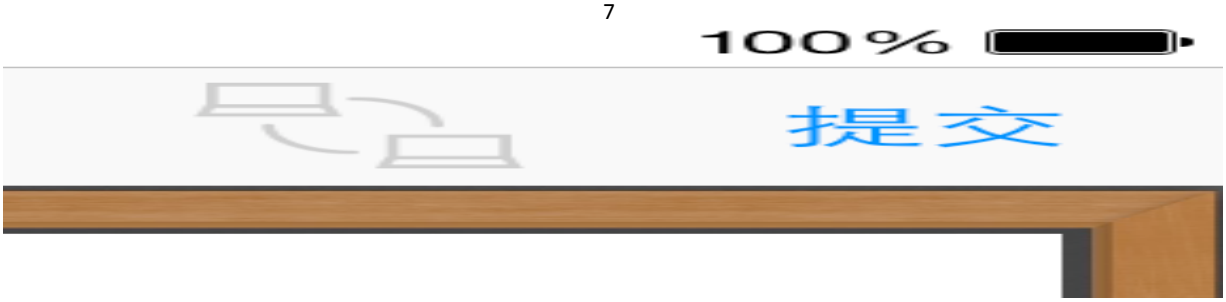


Diagram 11

The above diagrams 6-11 show the functions of certain buttons. For example, the "point-to-point" transformation button, different button functions for teacher and students mode.

Besides, after students finishing answering the questions, teachers could see the result of their answers and recording of their answering: time consuming, student, marks, feelings about the tasks, trials, and the groups they belong to for teachers to understand more about the students and conduct much more efficient teaching plan in the future.

Diagram 12

Then it comes to the most part in our application-reward and "Gamification".

The following page shows the gifts list chosen by teachers. If the students' answers are correct, then they could get an icon chosen by teachers in advance.- Which is shown in the next picture.

