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Development of a Gamified Learning Management System for ECE Subjects Through Utilization of Fuzzy Inference System (FIS) Models for Effective Learning

A Project Study presented to the Faculty of the

Department of Electronics Engineering

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In Partial Fulfillment of the Program Requirement for the Degree of

Bachelor of Science in Electronics Engineering

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ABSTRACT

Gamification of education is a developing way to increase learner motivation and engagement by incorporating game design elements in educational settings. Due to the trend of gamifying learning management systems, innovative approaches are needed to create an effective online learning platform. This project develops and presents an efficient and reliable LMS for electronics engineering (ECE) subjects that utilize predictive analytics. ECEdemy is a gamified Learning Management System (LMS) that serves as a licensure exam reviewer to facilitate the learner's conceptual understanding of ECE courses (FIS). This study compares Mamdani- and Sugeno-type fuzzy inference system models. The proponents tested the accuracy of each proposed model using simulated inputs with correct and incorrect answers and measured the algorithm's speed by its average runtime. The results showed that among the ten models, the triangular type of Mamdani-type FIS model has the highest accuracy and fastest average speed on different volumes of simulated input ranging from 3.83ms to 4.53; thus, it was chosen as the system's final model. The proponents measured the effect of the gamified LMS on user-engagement, motivation, and performance by using descriptive statistics. Most student respondents strongly agreed with the technology's effectiveness, garnering high means ranging from 4.210 to 4.730. It revealed that most users like being rewarded with XP points for correctly answering questions. In addition, seeing their XP points, badges, leaderboard rank, and game levels motivate them to work harder during the game while improving their performance by applying and practicing their knowledge.

APPROVAL SHEET

This project study with the title **"Development of a Gamified Learning Management System for ECE Subjects Through Utilization of Fuzzy Inference System (FIS) Models for Effective Learning"** has been prepared and submitted by the following proponents:

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The Authors

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Chapter 1

THE PROBLEM AND ITS SETTING

This chapter discusses the introduction, background of the study, objectives, scope and delimitations, and significance of the study.

1.1 INTRODUCTION

The COVID-19 pandemic has triggered new ways of learning. Due to the rapid spread and severity of the deadly virus, 1.2 billion children in 186 countries are out of the classroom [1]. Schools, therefore, are forced to migrate to online platforms — an unplanned shift from traditional learning to a setup that exclusively involves digital teaching and learning.

Online learning, as one of the fastest-growing trends in educational uses of technology, has benefits associated with it: added flexibility and self-paced learning, better time management, efficiency, accessibility of time and place, affordability, and improved student attendance [2][3]. It requires just as much work and amount of time as an on-ground format but provides individuals with the opportunity to attend classes from any location of their choice. With its range of options and possibilities, it is the best way to create a perfect learning environment suited to the needs of each individual.

Although it has long been acknowledged that online instructional methods are efficient learning tools [4], many people still express concerns about the challenges attached to them. Because of the limited non-verbal communication, they are not motivated and engaged. The anonymous feeling of the online environment can make it easier for students to withdraw, participate minimally, or completely disappear from the course [5].

Then for many students, one of the biggest challenges is the struggle with staying focused—especially for long periods while staying in one place all day. Social media or other sites easily distract students. There are sights, smells, and sounds at home that make it hard to focus on schoolwork, too. Plus, many kids are feeling sad or anxious because of the pandemic. They may miss seeing friends or attending events, while some are also coping with the trauma of family members losing jobs or getting sick [6].

Some studies, like the one conducted by Greenhalgh [7], show that students' performance was worse in online courses with respect to course persistence and end-of-course grades. In addition, according to Sintema [8], the level of academic performance of some students significantly dropped due to reduced contact hours for learners and a lack of consultation with teachers when facing difficulties in learning/understanding. Because of a lot of adjustments, the change to e-learning does not go as smoothly as anyone wants it to be.

1.2 BACKGROUND OF THE STUDY

Learning Management Systems (LMSs) were created as a response to the need for a suitable platform to facilitate student-teacher interaction in a technology-based environment. At the most basic level, Ellis [9] defined LMS as a system that automates the administration, tracking, and scoring of particular training or education courses, with common features being content access, content development, and assessment systems available to users among other things. Its primary purpose was to act as a breeding ground for the interaction between students and teachers through forums and group collaboration

tools but as years passed by, the systems now act as content management systems rather than a collaborative learning environment [10].

On top of that, LMSs present a challenge for the users in terms of their usability and lack of interactivity. They do not adjust themselves to the needs of the users as to why they tend to be static in the way they are presented [11]. Because of the changing nature of the new generation where young people are empowered to create knowledge—not just absorb and be more engaged with their education—the system needs to cater to the needs of the students and not the other way around [12].

Nevertheless, as specified by Ingwersen [13], a whopping 89% of LMS users report that they would be more engaged with their eLearning application if it had a points system. Gamification is the use of game mechanics and design features in non-game contexts, meaning in areas that aren't meant primarily for entertainment [14]. Gamified elements are intended to engage and motivate people by encouraging them to achieve certain goals. It works to involve students by applying game principles (points, progression, competition) to learning activities. Since the learning content is incorporated into an actual game and learning occurs through gameplay, gamification is sometimes considered synonymous with game-based learning.

Recent versions of LMS applied many gamification elements to influence behavior as well as to improve motivation and engagement during the learning process [15]. With the biggest names that are currently dominating the LMS market today specifically Docebo, TalentLMS, Stream LXP from Learning Pool, and iSpring Learn [16], the use of gamification encouraged the enhancement of traditional learning formats with game mechanics and aesthetics to engage and motivate the learners. Awarding points and badges,

unlocking levels, and granting rewards are also evident, as well as leaderboards and the creation of online tests to assess the learners' capabilities.

A project named Multimedia Content Production (MCP) by Barata et al. [17] then evaluated how gamification in a learning system affects engineering students. The students viewed the system as interesting and motivating because of gamification, they felt more engaged with the courses even though it requires more time and effort. With their approach, gamification was seen as prominent in the learner's potential when it comes to encouraging the students to become more dedicated and attentive to the course.

On the contrary, predictive analytics have begun making their way into the realm of online learning and are often found incorporated in LMSs. Predictive analytics is a statistical method that utilizes algorithms and machine learning to identify trends in data and predict future behaviors [18]. An LMS with predictive analytic capability can help improve a learner's proficiency by applying an instructional approach where the curriculum, content, format, and delivery method are optimized to meet an individual's needs. By implementing personalized learning through the power of machine learning, AI systems can create individual learner profiles and customize the training programs for each learner, based on their ability, job role, the preferred mode of learning, and experience [19].

With the current trend of gamified learning management systems, designing new approaches must be done to attend to the need for an effective online learning platform. The proponents address these concerns by developing an efficient and reliable system for ECE subjects through the use of predictive analytics that will lead to the goal of this study.

1.3 STATEMENT OF THE PROBLEM

Adding gamification functionality to LMS in the form of badges, points, achievements, and leaderboards can create a learning environment in which learners are motivated, intrigued, engaged, and eager to learn. However, a game-based learning tool that is primarily for ECE students is non-existent.

In response to the need for an additional resource of training for ECE students, especially during an online setup, the proponents address this concern by developing a web based gamified LMS for ECE subjects that can serve as a licensure exam preparation tool. Predictive analytics such as Fuzzy Inference System (FIS) will also be used to optimize users' learning. This will ensure that the tool will have an adaptive system that will adjust to the learner's needs by determining the level of difficulty of questions given based on the learner's correct and wrong answers.

The study will help assess the students' competency level in different ECE subjects, allowing them to pace and calibrate their learning rhythm according to their own needs and capabilities. Thus, offering them flexibility and the opportunity to participate in the context of distance learning.

1.4 OBJECTIVES

1.4.1 GENERAL OBJECTIVES

The study aims to develop a web-based gamified learning management system (LMS) for Electronics Engineering (ECE) subjects by utilizing Fuzzy Inference System (FIS) models.

1.4.2 SPECIFIC OBJECTIVES

Specifically, the objectives of the study are as follows:

1. To develop a web application that employs gamification in a learning management system (LMS) containing a database of questions needed based on the ECE licensure exam.
2. To determine which model is better to be utilized in the system between the Mamdani and Sugeno Method of Fuzzy Inference System (FIS) with different types of membership functions.
3. To measure the effect of the gamified LMS on user engagement, motivation, and performance of the users.

