Chapter 3 System Design and Implementation

A tablet-based and web-based application was employed in this study for the experiment. A client which is students used the tablet-based app, and the web-based application was used by the teacher and administrator to manage and monitor students activity. The name of the tablet-based app was Authentic Ubiquitous Fraction (Authentic U-Fraction). Meanwhile, the web-based app was U-Fraction Management Dashboard. The tablet-based app was deployed on Asus Zenpad 3S 10 using Android 7.0 operating system, and the web-based app was deployed on 64-bit Linux machine. These chapters detail description of all features in tablet-based and web-based app of Authentic U-Fraction.

3.1 System Design

3.1.1 System Architecture

In this study, we designed a system architecture that applies all popular web and mobile technology for client and server side. We also divided the system architecture into two sides: server side and client side. In the server side, we designed the API server, dashboard management server, system storage, and user storage. The API server we designed will handle all data transaction between dashboard management server, system storage, and user storage and the client side. The dashboard management server will handle the web-based system app that able to manage the Authentic U-Fraction. Finally, the system storage and user storage will store information used by the user and by the system itself.

Between the API server and dashboard management server, we utilized the same technology. We utilized the 64bit Linux machine for both server and utilize Apache 2.4 and PHP 7.3 for the web server. To make the development process easier and easier to maintain, We utilize the CodeIgniter 3.1 framework to both servers. The reason why we use the x64 Linux machine is that it is efficient, powerful, and also open source. Linux machines are preferred because their reputation is very good for security, consistency, and flexibility. Linux machines are also the best choice for servers because they do not need a graphical user interface; all commands can be executed through the terminal that helps users to achieve maximum system performance. The Apache 2.4 was chosen for powering booth the Authentic U-Fraction server because Apache is better at hosting the static files, providing load balancing or the failover, security or filtering, rewriting, .and so on, than Ruby or Java. Moreover, nowadays, it is quite common to use Apache as a web server.

