# Gamification for Learning Science :

## ELISA (Enzyme Linked Immuno Sorbent Assay) Game Study Case

Ariana Yunita [1], Andrew Moore [2], Julian Andres Galindo Losada [2]

[1] Dept of Computer Science, Universitas Pertamina, Jakarta, Indonesia

[2] School of Information Technology, James Cook University, Australia

ariana.yunita@universitaspertamina.ac.id, andrew.moore@my.jcu.edu.au , juldtb@gmail.com

*Abstract*—**This paper looks at how gamification can be used to learn ELISA (Enzyme Linked Absorbent Assay) concept works. In this paper, we designed and implemented a game that can be used by both students and lecturers in their learning activity. The importance of this research is to facilitate science students to conduct ELISA test on a simulation game, as a result they could understand the concept of ELISA without conducting the test in an actual laboratory. This game allows users to do the simulation by drag and drop the substances into a virtual tubes and then wash and rinse the substance by clicking the button. After doing test for ELISA game, the result shows that this game is usable for veterinary science students.**

*Keywords— ELISA, enzyme-linked immuno sorbent assay, gamification, simulation, applied computing*

## I. INTRODUCTION

Immunology is a science that studies the immune system of human and animal. It is a discipline that in its development rooted in the prevention and treatment of infectious diseases. While Serology is a science that studies the antibody antigen by invitro. Serologic examination is often performed as an attempt to make the diagnosis. Although the current serologic examination is not limited to infectious diseases, but to support the diagnosis of infectious diseases is often conducted and it allows in vitro observation of antigen-antibody complex changes (Ag-Ab).

ELISA (Enzyme-linked immunosorbent assay) is a serological test commonly used in immunological laboratories. This test has several advantages such as relatively simple, economical, and has a high enough sensitivity. ELISA was firstly introduced in 1971 by Peter Perlmann and Eva Engvall to a nalyze the presence of antigenic interactions with antibodies in a sample using an enzyme as a reporter [1]

To conduct an ELISA test, there are several equipments that should be prepared, such as ELISA reader, washer machine, pipe and microplate. Those equipments are in a various range of price and it will be costly to conduct a real test for huge number of students. Therefore, using a simulation game, students can learn the cost independently as well as it can decrease cost for laboratory practical.

The rest of this paper is organized as follows: section II perform the previous efforts in how to embed game in education, especially learning science in higher education. In section III, the game design is explained. Section IV reports the implementation of the game. The last section includes the conclusion, limitations and future works that should be done in this research.

## II. RELATED WORKS

Games are usually associated with play and play is often associated with children, but a digital game has been found that can be effective and motivational for learning and it effects for both gender : males and females [2]. Since it was found that games support learning in complex or boring contexts [2], researchers have developed and research for effective games for helping education in various fields, for example a game for dental learning in higher education [3], a game of mathematical logic to help computer science students learn about logic [4] and a game for civil engineering students [5]. Those games were developed for higher education and found to be effective in their learning environment.

Games attempt to be challenging and engaging. For more than ten years, the term "serious game" has been introduced and intended not for entertaining, but for educating, military, health and also training and development[6] . According to Richards [7], the first serious game was training simulations for the military and first responders. Some examples of military games are Virtual Battlefield Simulator (VBS1) by Interactive Bohemia and Joint Conflict and Tactical Simulation (JCATS) by the United States Joint Forces Command. Games and simulation are very similar, but games have some characteristics which are competitive and fantastical [8]. Moreover, recently several serious games are embedded with Intelligent Virtual Agents (IVAs) to improve engagement with users, for example Dr Evie, a therapeutic alliance that has been implemented to plan treatment for child patients in urinary incontinence [7] and as a synthetic character for reducing bullying at school [9].

ELISA game is claimed to be a simulation game because it is fantastical but not competitive.