1.5 SIGNIFICANCE OF THE STUDY

The study pursues the development of a gamified learning management system (LMS) for ECE subjects through the utilization of FIS models. The system will serve as a licensure exam preparation tool that could benefit ECE students since the course subjects involved are based on the scope of their examination. Incorporating gamification and FIS models into the content could increase their learning engagement while enhancing their course practice. After passing, these knowledgeable and efficient Engineers will then benefit the community since they could provide innovations and inventions that will improve the way people live and work.

College professors may also recommend the web application to their ECE undergraduate students to improve class participation, given that the system allows learners to answer problems in one subject area only if they wish to do so. Professors could also

play and try to complete the levels to have access to the questions gathered by the proponents.

Future researchers will be able to use the study as a reference and can even provide improvements and enhancements to the system itself. Then as ECE students themselves, the proponents will be able to use the system as a tool that will help them be more prepared for the licensure exam, as well as able to experience developing a gamified LMS through the utilization of FIS models.

1.6 SCOPE AND DELIMITATIONS

This study will focus on the development of a gamified learning management system designed to encourage the advancement of the student's conceptual understanding of the courses in Electronics and Communications Engineering (ECE). It will be carried out as a web application wherein students will be able to solve and answer problems based on the scope of the ECE licensure exam particularly in MATH (Engineering Mathematics), ELEX (Electronics Engineering), GEAS (General Engineering and Applied Science), and ESAT (Electronic Systems and Technologies). Aside from choosing one major subject per game, a learner could also just pick from the list of subtopics and specifically solve problems about it.

Other than these, self-assessment tools will be featured to guide the learners with their learning path by providing game elements or strategically placed rewards such as experience points, badges, and achievements, through the completion of quests and answering more problems. When progress has been made, problems previously solved will be accessible to easily review them, too. An overview of their progress is also included in

the profile consisting of the following: their rating, winning percentage, problems solved, total correct and incorrect answers, best streaks, number of days of practice, and topics mastered.

FIS models will also be utilized to ensure that the tool will have an adaptive system that will help determine the difficulty level of questions given based on the past performances of the user. The said web application will be deployed in a small-scale set up.

Moreover, the flexibility and functionality of the gamified LMS will be limited compared to a full-blown learning management system (LMS). It will not provide video lectures for any topics it covers hence; video solutions are also not provided to the learners and will only be available in a text format. The scores garnered by the users should not serve as a basis of the grading system but rather be used only for enrichment.

Chapter 2

REVIEW OF RELATED LITERATURE

This chapter will discuss the review of related and supporting literature and studies. After the problem has been identified, information is needed to support the problem under study so that it can be put in the proper context and the research study can proceed effectively. In order for research to make a substantial contribution, it must be based on adequate knowledge of the field of study.

2.1 CONCEPTUAL LITERATURE

2.1.1 Gamified Learning Management System

2.1.1.1 Gamification

In accordance with Werbach [20], gamification is the use of different methods and components from game design in non-game contexts. The game components include experiencing points, resource collection, development of the gamers, unlocking levels, quests, and even characters that can be personalized to teaching and learning purposes. The gamification methods, on the other hand, are the learning apparatus which are formulated to be more consistent and expert for the reason of enjoyment just like games. Moreover, the good side of using gamification apps is it can build up motivation, increase competitiveness, sharpens your mind in problem solving and helps you in decision making which gives a wider perspective on how a game will have an effective influence rather than antithetical.

2.1.1.1.1 Gamification Elements

Gamification elements are vital in eLearning systems. They engage students by integrating learning content with game aspects in a stimulating way. Completing activities leads to points, higher levels, and awards. All are geared toward reaching specific learning objectives [21]. The design of the learning program depends on the identified objectives.

These gamification elements are self-elements and societal elements. Self-elements are rewards that students get for doing activities on their own. These can be in the form of experience points, achievement badges, levels, or time constraints. These allow students to focus on competing with themselves while recognizing self-achievement. On the other hand, social aspects are for activities that demand interactive competition or cooperation with other learners, such as leaderboards. These aspects make students part of a big learning community, and their progress and achievements are public. With both self and social gamification features, education may be entertaining, engaging, and successful for the students. [22].

2.1.1.2 Learning Management System

A Learning Management System (LMS), often called technology-mediated learning, manages the learning process and allows students and instructors to connect more efficiently. This system handles all aspects of learning [23]. In general, a learning management system (LMS) is a

framework that distributes and organizes instructional content, sets and evaluates individual and organizational learning objectives, monitors progress toward these goals, and gathers and presents data for overall learning process supervision [24].

More teachers will need to use an LMS as institutions provide more online courses, especially during the pandemic. Instruction should consider the benefits of an LMS. LMS can instruct online, utilizing several modalities to fulfil diverse learner needs [25]. Through e-learning via an LMS, students can access educational content from anywhere via the web. Moreover, an LMS's built-in function that tracks students' records and course involvement can also help assess their growth and performance.

While LMS is regarded as an integral part of learning, most users do not efficiently utilize the system. Thus, even though the content is always available to students, it has no effect on their learning [25]. In addition, earlier research showed that many instructors in higher education use only the parts or functions of LMS that replace older techniques for reproducing and distributing documents [26][27]. Fortunately, most LMSs now provide more tools and features to help simulate experiences and activities typically occurring in a traditional classroom, thereby increasing user engagement.

2.1.2 Web Development

2.1.2.1 Django

Django is a Python web framework that promotes rapid development and clean, pragmatic design. Experienced developers built it to eliminate the hassle of web development, allowing anyone to focus on writing their app without reinventing the wheel. It is open-source and free [28].

Django [29] helps you develop software that is (1) Complete: everything you need is part of the "product". It all functions flawlessly, follows consistent design principles and includes substantial and up-to-date documentation; (2) Versatile: used to develop nearly any form of a website, from content management systems to social networks. It can work with any client-side framework and deliver content in nearly any format. (3) Secure: allows developers to avoid many common security errors by providing a framework that "does the right thing" to secure the website; (4) Scalable automatically: uses a "shared-nothing" component-based design. A clear separation of the various elements implies that it can be expanded to accommodate increased traffic by adding hardware at any level: caching servers, database servers, or application servers. (5) Reusable and maintainable code: Django code is written using design principles and patterns that promote reusability and maintainability. It uses the “Do not Repeat Yourself” (DRY) concept to eliminate unnecessary duplication, reducing code; and (6) Portable: it is developed in Python, which operates on multiple platforms. That implies anyone is not tied to a server platform and may run their programs on Linux, Windows, and Mac OS X. Django is well-supported

by numerous web hosting providers, who provide infrastructure and documentation for hosting Django sites.

2.1.2.2 Python

Python is a powerful programming language that can be used for a variety of purposes. It is also very succinct and simple to learn, making it an excellent choice for a first language [30]. Python can do web development, machine learning, and data science. The language builds server-side web applications. Developers rarely build web apps without using open-source libraries to speed up the process.

Web browsers do not use Python; Javascript is used in Chrome, Firefox, and Internet Explorer. Pyjs is a Python-to-JavaScript compiler, and most Python developers combine Python and JavaScript to develop web applications. Python runs on the server, while JavaScript is downloaded and run by the client [31].

2.1.2.3 HTML 5

HTML5 is a newer version of Internet protocol that aids in the development of immersive and rich web pages. HTML has progressed dramatically from focusing solely on audio, video, and animation development to enabling offline functionality, storage device, and geolocation on any client-side database.

As per HTML5's growth, it has resulted in a wide range of multimedia applications. It supports graphics and can play audio and video without the use of

proprietary browser techniques. The new features introduced by HTML5 will provide new value for web developers and designers [32].

Furthermore, HTML 5 elements are being adopted by a large number of websites and browser designers. The major attraction for web developers and browsers is the possibility of creating immersive web pages, web-based software, and improved forms without having to learn or license several proprietary techniques [33].

2.1.2.4 CSS 3

Cascading Style Sheets (CSS) allows for flexible and scalable web designs. It isolates website content from layout, an essential concept in progressive improvement.

