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Developing a Learning Monitoring System Dashboard for Augmented Reality in Ubiquitous Geometry (Authentic-UG)

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***Abstract*— The Authentic-UG mobile app requires a monitoring system to process the data produced on AR technology so that it can be displayed with interactive data as a method of assessing student learning behavior. The purpose of this study to develop a Learning Monitoring System Dashboard (LMSD), that can record and analyze student learning behavior during using the Authentic-UG app. This is a research and development (R&D) with the method of agile Extreme Programming (XP). We use white-box testing with nit testing and black box testing with the Unit Acceptance Test (UAT) to measure the system development. The result of this study, we created LMSD with a three-part of main architecture: data source, web service and consumer who can manage, monitor, and analyze the AR technology with the results of testing using unit testing passed 36 scenarios of 36 (100%) and UAT passed 40 scenarios of 40 (100%) which means all functions on LMSD can work successfully. Finally, for the future of the LMSD also can be applied to another AR mobile app.**

Keywords*: *Learning Monitoring System Dashboard (LMSD), Authentic-UG mobile app, AR technology, Augmented Reality

I. INTRODUCTION

The development of educational technology in the past decade has given attention to the implementation of Augmented Reality (AR) technology [1]. This is because AR technology can combine the real world with the digital world including real interaction on virtual 3D objects. Accordingly, learners do not only practice with virtual tools but also can observe the real environment. Therefore, the use of AR is one of the good choices to support authentic learning activities [2]. Thus, we develop an AR mobile application, namely Authentic-UG, which is a mobile android application implementing AR technology to support geometry learning experience more real and authentic. Authentic-UG is a new version of mobile application development from Ubiquitous Geometry which developed through research by Hwang [3]. Authentic-UG can facilitate learners to learn geometry measurement in the geometry topics, such as learning line segment, angles, combinations of angles, triangles and quadrilateral with real size and to solve geometry problem [4]. For example, the learners can learn with real geometry authentic problems by making a rectangle (quadrilateral) with specific criteria: two meters of long; one meter of wide; and 90-degree angles, and can match the rectangle with the objects in their surroundings that show on Figure 1.

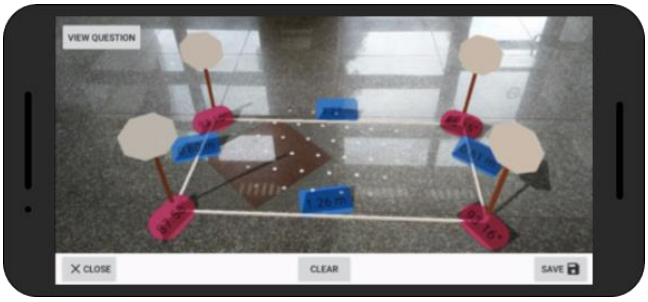


Figure 1. Authentic-UG mobile application

Authentic-UG simultaneously records authentic activities and problem-solving processes that are randomly given by the system following the surrounding environment. We conducted a Research & Development (R&D) research to build a web-based Learning Monitoring System Dashboard (LMSD). Through LMSD, we could manage, monitor, and analyze learners learning behavior in the Authentic-UG mobile application that could be visualized into one view so that it could be used by teachers in the process of geometry learning and process of learning assessment.

I. Technology Architecture

The development of technology architecture uses a web service system that divided into various microservices to be able to process data quickly and minimize bandwidth usage [5], so that learner can learn geometry use Authentic-UG anywhere. The following is the architectural technology design used in the Learning Monitoring System Dashboard (LMSD) which can see in Figure 2.