## III. DESIGN

A simulation game called ELISA is designed using Flash Action Script 3.0 and it is embedded on a website built using Drupal CMS. The flowchart of the website shown in figure 1.
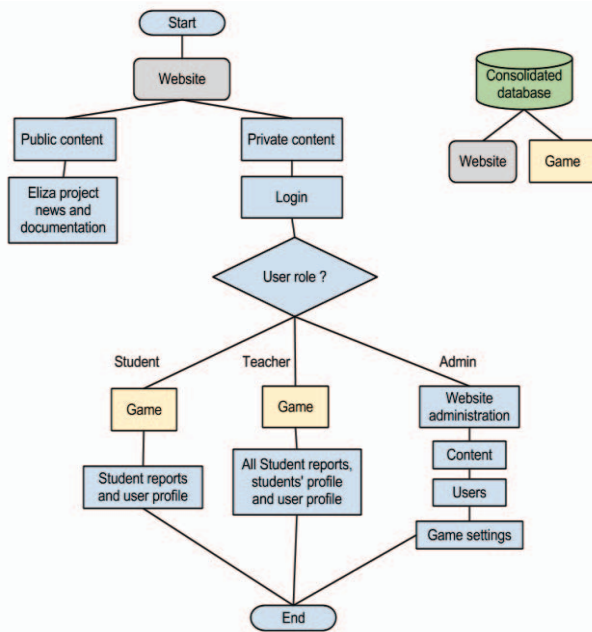
Figure 1. Flowchart of The Website

Before designing database, basic data requirements are given from Veterinary Science Department which is combinations of ELISA technique. It is shown in figure 2 below.

| Start | Capture Antibody (Plate is coated with this) | Testing for… in patient's serum (The Antigen will bind to the capture Antibody if it is present in the patient's serum) | Primary Antibody (Must be specific for the Antigen and different to capture Antibody) | Secondary Antibody Conjugate (Must be specific for the Primary Antibody. Has either an enzyme or fluorophore attached) | Detector | Positive Result (If the patient does have the Antigen present in their serum and all subsequent stages have bound correctly) |
|---|---|---|---|---|---|---|
| ELISA Plate | Mouse Anti-Ag (mouse) | Test Antigen (e.g. virus) (virus) | Sheep Anti-Ag (sheep) | Pig Anti-Sheep conj. Enzyme (pigsheep_e) | Enzyme's Substrate | Colour Change |
| | | | | Goat Anti-Sheep conj. Enzyme (goatsheep_e) | | |
| | | | | Rabbit Anti-Sheep conj. Enzyme (rabbitsheep_e) | | |
| | | | | Pig Anti-Sheep conj. Fluorophore (pigsheep_f) | Light | Fluoresce |
| | | | | Goat Anti-Sheep conj. Fluorophore (goatsheep_f) | | |
| | | | | Rabbit Anti-Sheep conj. Fluorophore (rabbitsheep_f) | | |
| | | | Sheep Anti- Ag conj. Enzyme (sheep_e) | | Enzyme's Substrate | Colour Change |
| | | | Sheep Anti- Ag conj. Fluorophore (sheep_f) | | Light | Fluoresce |

Figure 2. Examples of ELISA Combinations

Then, the database could be designed based on the documents of ELISA combinations. Combinations consist of antibody, antigen, detector, conjugate, capture antibody. They store in ElementType and will be checked in

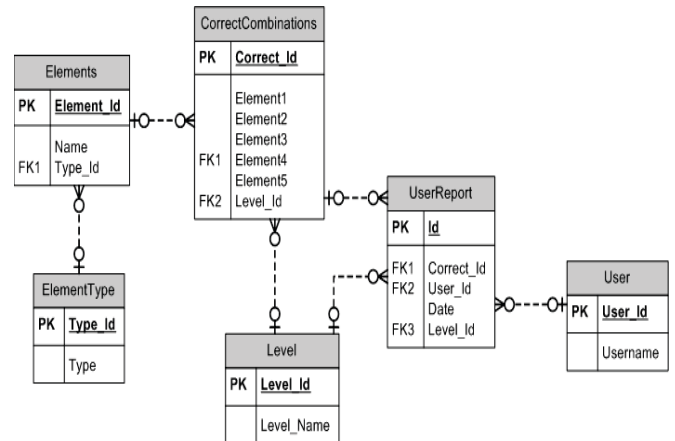CorrectCombinations entity. Figure 3 shows the database design of ELISA game.



Figure 3. Database Design of ELISA Game

After designing database, according to procedures of ELISA method and also correct combinations given, game flowchart was designed. Basically, every elements need to be incubated and washed. Then, every elements that put into the tube could not be the same as the previous ingredients. For example, first we would like to input Capture Antibody which is namely Pig-antiAg, then it should be incubated and washed, after that another element is chosen and it should be incubated and washed and it will be iterated until the correct combinations are made. Error prompt will be displayed once the users not following the ELISA rule. The game flowchart shown in figure 4.

## IV. IMPLEMENTATION AND TESTING

The main target users are third year JCU science students. The students are assumed to be familiar with biological concepts and have an understanding of how they are applied in ELISA. The other remaining target group is teachers, who will use the application to view student results produced from the ELISA game.