CSS Level 3 is the most recent and separates the standard into modules, which the CSS Working Group claims will allow for rapid, incremental improvements [34] [36]. Some CSS 3 modules are already recommendations or candidates, and one of the selectors has a level 4 functioning draft. [35].

2.1.2.5 Heroku

Heroku is a cloud platform for building, delivering, monitoring, and scaling apps in which programming languages such as Ruby, Node.js, Java, Python, Clojure, Scala, Go, and PHP are supported [37]. As a PaaS solution, it is always faster than configuring a VPS from scratch. It also simplifies app development and deployment, focusing on customer-focused apps. Heroku

manages hardware and servers so businesses can focus on their apps rather than their infrastructure; hence, more time is spent ensuring that users get the best possible experiences [38].

2.1.3 Predictive Analytics

Predictive analytics uses data, statistical and quantitative analysis, statistical algorithms, and machine learning to forecast future events based on historical data. It predicts future occurrences by analyzing the volume, truthfulness, velocity, diversity, and value of enormous amounts of data. Predictive analytics predicts the best plans by analyzing who, when, where, and why [39].

Predictive analytics models use historical data to train a model that can forecast outputs for new data based on input variables' estimated significance [40].

Predictive analytics can decrease risks, optimize operations, and boost income. Predictive analytics can help enhance the quality of education by allowing decision-makers to handle significant issues such as curriculum management and development [39]. Interpretation of student data to assess academic progress, forecast performance, and identify potential issues.

2.2 RELATED STUDIES

2.2.1 Predictive Analytics

In the work titled Improved Fuzzy Modelling to Predict the Academic Performance of Distance Education Students, Yildiz et al. developed a fuzzy inference system to predict distance education students' year-end academic performance. Data

comprised five inputs and one output. Three were acquired through Moodle. The first is recency, which is the last time a student logged on to the system section; frequency represents how often a student logged on; and monetary is the amount of time (minutes) spent on the system associated with the course. The fourth and fifth inputs were the online Moodle quiz and midterm exam results [41].

Fuzzy logic has three stages: (1) fuzzification, where actual values in the system are blurred, and each input value is assigned a membership value and translated into linguistic forms; (2) inference engine, where "if-then" rules are processed. Inputs are handled according to the rule table; (3) fuzzy values are turned into actual values.

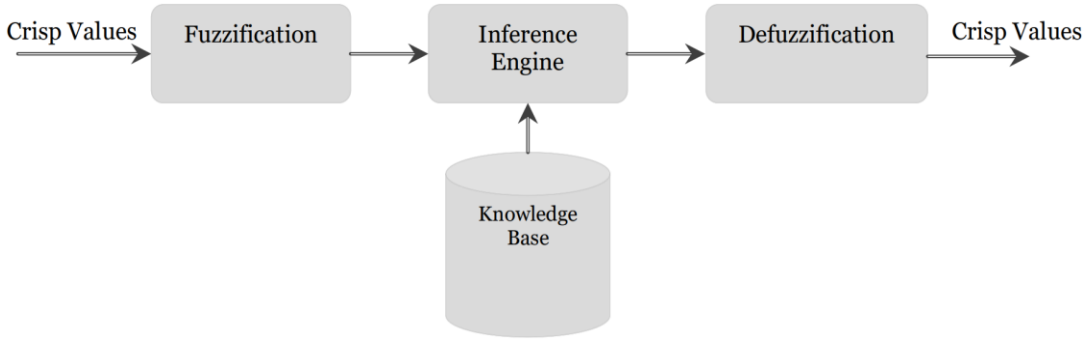

Figure 2.1 *Structure of a Fuzzy Logic Model [42]*

Based on trial and error and expert opinion for determining the intervals of membership functions, the accuracy of results is hereby enhanced by optimizing the intervals through a genetic algorithm. This method of optimization is based on natural selection and evolution. Hence, the best result is provided by the gene-fuzzy model, which is based on the optimization of the intervals for membership functions using a

genetic algorithm, gaining an 82.50% accuracy value compared to classic fuzzy and expert fuzzy.

Five technical components in building a Computerized Adaptive Testing (CAT) are discussed in the study of D. V. Balas-Timar and V. E. Balas entitled Five technical components in building a Computerized Adaptive Testing (CAT) [43] namely calibrated item pool, starting point or entry level, item selection algorithm, scoring procedure, and termination criterion.

A Fuzzy Item Response Model (FIRM) approach was also proposed, which combines item response theory (IRT) with fuzzy theory in estimation of abilities or competences. This would improve the predictive validity of psychological measurement like the scoring algorithm of items in a CAT.

For the fuzzy scoring algorithm of the CAT for MAB-II, each informational function of the item from the calibrated base (linguistic variable for FL) considered is modelled in MATLAB environment (Fuzzy Toolbox) using two fuzzy sets-linguistic terms. Linguistic variables such as discrimination, difficulty, probability, and response were used upon entering the system, then the rate of acceptance with its linguistic terms as the output. The scale comprises seven classes for the expression QI from MAB-II: level hateful, very low, low, medium, high, very high, and excellent.

Figure 2.2 *Model with Fuzzy Logic System*

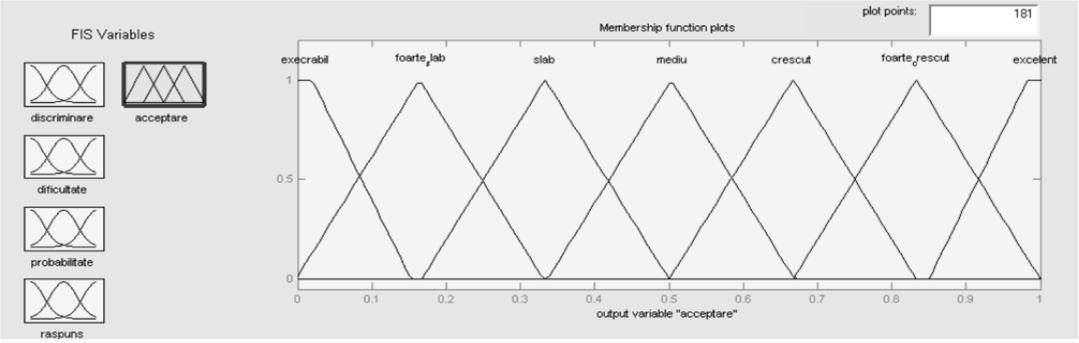

Figure 2.3 *The Rate of Acceptance*

1. If (discriminare is mare) and (dificultate is mare) and (probabilitate is mare) and (raspuns is da) then (acceptare is excelent) (1)
2. If (discriminare is mic) and (dificultate is mica) and (probabilitate is mica) and (raspuns is nu) then (acceptare is execrabil) (1)
3. If (discriminare is mic) and (dificultate is mare) and (probabilitate is mica) and (raspuns is nu) then (acceptare is execrabil) (1)
4. If (discriminare is mare) and (dificultate is mica) and (probabilitate is mica) and (raspuns is nu) then (acceptare is execrabil) (1)
5. If (discriminare is mic) and (dificultate is mare) and (probabilitate is mare) and (raspuns is da) then (acceptare is excelent) (1)
6. If (discriminare is mare) and (dificultate is mare) and (probabilitate is mare) and (raspuns is da) then (acceptare is excelent) (1)
7. If (discriminare is mic) and (dificultate is mica) and (probabilitate is mare) and (raspuns is nu) then (acceptare is foarte_slab) (1)
8. If (discriminare is mare) and (dificultate is mica) and (probabilitate is mare) and (raspuns is da) then (acceptare is foarte_crescut) (1)
9. If (discriminare is mic) and (dificultate is mare) and (probabilitate is mare) and (raspuns is nu) then (acceptare is slab) (1)
10. If (discriminare is mic) and (dificultate is mare) and (probabilitate is mare) and (raspuns is da) then (acceptare is crescut) (1)
11. If (discriminare is mare) and (dificultate is mare) and (probabilitate is mica) and (raspuns is nu) then (acceptare is mediu) (1)
12. If (discriminare is mic) and (dificultate is mica) and (probabilitate is mare) and (raspuns is nu) then (acceptare is slab) (1)
13. If (discriminare is mare) and (dificultate is mica) and (probabilitate is mare) and (raspuns is da) then (acceptare is mediu) (1)
14. If (discriminare is mare) and (dificultate is mica) and (probabilitate is mare) and (raspuns is da) then (acceptare is crescut) (1)
15. If (discriminare is mic) and (dificultate is mica) and (probabilitate is mare) and (raspuns is nu) then (acceptare is slab) (1)
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17. If (discriminare is mic) and (dificultate is mare) and (probabilitate is mare) and (raspuns is da) then (acceptare is foarte_crescut) (1)

Figure 2.4 *The Rule Base*

In another study entitled Computerized Adaptive Test based on Sugeno Fuzzy Inference System, Ridwan et al.[46] designed Sugeno Fuzzy Inference Systems (SFIS) to evaluate examinees' competence in the CAT system, which involves four inputs, one output, and twelve fuzzy rules.