Diagram 13

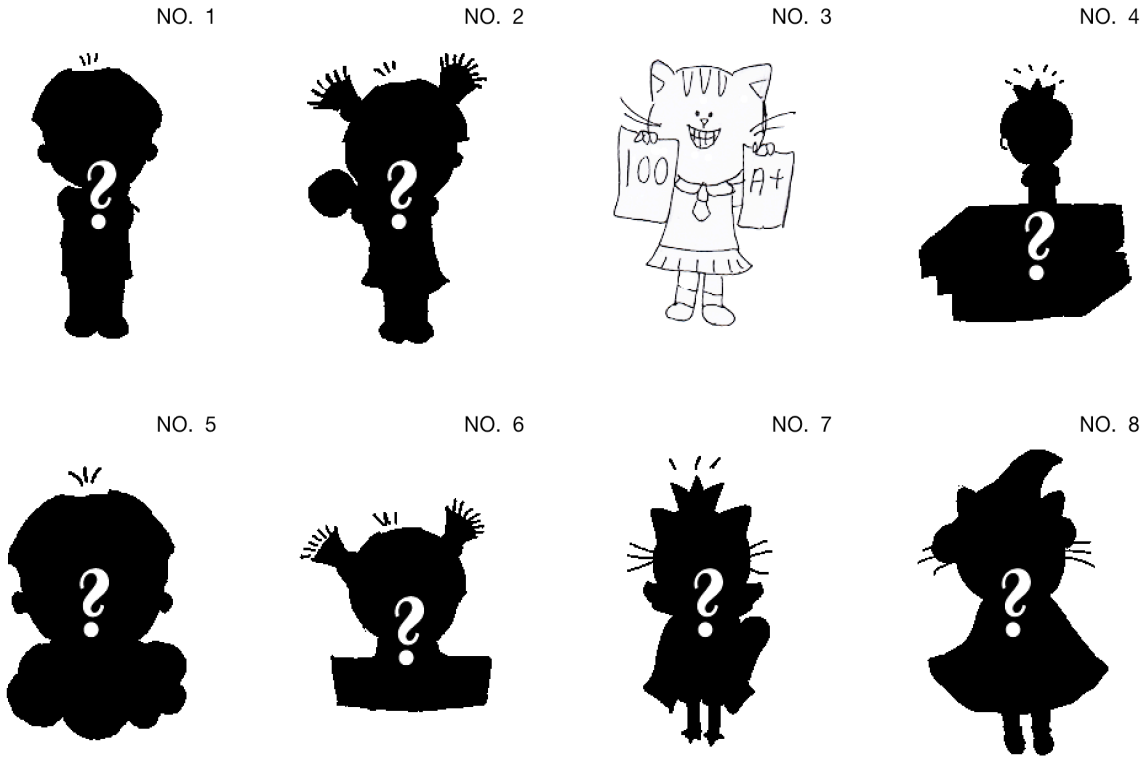


Diagram 14

6. Theoretical results

6.1. Testing server

6.1.1 Xcode

```
#define kPostURL @"http://localhost/testingServer/Login.php"
#define kName @"name"
#define kPass @"password"
```

```
-(void) postMessage:(NSString*) password withName:(NSString *) name{

    if(name !=nil&& password !=nil){
        NSMutableString *postString =[NSMutableString stringWithString:kPostURL];
        [postString appendString:[NSString stringWithFormat:@"?%@=%@", kName,name]];
        NSLog(kName);
        [postString appendString:[NSString stringWithFormat:@"&%@=%@", kPass,password]];
        NSLog(kPass);
        [postString setString:[postString stringByAddingPercentEscapesUsingEncoding:NSUTF8StringEncoding]];
        NSMutableURLRequest *request=[[NSMutableURLRequest alloc]initWithURL:[NSURL URLWithString:postString]];
        [request setHTTPMethod:@"POST"];
        postConnection=[[NSURLConnection alloc] initWithRequest:request delegate:self startImmediately:YES];

    }
}
```

Diagram 15

6.1.2 PHP

Besides, we need to connect the codes in xcode with php server and implement basic functions in the php file:

login.php | getjson.php

```
<?php

$username="root";
$database="testdb";

mysql_connect(localhost, $username);

@mysql_select_db($database) or die ("Error");

$query ="SELECT * FROM Login";

$result=mysql_query($query) or die (mysql_error());

$num =mysql_numrows($result);

mysql_close();

$rows=array();
while ($r = mysql_fetch_assoc($result)){
    $rows[]=$r;
}

echo json_encode($rows);
?>
```

Diagram 16

The result is like this: after inputting the username and password into the login page, the database will record the username and password in pairs.