Characteristics of users :
- Age: approximately 20 years (science students), and above 30 years (teachers/lecturers)
- Gender: Female and Male
- Educational background: Veterinary Science
- Language: English (as the main language in James Cook University, Australia)
- Computing skills: know the basic of computing
- Physical abilities and disabilities: perhaps there are disabled persons or colour-blind persons who are amongst the target users.
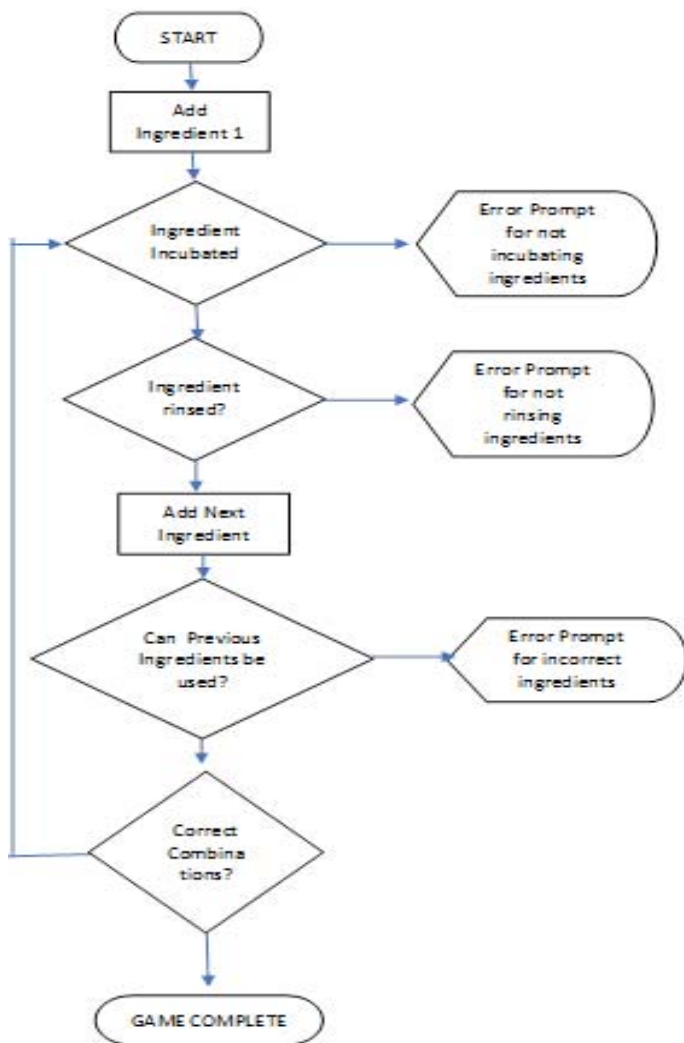- Domain-related knowledge and skills: biology

Figure 4. Game Flowchart



Figure 5. Main Menu of ELISA Game



Figure 6. Antigen Detection Menu

This game challenge users to design an ELISA to detect the two type of detections which are antigen detection and antibody detection. In antigen detection menu, users are challenged to design ELISA for hepatitis B, dengue virus, ross river virus, influenza, HIV and Herpes virus simplex 1. Furthermore, for antibody detection, users should design ELISA to detect an antibody against one of the following viruses. It includes chicken pox, measles, hepatitis A, rubella.