Input fuzzy is composed of four things: (1) Item difficulty level (bi), which has three levels: easy, medium, and hard; (2) Question discrimination (ai), which has two levels: satisfactory and good; (3) Probability of the examinees getting the question right (pi), which has two levels: min and max; and (4) Participant's response or answer (ri), which is worth one if the answer is correct and 0 if it is wrong. On the other hand, the

fuzzy output is the value of the examinee's abilities (theta). It has five levels: Very Low (VL), Low (L), Average (Av), Great (G), and Excellent (E) (Ex).

The researchers concluded that for the interpretation of responses, a more detailed view of levels of competence to the Bayesian method was provided by the Fuzzy Item Response Model (FIRM), which is one output data rejection or acceptance of the candidate.

As an alternative framework for the well-established mathematical tool called Item Response Theory (IRT), the research entitled Adaptive Testing System Modeled Through Fuzzy Logic revealed the main ideas behind a computerized adaptive testing (CAT) system whose evaluation administrator is based on a fuzzy logic model.

Sineglazov & Kusyk [44] claimed that exploring new items to obtain is made by using vague or fuzzy terms instead of probabilistic assignations normally used in adaptive evaluators with 1PL, 2PL, or 3PL models, although it could be based on a student historical record and the answer to previous questions. They insist that the adaptive testing acts in a fuzzy way instead of a probabilistic one, the same as it seems possible to build a CAT by using a fuzzy model as an item administrator.

"Computer Adaptive Testing for an Intelligent E-Learning Platform"[45] aims to integrate a CAT model based on IRT, data mining, and social behaviour into an E-learning platform. Making an item bank is part of a CAT model. The Basic Model has three steps: initialization, which loads the test configuration (an IRT model (1PL, 2PL, or 3PL), a stopping rule, and an item bank); selection, which utilizes the IRT model's Maximum Likelihood Function to determine a student's competence for each answer; and scoring. This ability chooses the next question. The grading process converts the

student's final ability value (-3 to 3) into grades (0 to 5). algorithm converts the student's final ability value (-3 to 3) to the grade scale (0 to 5). [45].

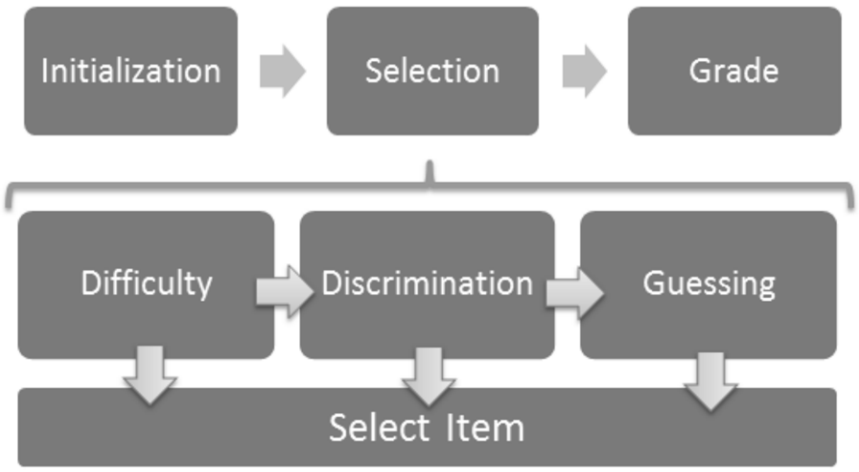


Figure 2.5 *Basic Model Structure*

Additionally, three issues were investigated and identified. The first parameter is difficulty. With the parameters set by professors using integer values (such as 1, 2,..., 7), each time a question is answered, the difficulty of the next item will increase or decrease by one unit. Since the test starts with a medium-level question, if a student misses three in a row, he or she moves on to a question with a lower difficulty level. If they miss one more question, the difficulty level will be off the scale, and the test will be over. The same thing happens when there are four correct answers in a row, but the difficulty level goes above the top of the scale. The discrimination parameter is linked to the second and third concerns.

The Question History Model was proposed as a second model to address these issues. This model takes the structure of the Basic Model and adds a history of questions. The past data will be used to determine whether or not the difficulty of the

next question will change. Individual and overall test results analysis revealed that the record/s of the question history contributes to the fairness of the test.

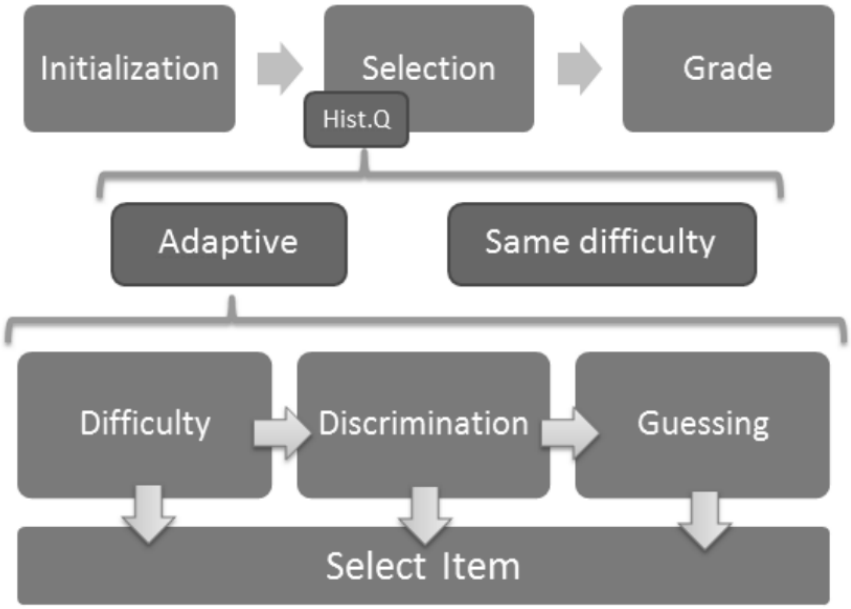


Figure 2.6 *Question History Model*

Another model is the Topic History Model that shows all exam questions in a test. During selection, students' answers are saved in *th*. When a query is read, the algorithm looks for a non-*th* topic. Adaptive and identical difficulty selection use array *th*. If the algorithm cannot identify an alternative topic in *th*, it removes the initial item and looks again. When a student answers all questions, *th* empties.

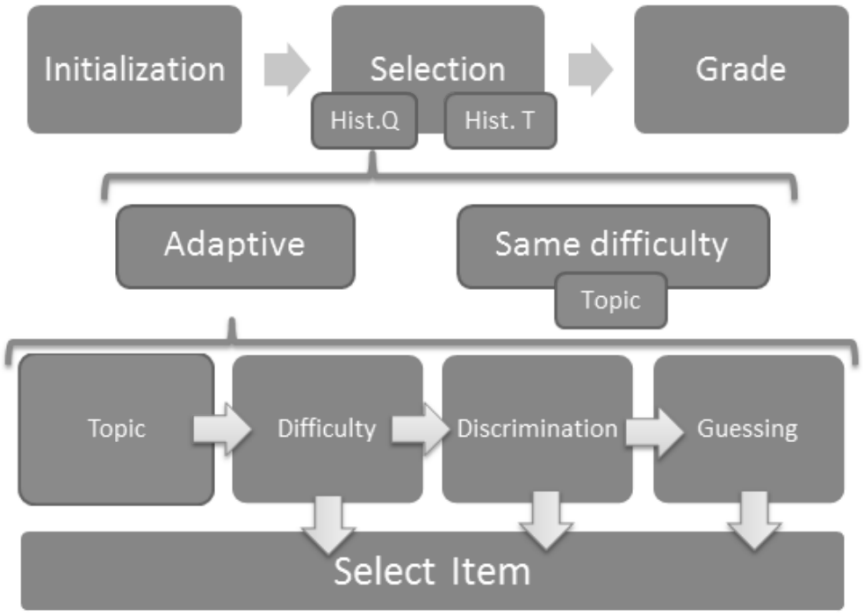


Figure 2.7 *Topic History Model*

Ridwan et al. [46], designed Sugeno Fuzzy Inference Systems (SFIS) to test the examinees' ability on the Computerized Adaptive Test (CAT) system in their study entitled "Computerized Adaptive Test based on Sugeno Fuzzy Inference System". This SFIS involves four inputs, one output, and twelve fuzzy rules.