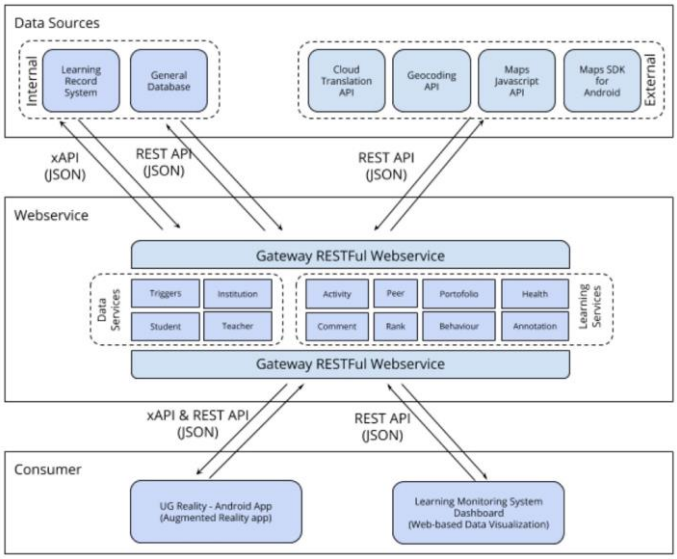


Figure 2. Technology architecture design

There are three main sections on LMSD, the first is the data source section as a data storage, the web service section as a data processing system, and the consumer section. Each section can communicate together with others using the xAPI or REST API protocols with JSON format which processed by the web service gateway according to the type of service to be used.

In the data source section there are two sources: 1) internal source there are Learning Record System (LRS) as a place to store learning behavior of learners who use xAPI and general databases as storage places for various multimedia such as annotation text, portfolio images, video record of learning and various custom data that does not use the xAPI standard and 2) external sources that use data sources from Google Cloud Platform (GCP) with the services used include: Cloud Translate API to translate text annotations from Chinese Taiwan (zh-TW) into English (en), Geocoding API to translate latitude & longitude data from GPS into the location address context, Maps JavaScript API to show marker & heatmap points into the map, and SDK Maps for Android to show map to be used for consumers.

Furthermore, the web service section is an important part as a system for processing the main data on the system to processing of learning behavior data including various services. The processing data can be interpreted as activities to create data, manipulate data, delete data, retrieve data and show the result of the analysis. In the data services to process various teacher data, student data, institutional data and trigger questions, while in the learning services to show various of activities divided into microservices, such as 1) activity service to record logs of all forms of consumer activities when using application, 2) peer service to process matching of learner with another learner in order to learn together, 3) portfolio service to process authentic learning activities, 4) health services to process health data from step movements of learner while authentic learning by calculating data from pedometer sensors, 5) comment service to process various comments between peers and between another learners, 6) rank service to process ranking on leaderboard to motivate all learners, 7) behavior service to process various activities, and 8) annotation service to process various annotations on portfolio of authentic learning activity.

In the last section, there is consumer section including two systems, the name Authentic-UG, which is an android application for geometry learning using Augmented Reality technology and Learning Monitoring System Dashboard (LMSD), which is a web-based application for displaying learning outcomes from Authentic-UG.

II. METHOD

The development uses the Agile Extreme Programming (XP) method because related the need and more efficient of the manufacturing process, is flexible and responsive according to user needs, simple development, using feedback and always try to experiment with new codes [6].

The stages of using extreme programming for LMSD are described as follows, the first stage is planning to communicate about the variety of experiences from the teacher's story related to the learning assessment. Communication is a basic description of the need for LMSD development. The second stage is the design of LMSD is not like in LRS which can only store activities of student learning activities, in LMSD can be used to record learning activities that use AR technology, because each data generated from the AR application use coordinate data (activity), solving quizzes diverse authentic problems (triggers) and special geospatial data (behavior) that can only be done using LMSD. The third stage is coding the entire system development with open-source software and the final stage is the testing process is not focused on testing the quality of the software as a whole, but rather on the quality of the functionality and look for programming errors to be more efficient. The functionality testing on web development can use white box method with unit testing to test functionality on programming code [7] and black box testing with Unit Acceptance Test (UAT) to testing functionality item on web LMSD using scenario [8]. The scenario builds based on the number of functions on the logic program.