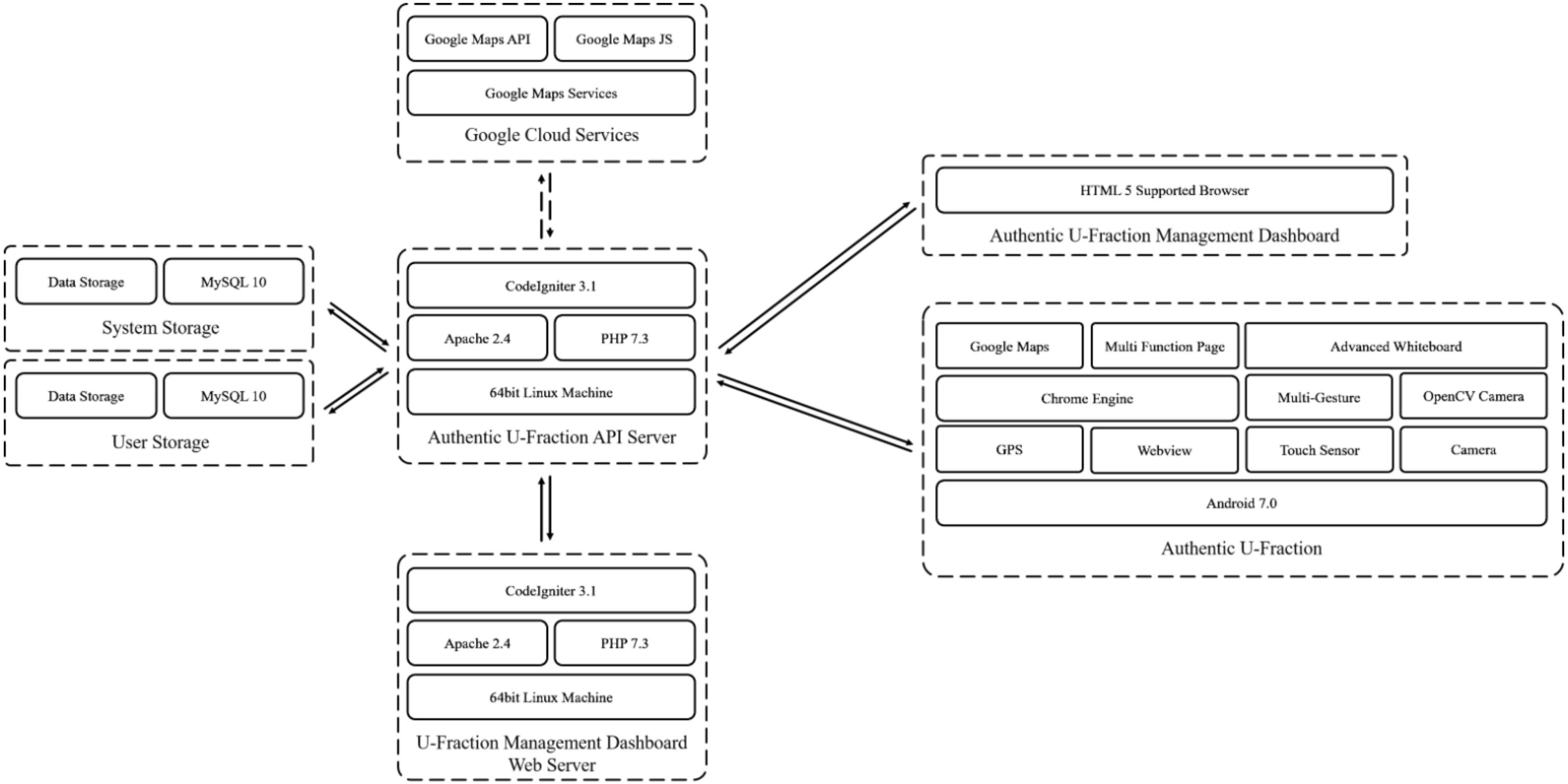


Figure 1. General System Architecture of Authentic U-Fraction

PHP 7.3 was chosen for the web programming language for booth server because it is new and has many improvements. The PHP 7 family has better performance than its previous version, PHP 5.6. With the PHP 7 family, we can have 50% better memory consumption. Moreover, PHP 7 family support 64bit for the server operating system, so it has better performance than PHP 5 family.

We also designed the storage system to store the physic data and the metadata from both the server and the client. We used the physical drive to store the physic data and MySQL 10 to store the metadata. We utilized MySQL 10 to store the metadata because it has a good reputation in its scalability and flexibility. Moreover, MySQL has high performance because it supports the speed load utilities, distinctive memory caches, full-text indexes, and another performance-enhancing mechanism. Another reason MySQL 10 was chosen to store the metadata is that it has strong data protection. MySQL provides powerful mechanisms for ensuring only authorized users to have entry to the database server.

From Figure 1, We can see that there is another component in the server side. We utilized a Google Cloud Services to the Authentic U-Fraction API server. From Google Cloud Services, we utilize three tools: Google Maps Services (GMS), Google Maps API, and Google Maps JS. GMS required to every Google Maps based app, so we applied this service. Not only GMS, but we also apply the Google Maps API and use the authentication key to be applied to the Google Maps JS. Finally, the Google Maps JS was utilized to the Authentic U-Fraction Server to support a Map function that will be used for both clients.

Move to the client side; we have two kinds of client. One client is an Authentic U-Fraction management dashboard, and the other one is an Authentic U-Fraction for the students. Both clients have a different function. Authentic U-Fraction has the function to manage the student's client. So, in the management client, we only apply the HTML 5 supported browser to open the management dashboard app from the Authentic management dashboard server.

Different from Authentic U-Fraction management dashboard, in the Authentic U-Fraction for students, we applied many technologies. Because it was mobile technology, so we want to make sure the sure have the authentic experience during learning activity using the Authentic U-Fraction. The basis technology we used is Android 7.0 (Nougat). The reason We used Android 7.0 because, at the time, we started to develop the system (Februari 2018), Android 7.0 is officially the most-used version of Android based on data from Google Developer Portal. Moreover, Android 7.0 is easier to use and has security improvement than the previous version.

In the second layer, we put four main technology: GPS, Webview, Touch sensor, and Camera. The first technology we applied to the students' client is GPS. We use GPS because we need to locate students while they use the app. Based on the student's location, we can apply the location-based fraction problem and location-based peer sharing. Moreover, using the latitude and longitude data that we get from the student's location, we wanted to make a location-based students record. A webview technology also applied to this app because we want to display some web-based information from the API in the Android device natively. Because we have much web-based information that must be displayed natively, so we applied the webview technology combined with other technology.

The next technology we applied in the second layers is the touch sensor. We applied this technology to this app because we wanted to develop an advanced whiteboard that can be used for the students while they try to solve a fraction problem authentically. The more detail explanation will be explained in another section in this chapter. The last technology we applied in the second layer is the camera sensor. We wanted to extend the functionality of the camera sensor from the device to bring more experience to the students while they are using the camera to solve a fraction problem using the system authentically.