The research entitled "An Empirical Evaluation of the Slip Correction in the Four Parameter Logistic Models with Computerized Adaptive Testing" used an empirical experiment to evaluate the calibration efficiency and accuracy of the 3PL and 4PL IRT models under normal conditions, as well as to evaluate their output in terms of reducing estimation error induced by missing early items in a test. Participants' demographics, item bank characteristics and an overview of the four CAT systems were indicated from this study.

P3CAT, P4CAT, N3CAT, and N4CAT are four variants of fixed-length web-based CAT systems developed for this research. The subjects in this research were

oblivious why the first two things would be judged as incorrect regardless of their answers, which resulted in a poor-start administration situation in P3CAT and P4CAT. The remaining tests were conducted following standard CAT procedures. The next two experiments, namely N3CAT and N4CAT were conducted except that N3CAT used 3PL IRT and N4CAT used 4PL IRT.

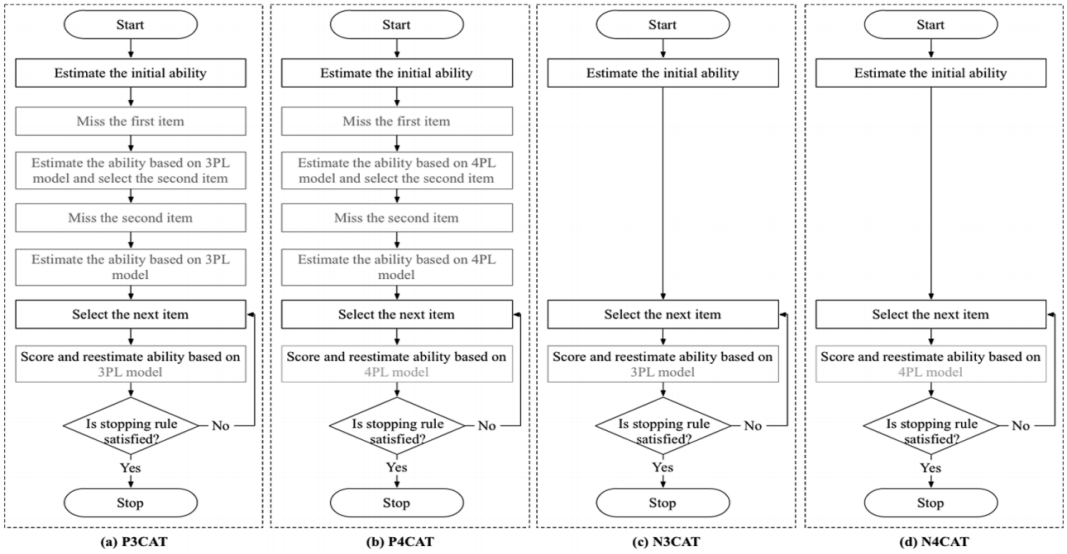


Figure 2.5 *The flowchart of four versions of Computerized Adaptive Test (CAT)*

According to the findings of this study [47], the precision of the 4PL IRT model is higher than the 3PL model under both administration settings. The goal of the examination is to correctly determine the examiners' actual ability. In addition to prior simulation trials, the 4PL IRT model might reduce estimation errors owing to missing items early on, as well as the model might enhance measurement accuracy and efficiency. It was also claimed that using the 4PL model meant sacrificing accuracy for all scores to decrease the effect of one of two errors on scores for the highly competent.

Furthermore, the 4PL IRT model could not only alleviate the difficulties of ability underestimate caused by early thoughtless errors in practical circumstances, but it could also increase measurement efficiency.

2.2.2 Learning Management System

To make ASEAN Economic Community (AEC) vocational high school students more competitive, the authors of "Developing an LMS-Based Cross-Platform Web Application for Improving Vocational High School Students' Competitiveness" [48] used the ISD R&D model. Instructional design entails several steps, such as goal setting, analysis of the learner and the environment, the creation of performance objectives, the creation of an assessment instrument, the formulation of an instructional strategy, the creation and selection of instructional materials, and the creation and administration of formative and summative assessments [49].

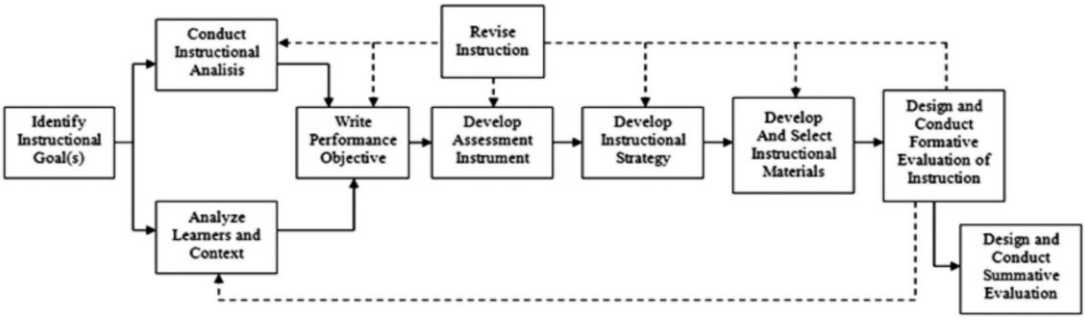


Figure 2.6 *Development Procedure by Dick, Carey, and Carey [49]*

Learning strategies were grouped into four domains. The first one was (1) live synchronous instruction, which took place in the classroom while students approached the start of their apprenticeship. Three additional techniques for learning, including (2)

virtual synchronous, (3) self-paced asynchronous, and (4) interactive asynchronous learning, were applied online and established throughout the Learning Management System.

A Web-Based Learning Management System with Automatic Assessment Resources [50], SAW, was developed using PHP3, Javascript4, and MySQL5 database server. Among other LSMs, it can incorporate e-LMs to support the teaching and learning process of specific content providing interactivity in real time, including automatic assessment.

To enable reusability, its learning material is organized in components: course, lesson, topic, exercise, example, and text. A course denotes a topic that is part of some program. A lesson is a set of exercises designed to teach a specific topic over a specified period. A topic is a subtopic inside a lesson's subject. The events that comprise a lesson are exercises, illustrations, and documents.

The SAW architecture follows the client/server paradigm. There is an HTML interface in the client side which provides the use of the system and its associated e-LMs, while the server side presents three layers: (1) the interaction layer which is responsible for managing and dispatching the client requisitions to the next layer, (2) the task layer which is responsible for managing the authoring resources as well as for adapting the status of a component after any modification performed by some of the system users, and the data layer where the tasks results are stored in the database.

Th study, "Learning Management System (LMS) Success: An Investigation Among University Students" [51] used the DeLone and McLean information system success model to determine the factors influencing LMS success. The model consists

of six variables: system quality, information quality, service quality, use/intention to use, user satisfaction, and net benefits [52].

2.2.3 Gamified Learning Management System

In the study Engaging Engineering Students with Gamification [53], the authors added points, levels, leaderboards, challenges, and badges to a regular MSc course to improve its delivery. The study compared students' learning experiences between a non-gamified and a gamified course for two years and their performance and satisfaction. All group differences were evaluated using Mann-Whitney's U test. Its results showed that gamifying the course improves lecture attendance, slide downloads, and forum posts. The MCP is more motivating and fascinating than other courses, although requiring more work. Gamification increases student engagement, even requiring a greater workload [53].