III. RESULTS AND DISCUSSION

The needs of the LMSD functionalities are about learning behavior and learning assessment that uses web-based technology because the system must be able to display various detailed aspects of learning assessment, such as 1) all various of student learning behavior activities in applications, 2) management of students, teachers, and institutions so that the application can be used for learning in another institution, 3) management of authentic learning solving quizzes with various problem conditions and solving authentic learning based on map location, 4) show annotation statistics, 5) page statistics, 6) learning statistics on the learning material, 7) progress statistics of student learning, 8) portfolio of work and student assessment and 9) visualizing comments between peers.

The design phase for learning activity there is authentic quiz, for example in topic to make an angle with question about making an angle of 30 degrees with the length of line

more than 2 meters; or making an angle of 60 degrees with the length of line less than 2 meters; or making an angle of 90 degrees with the length of line is up to learner; or make an angle of 45 degrees with the length of line with 2 meters. The question seems to be the same but in authentic learning this is a different object because authentic activity must be the same as the original environment, then the function of LMSD can verify various authentic problem solving by designing algorithms that can recognize input questions from the input answers which are then compared according to logic criteria such as less than (<), more than (>) and with (=), and the results will run system of accuracy to produce feedback and will be displayed directly with LMSD so that the teacher can see the student learning process to solve the authentic problems. The design phase for technology or user interface refers to the design standards that already exist in the Semantic-UI framework.

The coding on the back-end side use Laravel PHP Framework which has been equipped with an internal testing system [9], the Web Service API system use Lumen PHP-Micro Framework, and on the front-end side use Semantic-UI and D3.js to visualize data interactively. In the coding process show on Figure 3, there are 76 main classes logic to build communication gates using the REST API and 36 logic in secondary classes that matches each function in the Web Service section and 40 logic in the various of classes on the front-end.

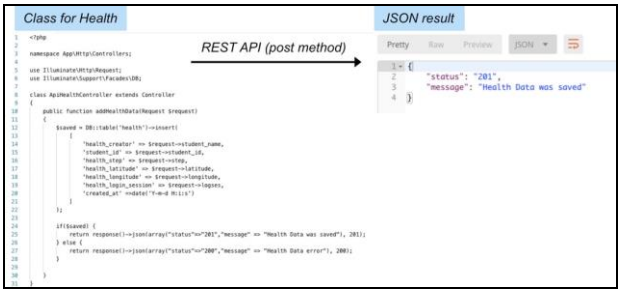


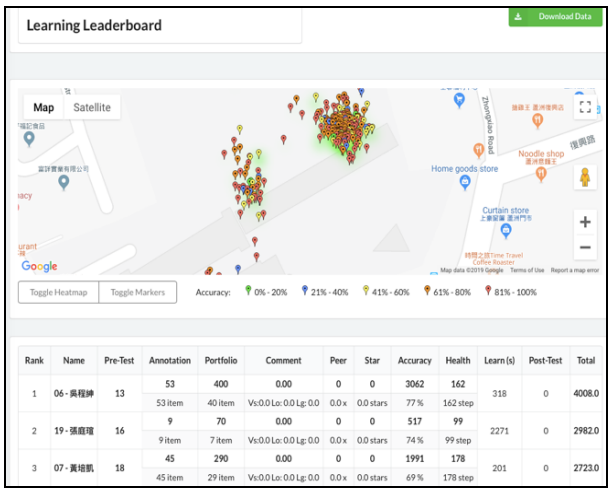
Figure 3. Coding process (left) and results after execution (right)

The Learning Monitoring System Dashboard (LMSD) testing include three parts according to the technology architecture that has been created. The data source section not through the testing process because on the external side it is guaranteed in terms of reliability by the Google Cloud Platform (GCP) and on the internal side using a cloud system that also has a Service Level Agreement (SLA) of 99%. We make testing in the web service and consumer described in Table 1.