Followings are some screenshots of ELISA game. Figure 5 shows which kind of simulation will be chosen whether antibody detection or antigen detection. Then, figure 6 and 7 shows what kind of virus will be detected using the antigen detection menu or antibody detection menu respectively. Figure 8 is the main board of the game and the users can do drag and drop the substances into the tube. Elements are also categorized, so the users can easily choose them.
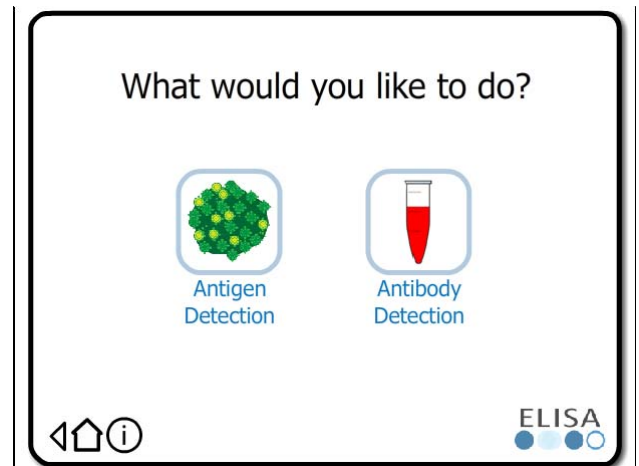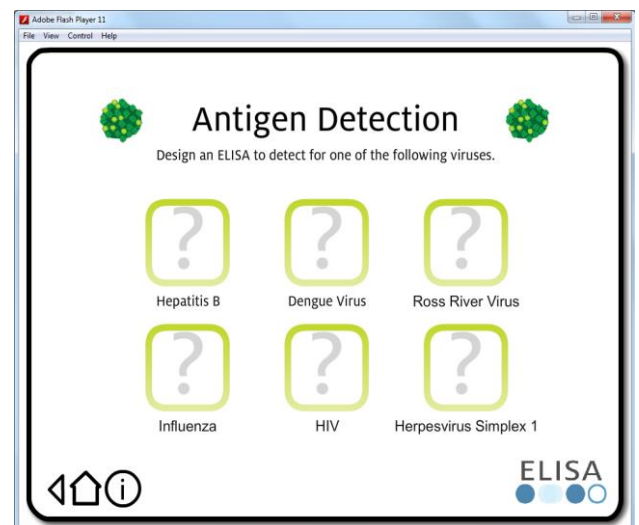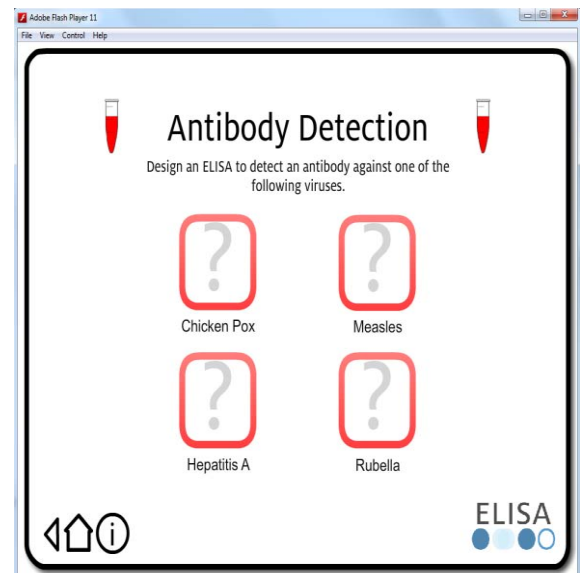


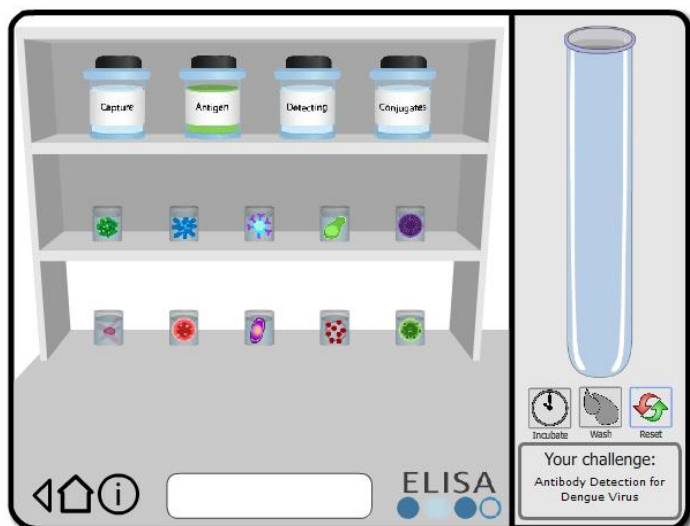Figure 7. Antibody Detection Menu

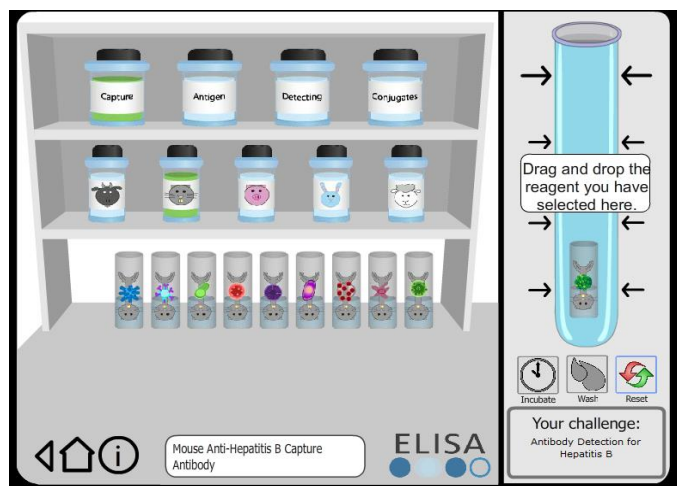Figure 8. Main Board of ELISA Game



Figure 9. Users Drag and Drop The Reagent



Figure 10. Users Made A Corest Combination of ELISA

After implemented the game, usability testing were conducted among 42 third year veterinary science students. Table 1 shows some questions that were asked into the testers.