Another study that evaluated gamification is entitled An Empirical Study on the Use of Gamification on IT Courses at Higher Education [54]. The Corvinus University of Budapest gamified an IT course utilizing their Moodle (Modular Object-Oriented Dynamic Learning Environment) e-learning platform. The study used Moodle version 2.5.1, which was constructed in PHP and supported relational and Object-Oriented databases like Oracle. Proponents included a reward system, multiple learning paths, feedback options, and social platforms. The e-Learning system has a leaderboard, badges, and a progress report. The course's quality was based on students' willingness to take online quizzes, final exams, and satisfaction surveys. During a two-year research period, results have shown that gamification increases the quality of IT

courses while it cannot fix all difficulties [54]. Thus, removing gamification from an existing e-Learning system has more impact than adding it.

In a study titled The Effects of Gamification on Engineering Lab Activities [55], students' performance in the gamification (GM) and non-gamification (NG) groups was compared based on results on the general knowledge test, midterm and final exam. The proponents developed two websites to examine the impacts of gamification on engineering lab activities a Gamification GM) and a Non-Gamification (NG) website. On these websites, students could submit multiple-choice questions (MCQs) and answer classmates' questions. Frequency analysis and two-sample t-tests were used to evaluate the number of students who registered to the websites and the significance of the differences in online activity between the two groups for each phase. T-tests were done to see how significant the differences in test scores between the two groups were for each phase. It showed that gamification made users more motivated, interested, and good at engineering tasks, proved by the fact that there were more engagements and a significant change in the number of questions asked on the GM website [55].

Furthermore, in the study 'Make-It-ECE', a Mathematics Learning Management System (LMS) for Engineering Students in the Philippines [56], a learning management system based on the ABET - Certified curriculum was created to aid prospective engineers' mathematics preparation for the Licensure Board Exam. It is designed to be as simple as possible and includes gamification of learning exercises. The system saves data about student performance in its database, making test question generation easier. Test question regeneration allows the system to adjust to the teacher's judgment of the

student's deficiencies. A survey evaluates MiE's acceptability, but the board examination will verify its effectiveness.

MiE, a pioneer open-access learning management system (LMS) in the Philippines, is meant to help engineering students from TIP pass the board exam in mathematics, despite the availability of review materials. The methodology combines gamification by allowing users to travel between themes by playing a lottery game. Its portal is separated into Lecture Notes (LN), Learning Activities (LA), Assessment Exam (AE), Forum, and Login/Logout History features. LN coursework is based on TIP's ECE math courses, which cover trigonometry, geometry, calculus, and differential equations.

Lastly, a Web-based Rapid Authoring Tool for LMS Quiz Creation [57] offers an appropriate and informative environment for online educators and learners, replete with interactivities. This research is a tool for quickly creating quiz data that can be imported into Moodle. The said software application works with practically all main online browsers and has a minimal amount of input boxes, requiring quiz producers to perform less copy-and-paste activities to finish quizzes. Based on this research, the user can use the writing tool naturally, like WYSIWYG apps, to obtain your quizzes in a desirable format without many attempts and errors. Moodle, which is developed in PHP, was utilized by the proponents for assessment monitoring and the distribution of instructional materials. Another tactic utilized by the proponents was Ajax. Ajax is a JavaScript communication mechanism used to instantly display web pages. Google Maps and Start.com are notable features of Ajax applications (MSN).

2.3 PATENTS

In this study, Methods and Systems for Improving Learning Experience in Gamification Platform [58], a gamified learning management system (TalentLMS) was developed that offers online courses and was designed based on specific guidelines aimed at exploring the perspectives of the teachers towards using gamification approach in online learning. It employed an experimental research design to examine and evaluate the positive and negative effects of incorporating game components in the course design features of the learning management systems features. Like students, teachers have a favorable opinion of gamification in online learning.

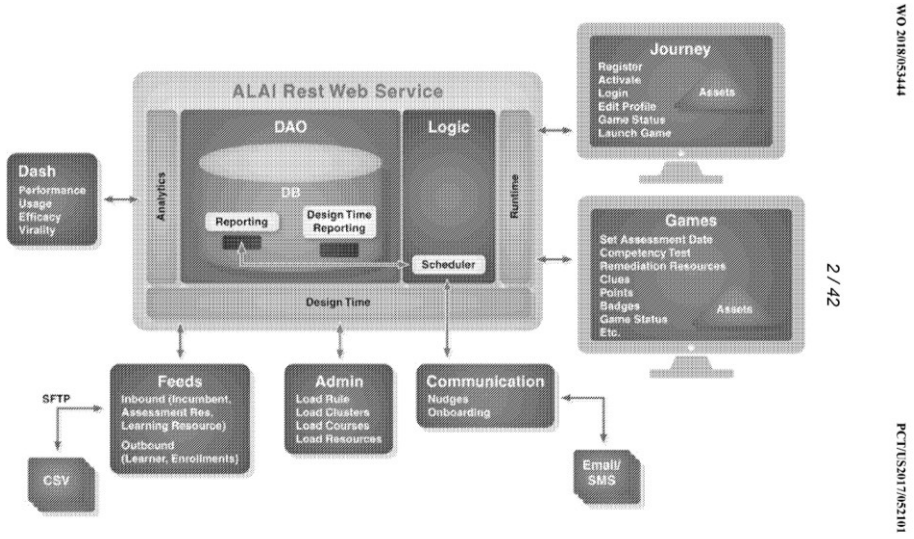


Figure 2.7 *Illustration of the Gamification Engineering Architecture Diagram*

According to Parallel Reality Gamification-Based Learning Management System [59], gamified online courses were integrated into an LMS to increase active learning. Two gamified activities were developed on a wiki platform wherein both activities have different levels, feedback, points, awards, and leaderboards. It also has an adaptive system

to player skills and demands. The study used an experimental research design and statistical treatments, Welch's t-test and Wilcoxon test, to compare group mean exam scores and ranked survey data. The study revealed that online gamified activities could improve statistical and math learning depending on the experimental group's academic performance.

Furthermore, a patent was developed for an instructional gamification system connected to a cloud database and Internet infrastructure [60]. The mobile app and web-based system feature missions, leaderboards, and XPs to encourage course practice, repetition, and exploration. Experience points serve as a currency in a course and can be exchanged for various course privileges.

Chapter 3

METHODOLOGY

This chapter presents the explanation to the methodology used in this study, consisting of the Theoretical and Conceptual Framework, Block Diagram, Research Design, Testing Procedure, Statistical Treatment of Data, Technical Evaluation, Work Plan, and Gantt Chart.