Table 1. Webservice and consumer testing

	Method	Instrument	Tools	Scenario	Results
Webservice	White-box Testing	Unit Test	PHPUnit 7.5 & Xdebug 2.5	36 REST API	36/36 Pass OK
Consumer	Black-box Testing	User Acceptance Test (UAT)	Scenario	40 use-case of process	40/40 Pass OK

The results of design on LMSD can show the overall data about learning and then the data can be downloaded directly that can be imported to spreadsheet or SPSS analytic, which can be seen the feature in Figure 4 and the dashboard can display student learning statistics when learners reading learning material which is divided into five topics and ten subtopics which show in figure 5.



Rank	Name	Pre-Test	Annotation	Portfolio	Comment	Peer	Star	Accuracy	Health	Learn (s)	Post-Test	Total
1	06 - 吳程紳	13	53	400	0.00	0	0	3062	162	318	0	4008.0
			53 item	40 item	Vs:0.0 Lo: 0.0 Lg: 0.0	0.0 x	0.0 stars	77 %	162 step			
2	19 - 張庭瑋	16	9	70	0.00	0	0	517	99	2271	0	2982.0
			9 item	7 item	Vs:0.0 Lo: 0.0 Lg: 0.0	0.0 x	0.0 stars	74 %	99 step			
3	07 - 黃培凱	18	45	290	0.00	0	0	1991	178	201	0	2723.0
			45 item	29 item	Vs:0.0 Lo: 0.0 Lg: 0.0	0.0 x	0.0 stars	69 %	178 step			

Figure 4. The Learning Dashboard

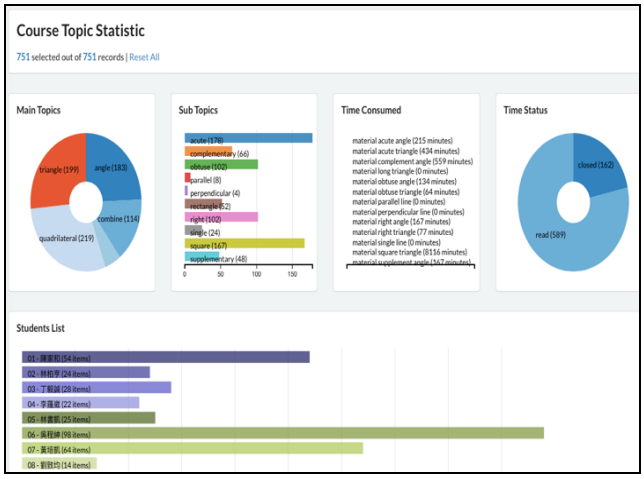


Figure 5. **Statistic of course each student**

The process of learning activities also can be displayed in Figure 6 about student portfolio results and the system can show the student learning process when learners try to create a portfolio. Seen in figure 7, the process of learners when making a final portfolio about solving authentic problems, with a trial twice before done to solve the problem.