In the third level of the students' client system architecture, we applied some API technology. We applied Chrome Engine API, Multi-Gesture API, and OpenCV API. The Chrome Engine API we used together with webview technology will handle the control in web-based information natively. So that the user can interact with the web-based information natively as if it is a native part of the app.

The combination between the touch sensor and multi-gesture API will be used for an advanced whiteboard for the students. Meanwhile, the combination between the camera sensor and OpenCV API will be used in the Advanced Image Capture function in the app. Applying all of these API would make this app more advanced than the previous version.

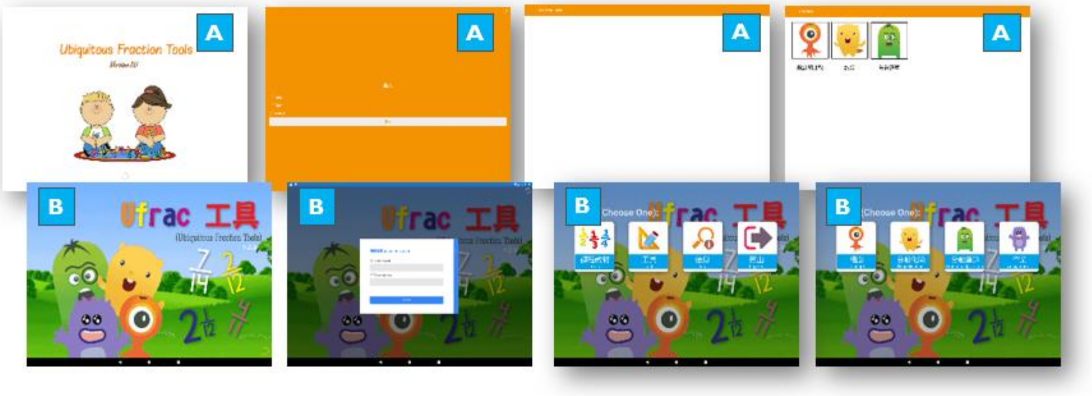
The last layer of technology we applied to the students' client are Google Maps, Multi-Function Page, and Advanced Whiteboard. We applied a new technology into the app are intended for making the app better. Each technology we applied in the last layer has a multi-purpose function. The Google Maps technology used in the location-based problem, location-based students record, and location-based peer sharing features. The Multi-Function Page used in many features that need to display information in web-based natively. Finally, the Advanced Whiteboard used in the assignment features. So, the application of new technology and API to the Authentic U-Fraction make the app better than the previous version.

3.1.2 System Improvements and Features

In these parts, the system features and improvements explained. We add improvements to the system and some new features to make the system better. All system's improvements and the new features do not change the main function of this app; To enhance fraction learning in an authentic context.

3.1.2.1 System Improvements

We made major improvements to the system, especially in its user interface and its user experience.



Note: A: The previous system
B: The improved system

Figure 2. The Difference between the previous system and the improved system from the UI/UX side

Figure 2 shows the difference between the previous version of this system and the new system. Many improvements applied to the new system to make the system better. Started from the splash screen, login screen, home screen, menu, .and so on, we make the system is easier to use and understand by the user (in this case: fifth-grade of elementary school). Moreover, we applied some guidelines from the Google Developers in designing app for the kids without changing its basic features.

3.1.2.2 New System Features

As mentioned before, we applied some new features to the system. The new features we applied to the system has a main goal for the students; they can get more experience in learning fraction using The Authentic U-Fraction in an authentic context. First features we applied to the system is an OpenCV camera. The OpenCV camera has a function to make it easier for the students in recognize rectangle and circle shape from the authentic object. We used the rectangle and circle shape from the authentic object to create a fraction representation in a bar or pie forms.

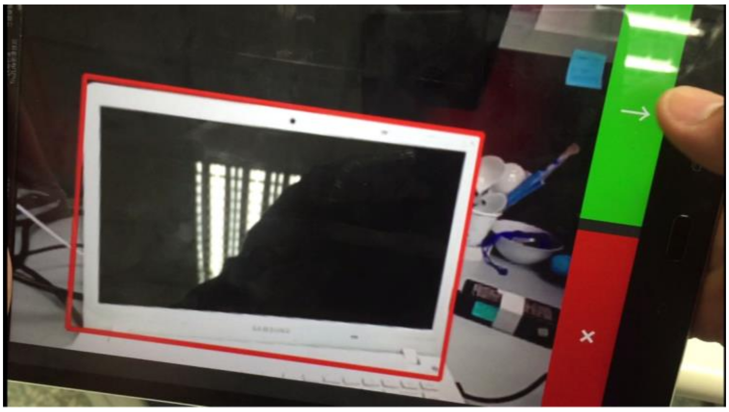


Figure 3. The OpenCV camera feature in Authentic U-Fraction

To complete the student's experience when using openCV camera feature, we also applied a multi-gesture feature to the captured image. After students capture an image using OpenCV camera, then they can drag and drop and also zoom in and the zoom out the captured image by pinching them using the finger in the advanced whiteboard.