3.1 THEORETICAL FRAMEWORK

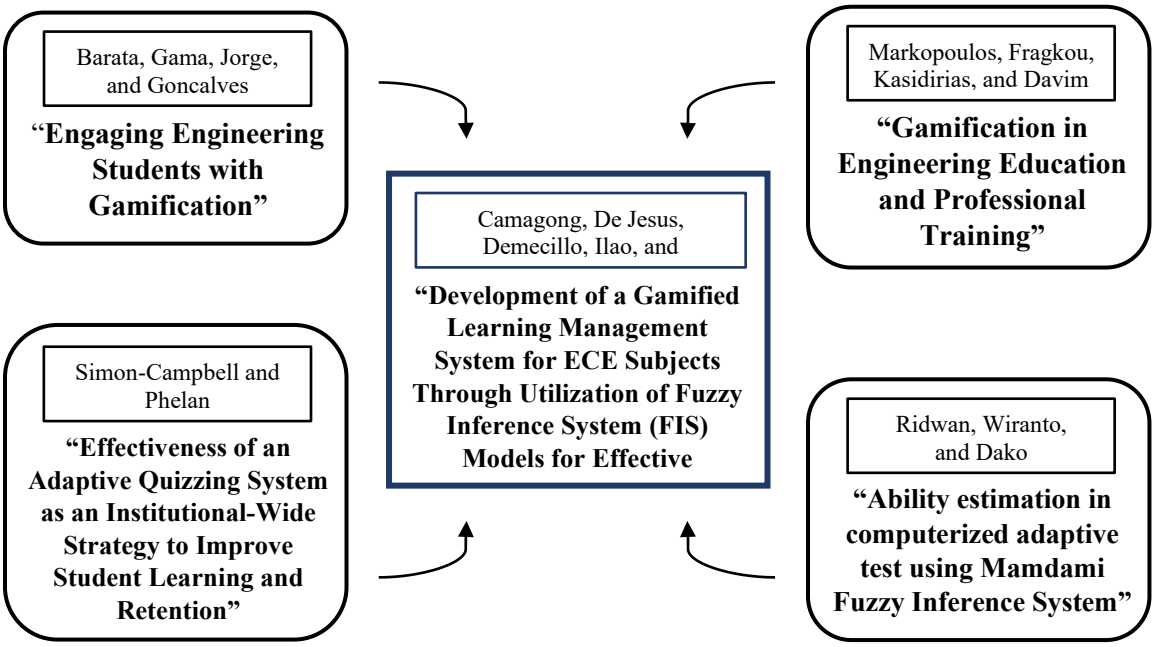


Figure 3.1. *Theoretical Framework of the Study*

The figure shown above depicts closely related studies and supports the proposed research study. The study of Barata, Gama, Jorge, and Gonçalves used game-like features, such as ranking, stages, leaderboards, competitions, and badges to enhance the delivery of a Master's degree College course. The proponents compared student satisfaction when

using the gamified course to that of other normal courses in the same academic setting [17]. In the study of Markopoulos, Fragkou, Kasidirias, and Davim, the proponents evaluated the related literature about gamification and provided insight into its current state by analyzing different aspects of this novel term. Some basic aspects like gamification practices and approaches are discussed as well as various terminology used. In addition, statistics on games, gamers, and gamification are discussed to demonstrate the widespread use of interactive gaming in daily life and to explain how gamification can influence people. The game types and mechanics used in teaching, as well as gamification of learning, are discussed, with suggestions on how these methods can be applied to technical learning. Lastly, the article discussed gaming strategies, gamification methods in school, and e-learning. The article particularly emphasized production, discussed engineering sports, gamification systems, and observational surveys [27]. In the study of E'Loria Simon-Campbell, they investigated the relationship between course use and mastery using an online Adaptive Quizzing System (AQS) called PrepU. The framework is a web-based programming interface with a vast database of calibrated test questions in a variety of formats such as multiple choice, fill-in-the-blank, hot-spot, graphics, etc. [34]. In the study of Ridwan, Wiranto, and Dako, based on the parameters of the questions and responses provided, the researchers designed a system that can estimate students' ability using the Mamdani Fuzzy Inference System (MFIS). The fuzzy system utilized 24 IF-THEN rules for the input that consists of the level of difficulty and discrimination of the questions, the probability of students answering correctly, the student's response, and the output estimated ability [62]. With the concepts and principles discussed in the previous studies, the present researchers combined the ideas and came up with a study entitled Development of a

Gamified Learning Management System for ECE Subjects Through Utilization of Fuzzy Inference System (FIS) Models for Effective Learning.

3.2 CONCEPTUAL FRAMEWORK

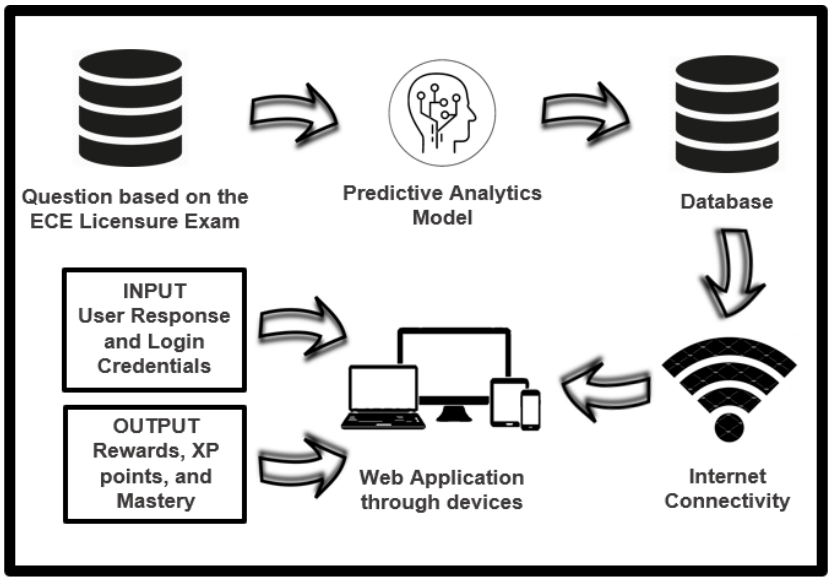


Figure 3.2. *Input-Process-Output (IPO) Model*

The Input-Process-Output Diagram shown above will be the basis for the development of the study. For the input, it is categorized into two: Login Credentials where the user logs in to the web application and provides information used for user identification and profiling on the database; and User Response in which the user must answer the different questions covered by the subjects on the ECE board exam such as Math, GEAS, ELEX, and ESAT.

After determining these requirements, the processes outlined for the study shall be implemented by the proponents. These guidelines include the following: Questions based on the ECE Licensure Exam, where the proponents must construct, gather, and sort

possible questions to be included on the web application and these questions must have corresponding answers and solutions that are verified and validated by the professors and/or engineers; FIS models determine the degree of difficulty for the next question presented to the user. The user device must have an internet connection for their learning outcomes to be recorded and graphically displayed on the web application's database.

After performing all necessary processes, successfully deploying the project, and meeting all the parameters distinguished for the study's objectives, the web application will summarize the user's progress, recent activities, user's summary of attempts, overall ranking, badges gained, quests completed, topics passed and mastered, streaks, rating per subject and other information about the user's activity on the web application to measure the effectiveness of the gamified LMS to user-engagement, motivation, and performance of the users.

3.2.1 Block Diagram

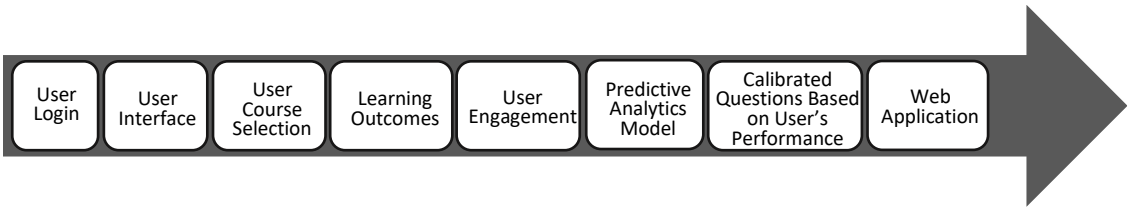


Figure 3.3 *Block Diagram of the Proposed Software System*

The figure above displays the block diagram of the model involving the input, process, and output. The process begins with the user logging into the web application and providing information used for user identification and profiling. The user will have a view of the web application's user interface which will help him/her explore and

navigate the web application. By that, the student may design his/her course by selecting a focused topic which may be under the 4 main subjects of the Electronics Engineering (ECE) board examination, particularly in MATH (Engineering Mathematics), ELEX (Electronics Engineering), GEAS (General Engineering and Applied Science), and ESAT (Electronic Systems and Technologies). Based on the student's chosen topic, the system will provide him/her with different related questions that can be answered with a limited number of attempts. By that, a user engagement occurs where the user must answer the given questions. The student's result for each question, which includes the user's frequency of right and wrong attempts, is then passed, and assessed by the chosen FIS model which decides the degree of difficulty for the next question to be provided to the user. The system will select a much easier question if the student has a series of wrong attempts. On the other hand, if the student gains consecutive correct attempts, the system will select more challenging and harder questions. The process repeats until the user gains a passing mark on that specific topic that he/she chose. From this, the learning outcome of the user will be recorded and displayed graphically on the web application. This includes the user's progress, recent activities, the user's summary of attempts, overall ranking, badges gained, quests completed, topics passed and mastered, streaks, rating per subject, and other information about the user's activity on the web application.