Table 1. Questions of ELISA Game Testing

| No | Aspects | Questions |
|---|---|---|
| 1 | Efficiency | How many steps were required to solve the problem (in the game screen)? |
| 2 | Accuracy | How many incorrect combinations were submitted? What were they? |
| 3 | | How many incorrect elements were submitted? What other elements were submitted in conjunction to them? |
| 4 | Recall | How much do you remember after using the prototype? Were there any significant moments during your use of the application? |
| 5 | Response | How do you feel about the tasks completed? Are you confident or stressed? Would you recommend the application to anyone? |

In term of efficiency, the results are users were able to navigate the application and locate the game screen with ease.The minimum amount of steps taken to solve the problem was 8. The longest test took 5-10 minutes with a significant number of clicks to get a solution.

In term of accuracy, 3 out of 7 tests took submitted 2 incorrect combinations. The remaining 4 out of 7 submitted only 1 incorrect combination. Overall, all users eventually submitted a good combination. In addition, 3 out of 7 users submitted 4 elements in the incorrect order, 2 out of 7 users only submitted 1 incorrect element. The remaining two users submitted 2 incorrect elements

Regarding to recall, users found the prototypes are easy to use. Once the users viewed the game they could remember elements and figure out how the ELISA test works.

Lastly, for the last question about response, users stated they liked the application and felt it was an enjoyable experience. Furthermore, several were unsure how to solve the problem but eventually found a solution.

## V. CONCLUSIONS AND FUTURE WORKS

ELISA game found to be usable for third year veterinary science students. However, it has not been researched whether it is effective for learning ELISA compared to in a real laboratory. ELISA game has not been tested among lecturers in veterinary science department. For future works, it is considered that Flash Action Script is no longer current technology for game. It might be better to develop using other current game technologies, for example Unity 3D.

Beaton and Nicole Adriana Potgieter as the front-end designer; Ariana Yunita, Andrew Moore and Julian Andres Galindo Losada as back-end developer; then also Angela McCarthy as a tutor in this subject.

REFERENCES

[1] E. Engvall and P. Perlmann, "Enzyme-linked immunosorbent assay, ELISA," *J. Immunol.*, vol. 109, no. 1, pp. 129–135, 1972.

[2] M. Prensky, "Digital game-based learning," *Comput. Entertain. CIE*, vol. 1, no. 1, pp. 21–21, 2003.

[3] D. Rodrigez-Andres, M. C. Juan, R. Molla, and M. Mendez-Lopez, "A 3D Serious Game for Dental Learning in Higher Education," in *2017 IEEE 17th International Conference on Advanced Learning Technologies (ICALT)*, 2017, pp. 111–115.

[4] A. Schäfer, J. Holz, T. Leonhardt, U. Schroeder, P. Brauner, and M. Ziefle, "From boring to scoring–a collaborative serious game for learning and practicing mathematical logic for computer science education," *Comput. Sci. Educ.*, vol. 23, no. 2, pp. 87–111, 2013.

[5] M. Ebner and A. Holzinger, "Successful implementation of user-centered game based learning in higher education: An example from civil engineering," *Comput. Educ.*, vol. 49, no. 3, pp. 873–890, 2007.

[6] B. Bergeron, "Developing serious games (game development series)," 2006.

[7] D. Richards and P. H. Caldwell, "Gamification to Improve Adherence to Clinical Treatment Advice," *Health Lit. Breakthr. Res. Pract. Breakthr. Res. Pract.*, p. 80, 2017.

[8] D. Charsky, "From edutainment to serious games: A change in the use of game characteristics," *Games Cult.*, vol. 5, no. 2, pp. 177–198, 2010.

[9] A. Paiva *et al.*, "Learning by Feeling: Evoking Empathy with Synthetic Characters," *Appl. Artif. Intell.*, vol. 19, no. 3–4, pp. 235–266, Mar. 2005.

This page intentionally left blank