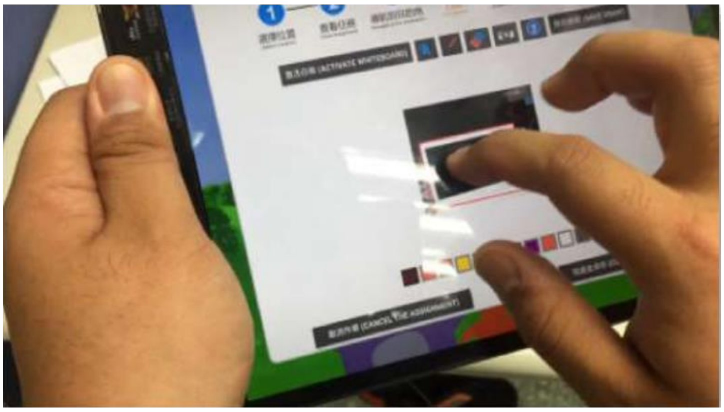


Figure 4. The multi-gesture function

OpenCV camera and the multi-gesture features become the advanced feature in the multimedia whiteboard we provide for the students. Because the multimedia whiteboard now has some advanced function, so the multimedia whiteboard becomes the advanced whiteboard. Not only OpenCV camera and multi-gesture features, but we also applied multiple captured image and problem viewer to the advanced whiteboard. The multiple captured image features give chances to the students to capture the image up to six images and put it in the advanced whiteboard. In the previous version of advanced whiteboard; multimedia whiteboard; the students can only capture the image one time. So, the students can not create more than a kind of fraction representation because they can only capture one image in one time. However, after we applied the multiple captured image features, now the students can put more than a kind of fraction representation into the whiteboard.

The problem viewer also becomes the advanced functionality in the advanced whiteboard. In the previous version, the multimedia whiteboard, the students can not review the fraction problem that they need to solve directly in the whiteboard. They have to back to the previous step to review the fraction problem, and it is wasting time. So, after we applied this feature, now the students can review the fraction problem that they need to solve directly in the whiteboard.

Besides we applied new features for the advanced whiteboard, we also applied the GPS and the Google Maps technology to the system. The application of the GPS and the Google Maps features was essential to the Authentic U-Fraction system. We applied the GPS technology to locating the student's position while they use the system. So, they could locate themselves and find out the nearest location fraction problem from their position using Google Maps. This function called location-based fraction problem. A location-based fraction problem assigned by the teacher at the specific location and the students can choose it based on the distance between their location to the fraction problem location.

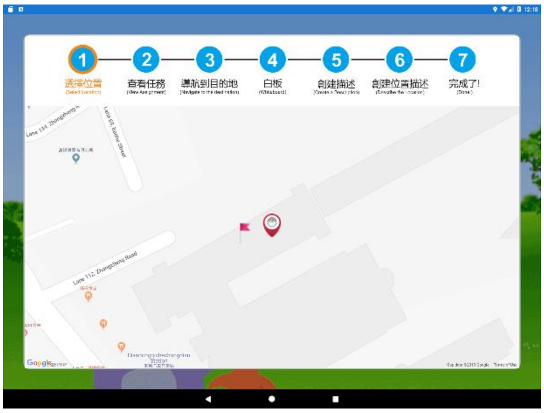


Figure 5. An example of students location and a location-based fraction problem. The pink marker with the user icon indicated the student's location and the pink flag indicates the location-based fraction problem

The location of the student's information provided by latitude and longitude data will be stored together with their learning record. The recorded location and the learning record will be used in location-based peer sharing. In the location-based peer sharing, the students can confirm other students record by coming close to the exact fraction learning record location. This function also uses the GPS function to locate the student's position before the system shows the closest other students learning records using Google Maps. After the system shows the other students learning records in Google Maps, the students can choose records and coming close to the record to make a confirmation and do a peer assessment.