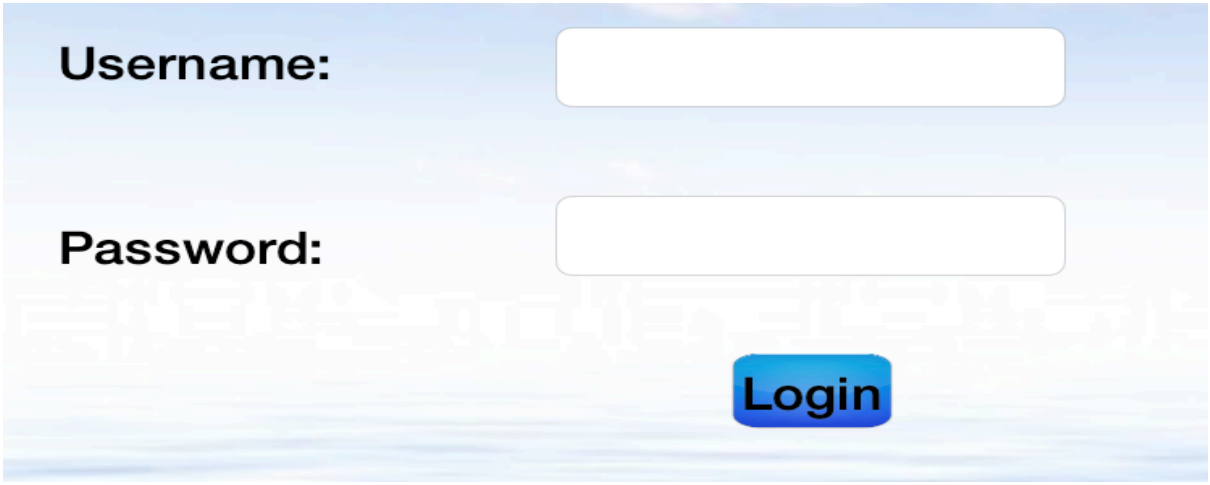


Diagram 17

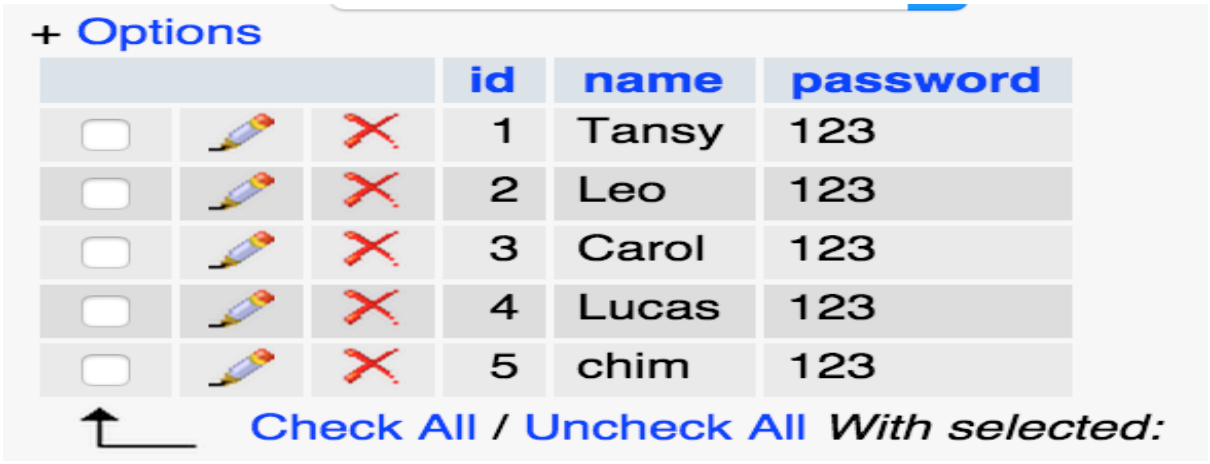


Diagram 18

6.2 “Add Button” function

```
- (IBAction)addButtonClicked:(UIBarButtonItem *)sender {
    NSLog(@"addButtonCliecked");
    [self processAddButton];
}
```

```
-(void) processAddButton{
    boardsNumber=boardsNumber+1;
    int i;
    for (i=0; i<boardsNumber; i++) {
        NSLog(@"processAddButton");
        // create button object
        UIButton * button =[UIButton buttonWithType:UIButtonTypeSystem];
        //set button size
        [button sizeToFit];
        CGRect buttonFrame =button.frame;
        buttonFrame.size=CGSizeMake(200, 138);
        button.frame=buttonFrame;
        //set background image
        [button setBackgroundImage:[UIImage imageNamed:@"whiteboard.png"]forState:UIControlStateNormal];
        // set button center
        button.center=CGPointMake(130+250*(i%4),145+205*(i/4));
        [self.view addSubview:button];  //显示button在view上
        [button addTarget:self action:@selector(whiteBoardButton:) forControlEvents:
            UIControlEventTouchUpInside];
        NSLog(@"action successful");
        UILongPressGestureRecognizer * longPress=[[UILongPressGestureRecognizer alloc] initWithTarget:self
            action:@selector(handleLongPress:)];
        longPress.minimumPressDuration=1;
        [button addGestureRecognizer:longPress];

        if (boardsNumber>=13) {
            NSLog(@"SORRY!");

            UIAlertView *alert = [[UIAlertView alloc] initWithTitle:@"Adding Whiteboards Warning"
                                                            message:@"You can only add 12 whiteboards at
                                                                most now ! "
                                                           delegate:nil
                                                  cancelButtonTitle:@"OK"
                                                  otherButtonTitles:nil];
            [alert show];
            break;
        }

    }
}
```

Diagram 19

The result is as follows:

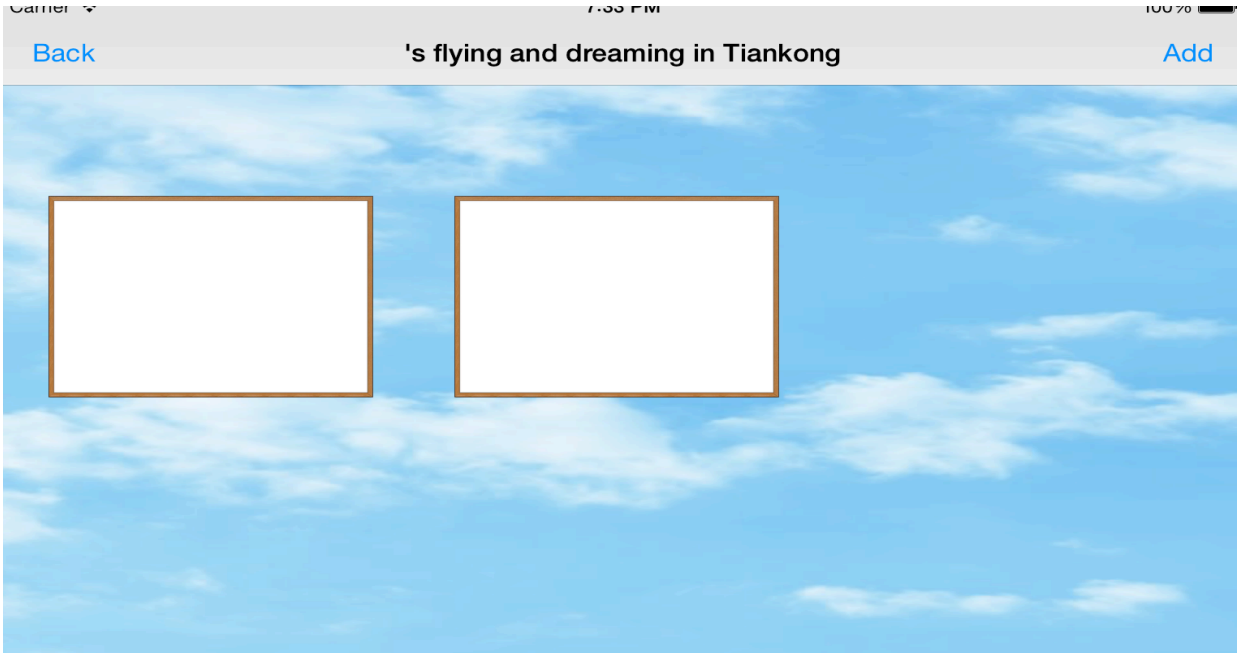


Diagram 20

In this case, only 12 whiteboards could be added on this main page.

6.3 Icons drawn and collection:

For better interest for primary school students, I drew some animation characteristics:

Diagram 21

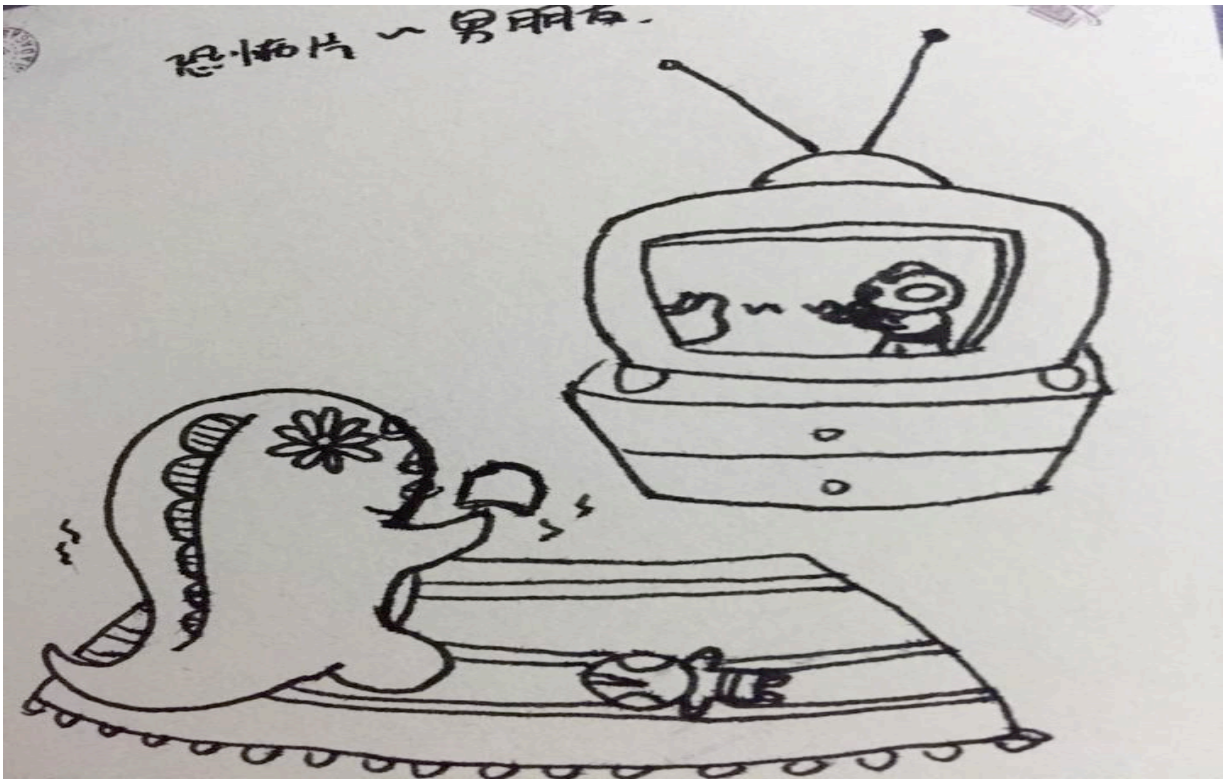


Diagram 22

Diagram 23

Diagram 24

Diagram 25

Diagram 26

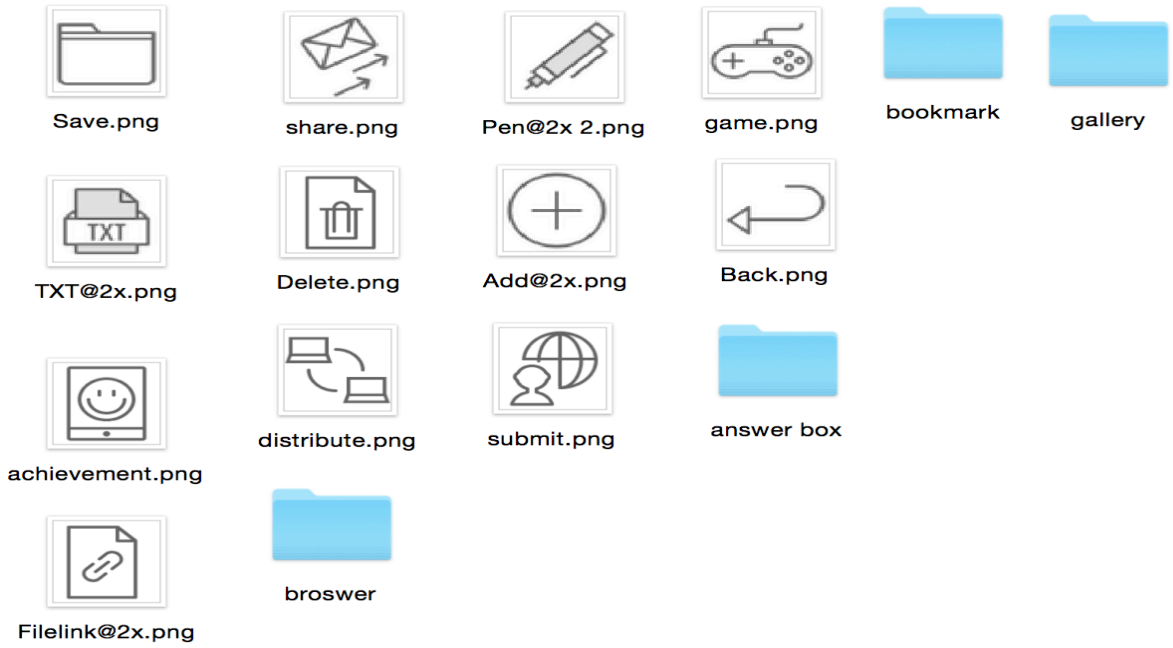


Diagram 27

The previous icons are standard icons of various formats I bought on the internet.

6.4 Testing

After iterative testing, we have several bugs below:

1. Account's name: iterative names

Diagram 28

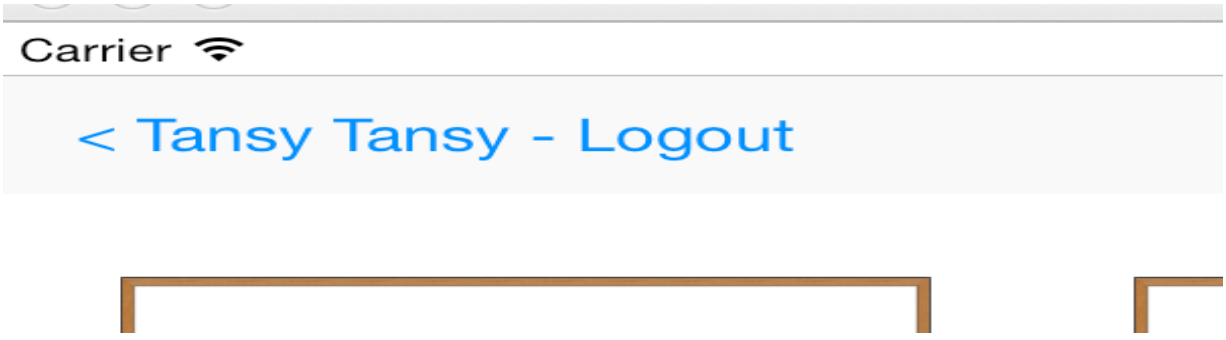


Diagram 29

2. When I log in as Leo:

After clicking the “add” button:

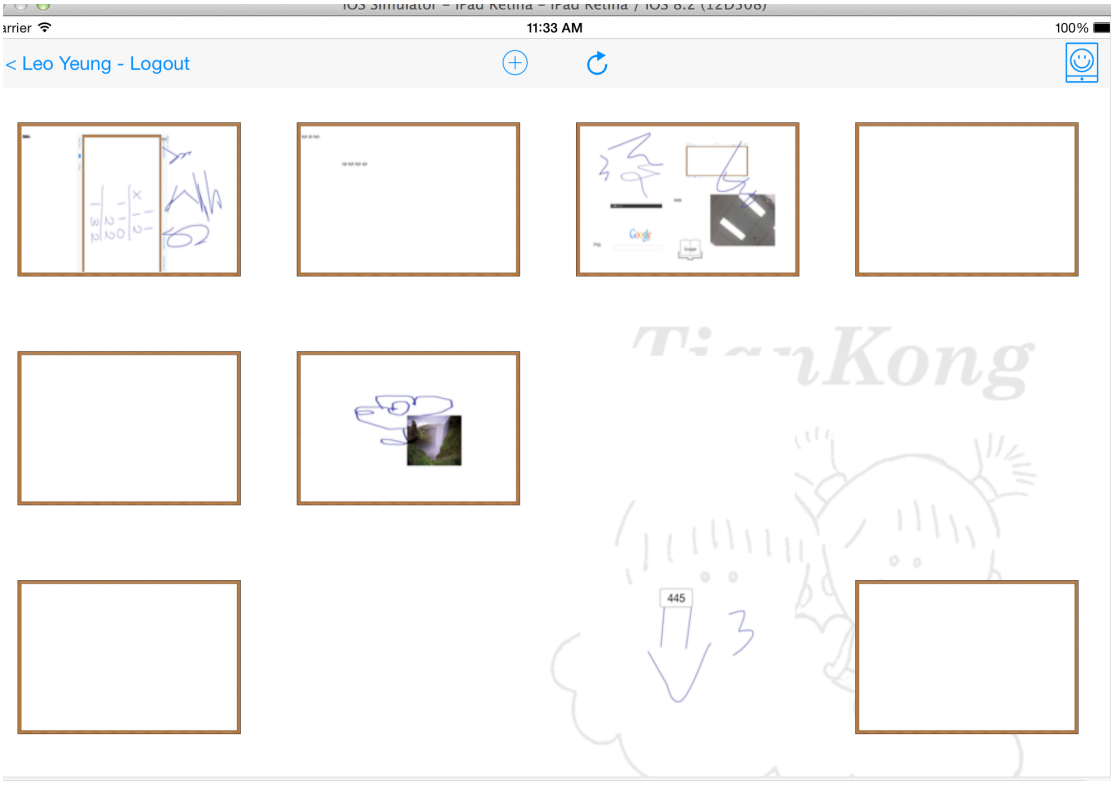


Diagram 30

3. Whenever I enter into a new page, this alert window comes out:

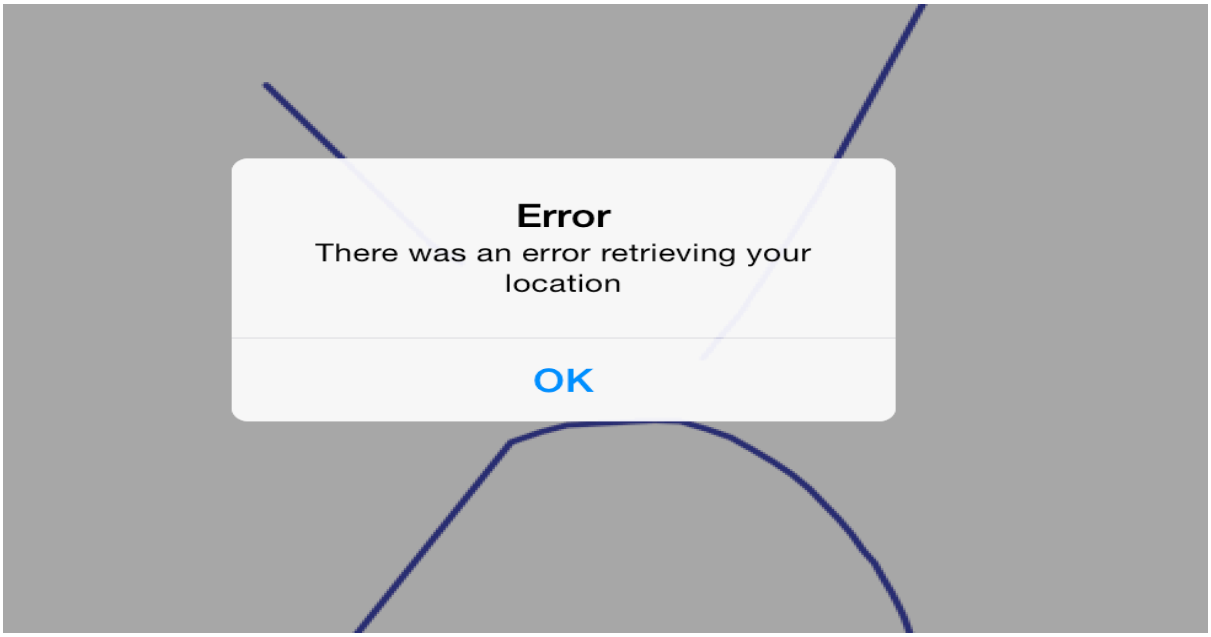


Diagram 31

7. Discussion

From previous analysis, we could say that for inputting methods:

1) You can draw and express whatever you want with enough space and pages, teachers and students could imitate, invent any symbols or use any ways to express their questions, answers, ideas and etc. They can use their imagination like flying freely in the sky.

2) Gulf evaluation and execution time are shorter: There is only one action to do: drawing. So obviously, it is much simpler and more convenient for primary school students to use.

3) Besides, we also would like to design some ready-made shapes like circle, cube, coordinate axis, and some elementary symbols for teachers and students to use and also for better user interface.

For interaction patterns:

As the interaction is the main issue we need to solve for teachers and students, certain design patterns are need to be designed.

Our design is based on the whiteboard due to the drawing function in the first part about input method. The interaction pattern consists of teacher to class, teacher to single student, student to student, students to class. Basically, we need a server to store data, to change information, and to do the communication actions. The concept is like that: teachers distribute questions or tasks on whiteboard using drawing method, in the meanwhile, enrolled students will receive the questions and answer them on whiteboards, submit it to server. After that, teacher will receive the answer and could see the process, he/she then gives grades, comments and feedbacks to students. As we can see, both actions could be done in and after class.

For “Gamification”:

It is quite a new concept I learned in the “User Interface Design” class, but I do believe that it is an excellent element and solution to our problem and app. There are some reasons for it: 1.