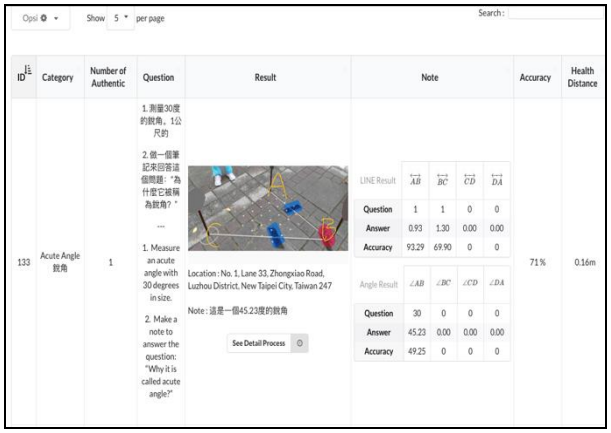


Figure 6. Learning Portfolio

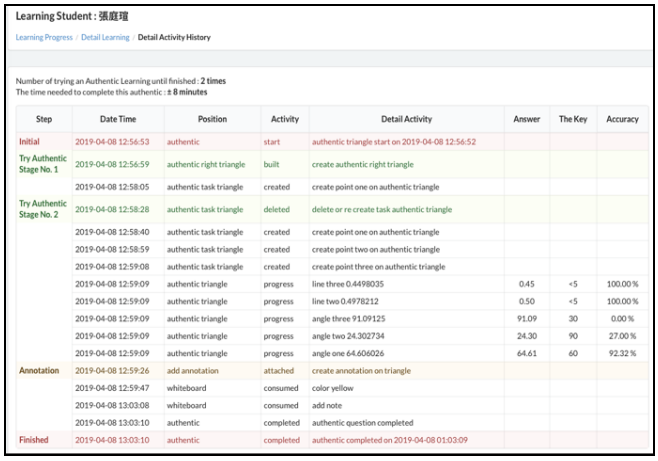


Figure 7. Learning Process

The dashboard system in Figure 8 showed the learners can make annotations on their portfolio and the system can display notes in the world cloud and automatically translate from Chinese to English. The dashboard system can also display a network behavior of comments between learners shown in Figure 9 with arrow directions to show the contribution of each learner with other learners in a wider environment to show learner behavior in a social context [10], and will be seen learners who are actively giving comments and given comments by other learners.

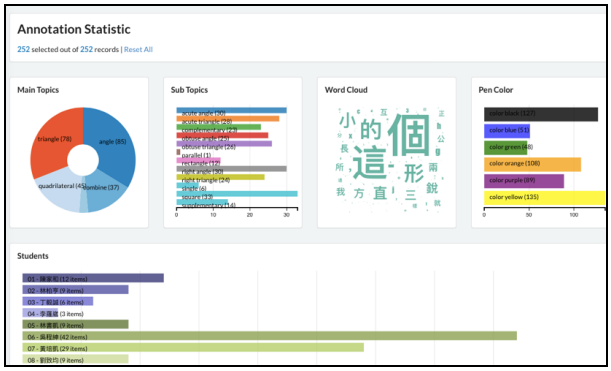


Figure 8. Annotation Creation

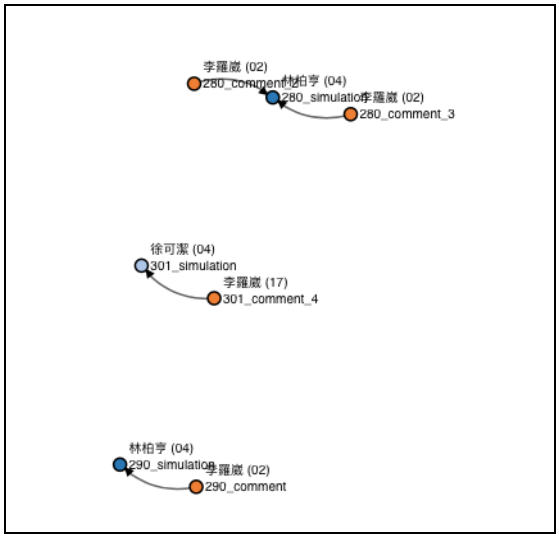


Figure 9. Social Network

IV. CONCLUSION

The development of Learning Monitoring System Dashboard (LMSD) is the contribution to education. The teacher can know the learning process of learners in geometry learning using authentic learning design. The LMSD in the current study is limited for Authentic-UG mobile application and that data in LMSD can be retrieved to be used by other systems using the REST API or xAPI protocols in the JSON format to communicate with LMSD web service.

Based on the results of testing use Unit Testing, it was able to pass 36 scenarios with 100% success rate, and use UAT it was able to pass 40 scenarios with 100% success rate, then all functions in the features of LMSD can run well based on scenario, Furthermore, we will develop LMSD with dynamic systems that can be used for other AR mobile applications, therefore for further research we will also standardize communication of data formats in LMSD so that the system in LMSD can be used by other AR applications that focus on education.

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