Figure 6. The location-based peer sharing. The students can look into the other student's fraction learning record by choosing a record indicated by a pink flag. Moreover, the students can also do peer assessment using this feature

Figure 7. The Students peer-assessment using the three scaffoldings and the old five-scales rating mechanism

Figure 7 is the example of the student's peer assessment using the three scaffoldings and the five-scales rating mechanism. In the location-based peer sharing, the students can do the peer assessment using these features. The three scaffolding we applied has a goal to guide the students to create meaningful assessments. However, we still applied the old five-scales rating mechanism in the peer-assessment. At the end of the experiment, we are going to compare the assessment results between the three scaffoldings and the five-scales rating.

The other features we applied to the Authentic U-Fraction is the learning guidance. The learning guidance we applied has a goal to guide the students when they try to solve a fraction problem in an assignment. There seven steps in the learning guidance that must be followed by the students. The first is choosing the location-based fraction problem. In this step, the students must choose the nearest location of the location-based fraction problem based on their position in Google Maps. After they choose a location-based fraction problem, the system will bring the students to the second step, understanding problem. In this step, the students must understand the fraction problem first before they can try to solve it. If they can not understand, they can return to the previous step and choose another location of the location-based fraction problem. However, if the students can understand the fraction problem and try to solve it, then the system will bring the students to the third steps, navigating to the location. In this step, a google map was provided to guide the students reach to a chosen location-based fraction problem. After they reach the location-based fraction problem, then the system will bring the students to the next step, problem-solving by exploration. In this step, an advanced whiteboard provided to help the students solve the problem. The students need to explore their surrounding to solve the problem. They need to find the object that has a rectangle or circular shape and capture it using the OpenCV Camera. They need to find that object because of a fraction representation in a bar or pie form needed to complete their record. Moreover, they need to write some explanation in text and also a mathematical symbol to explain more about the fraction representation they made. After they finish to solve the problem, the system will bring the students to the fifth step. In this step, the students must describe their record using text. A virtual keyboard provided to help the students write their explanation. The next step was to describe the location. In this step, the students must describe the location around them clearly in the text. A virtual keyboard also provided in this step to help the students write their location description. Finally, the last step is confirmation. In this step, the students must sure their record is correct because after they confirm the app to upload their record to the server, they can not change it anymore.

Figure 8. The Learning Guidance feature in the students' assignment

The last feature we applied to the system is the student portfolio. The last feature we applied has many sub-feature; Learning Record by Location, All Students Learning Record by

Location, Students Record Gallery, and Ranking. In the Learning Record by Location, it has the main function to show all learning records of students. Moreover, the students can review their record and also view the comments and also the rate.

Figure 9. The Learning Record by Location. The Students learning record indicated with a green marker, and the location students indicated with the pink marker

Another feature in the student's portfolio was All Students Learning Record by Location. In another word, it is called Location-based peer sharing. Because in this feature, the students can look into another students record, make a confirmation, and do a peer assessment. This feature already explained in the previous part.

We also applied a Students Record Gallery feature. Different from Learning Record by Location, this feature only lists all records of students, and the students can review their record.

Figure 10. The Students Record Gallery

The most popular feature we applied in this system is the ranking feature. In this feature, we display the students ranking based on the three criteria: Record quantity, Record Quality by the three scaffoldings, and Overall score. In the record quantity, we rank the students based on the assignment quantity they can solve. In the Record quality by the three scaffolding, we rank the students based on the peer assessment using the three scaffolding. Finally, in the overall score, we rank the students based on the three scaffolding, five-scales rating, and also the weight of the assignment (we provide the three weight categories in the assignment: easy, medium, and difficult).

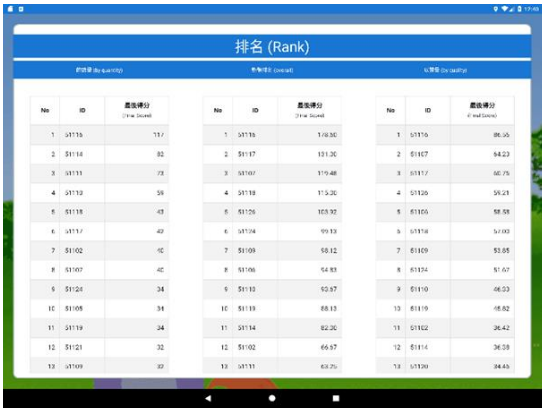


Figure 11. The Ranking features

3.2 Implementation

In this study, the students used Authentic U-Fraction for learning fraction such as fraction concept, fraction simplification, fraction addition, and fraction subtraction. The purpose of the study was to know the effect of the student's assignment quality by using the system to their fraction understanding, fraction representation, and problem-solving achievement. The study lasted for four weeks with various activities for the students such as learning fraction, solving the fraction problem by exploration using the location-based fraction problem feature in the system, and do the peer assessment using the location-based peer sharing.