Children love game; 2. It makes class more interesting; 3. It better enhances efficiency in learning; 4. It makes teachers much more relax when teaching a class. 5. It is practical, better combines the theory with real life.

However, game may also distract students from class and learning language. When teachers are using it, he/she must pay more attention to students and way of doing it. And that makes the design of game in the app a very crucial part.

Some good "gamification" examples and ideas are: 1. We can use poker cards to represent numbers; 2. We use prize system and interesting icons for students to collect. And more fascinating ideas are to be designed.

For whiteboard, they are drawings that "show" the learner an idea or concept through a series of live drawings. Being short and crisp, they align very well to the needs of the modern corporate learner and are fast gaining popularity as an impactful too for learning delivery in technology-aided learning.

With advancement in technology, e-learning developers are on a constant mission to make e-content suitable for the tech-savvy learners of today. Especially in the corporate world, learners can access e-courses through a variety of devices – laptops, mobiles, tablets or smartphones. They also have easy and constant Internet connectivity – which opens the avenue to deliver media-rich content that has a strong impact on the learner. There is a lot that can be done in terms of a suitable media strategy for your e-course. A popular and affordable option is that of Whiteboard. It is a known fact that videos are a powerful tool in training as they can grab the learners' attention instantly. Whiteboards are images that 'show' the learner an idea or concept through a series of live drawings. There is often a 'hand' that draws inside a screen that is the 'whiteboard'. The familiar image of the teacher's hand writing or drawing on the whiteboard finds instant connect with learners of all ages.

8. Conclusions

To enhance math learning, we use “drawing” method, whiteboard interaction pattern, and “Gamification in our app. All design ideas we do is for better user interface, user interaction, and achieve better efficiency in learning. In a word, we help teachers to teach, we help students to learn. And most importantly, after having interviews with teachers from primary school in Hong Kong, we got positive user feedbacks and will revise our applications in future.

9. Appendices

Software we use: xcode, xampp, filezilla, phpadmin

Xcode project structure:

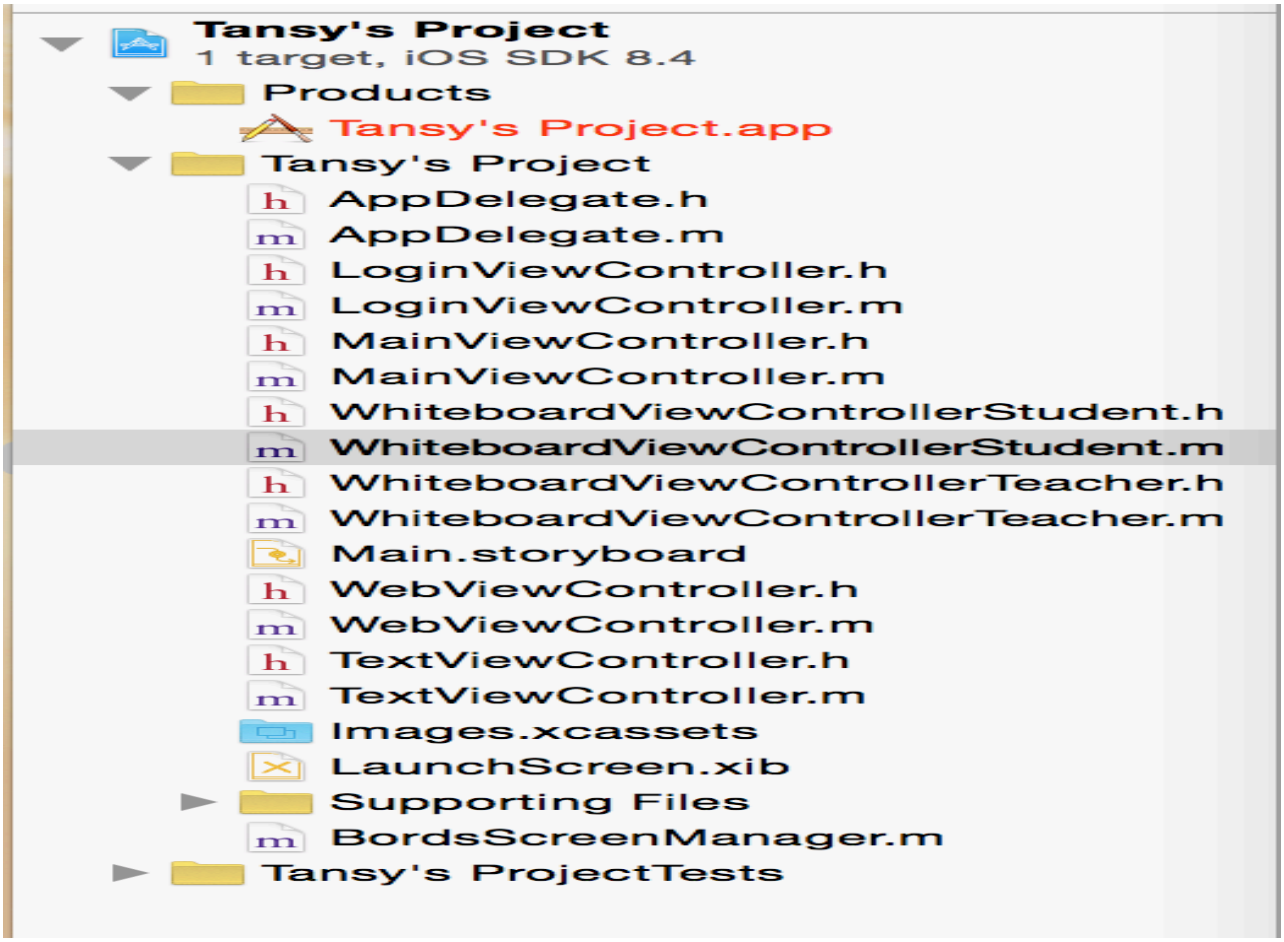


Diagram 32

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