3.3 RESEARCH DESIGN

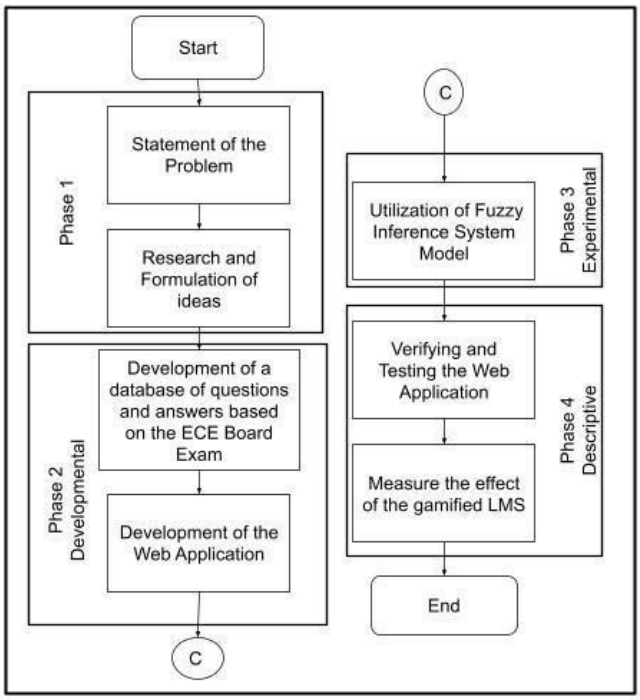


Figure 3.4 *Research Process Diagram of the Study*

Figure 3.4 outlines the overall methodology and procedure used in the study. Three research designs will be used to conduct this research. Developmental, Experimental, and Descriptive research designs will be employed.

The first phase focuses on how the research process begins with the identification of problems from previous research. The proponents develop concepts based on prior research to determine the essential parameters for this study.

The second phase focuses on the development of web applications. It will be conducted under the principles of developmental research. Developing, assembling, and classifying appropriate questions will be done for the Web application following the scope of the ECE Licensure Exam: Math, ELEX, ESAT, and GEAS. After that, the questions will be classified and tagged according to their difficulty level. The development of the web

application is divided into two distinct phases: The front-end component, which serves as the user interface for the output of the back-end component, and the back end, which is the portion of the web application that handles all front-end operations. The web application will be tested by distributing it to a random sample of ECE students to determine its functionality and usability.

For the third phase, the proponents will conduct experimental research to compare the models and collect data to determine which model should be employed in the study. The selected model will be utilized in computerized adaptive testing that is adapted to the user's ability and performance to maximize the user's engagement. After that, the selected model will be integrated with the Web Application.

The last phase of the study will involve the proponents doing descriptive research to characterize and measure the effectiveness of the gamified LMS on the user. The proponents will conduct a survey to determine the impact of the gamified learning management system on users' engagement, motivation, and performance.

3.4 Development of the Gamified LMS Web Application for ECE Licensure Exam

In order to accomplish the first objective of the study, the proponents shall carry out the following processes:

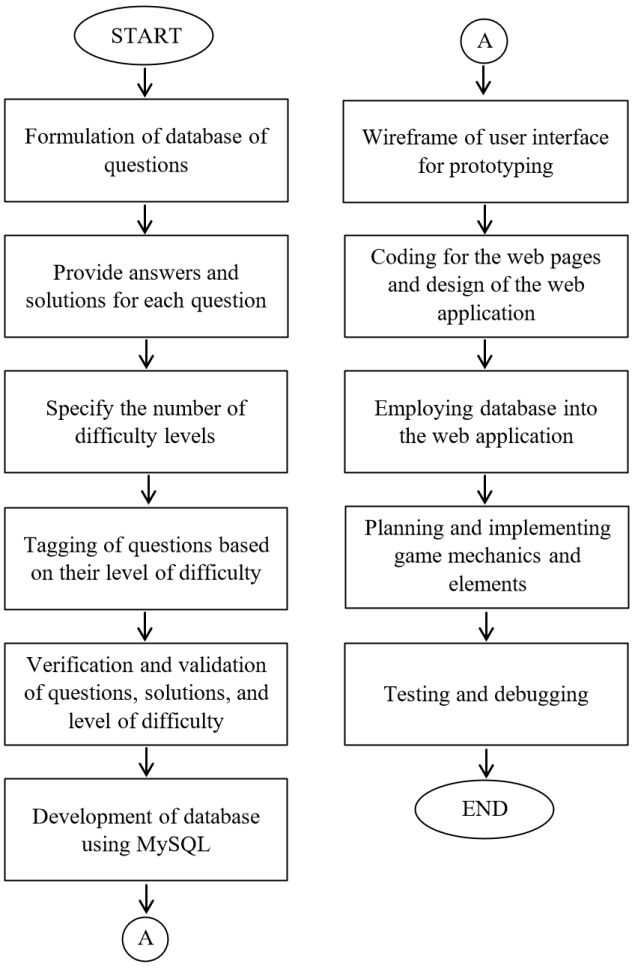


Figure 3.5 *Flowchart for Objective 1*

3.4.1 Formulation of Database of Questions

Proponents will construct, gather, and sort possible questions to be included on the web application using various review materials such as books, eBooks, and board

exam reviewers based on the scope of the ECE licensure exam such as Math, ELEX, GEAS, and ESAT.

3.4.2 Provide answers and solutions for each question

In this research, the proponents will be the ones to gather answers and solutions to every problem. If problem-solving answers are not available in the course materials, then the proponents will be the ones to provide them with the guidance of professors and/or Electronics Engineers (ECE).

3.4.3 Specify the number of difficulty levels that the questions can be categorized

In this part, there will be at least 1000 questions for every major subject (MATH, ELEX, ESAT, and GEAS) to establish 9 levels and to ensure that users are presented with a random assortment of questions each time they try to play a game.

3.4.4 Tagging of the questions based on their level of difficulty

Tagging of questions will be based on how time-consuming the solutions are and how complex the problems are to grasp, as comprehended by the proponents and verified by the professors and/or engineers.

3.4.5 Verification and validation of questions and solutions, as well as their corresponding level of difficulty, by consulting professors and/or Engineer

Professors or Electronics Engineers (ECE) will verify and validate the pool of questions and the solutions the proponents provided. This is to guarantee that the contents of the web application are accurate and precise.

3.4.6 Development of database using MySQL

After finalizing the verified questions and their corresponding solutions, it is then necessary to create the database system required for the web application using Django. Django already includes a built-in SQlite database for use during the development phase. The proponents intend to upgrade the database to a larger database such as MySQL or PostgreSQL in order to accommodate larger files during the production phase.

3.4.7 Designing the wireframe of user interface for prototyping

The wireframe of the user interface will be designed and drafted for prototyping in order to establish a platform that incorporates gamification into a Learning Management System (LMS) that includes the following pages: Sign up/Sign in, Register, Forgot Password, Home/Landing page, Play Page, Report, Hall of Fame, About Us, Contact Us, and other web application elements.

3.4.8 Coding for the web pages and design of the web application.

Apart from using Visual Studio Code as the main programming software in coding the system, developing web pages will require the use of Hypertext Markup Language 5 (HTML5), Cascading Style Sheets 3 (CSS3), and some JavaScript to design the system web pages, followed by Django to develop the platform's backend.

3.4.9 Employing a database to store all the data entered by the users into the web application

This is where user input is stored. Input is divided into two categories: User Interface, in which the user signs in into the online application and gives the information required for user identification and profiling on the database; and User Engagement, in which the user must answer questions from topics on the ECE board exam such as Math, GEAS, ELEX, and ESAT. These two user inputs will be recorded and visually presented on the web application through the employment of the database.

3.4.10 Planning and implementation of game mechanics and elements on the web application

For this part, game mechanics and elements will require formulation and implementation. These include XP points, achievements, badges, quests, leaderboard, and other key characteristics of the gamified LMS. Adding features and additional content, as well as integrating the Fuzzy Inference System (FIS) model into the platform will likewise be executed.

3.4.11 Testing, debugging, review, and launch

Testing and debugging of the web application will be done by the users to verify its functionality. It is important to find bugs as early as possible and to thoroughly test the web application before deployment.

3.5 Utilization of Fuzzy Inference System (FIS) Models in the Categorization of Questions Depending on the Level of Difficulty

In order to accomplish the second objective of this study, the proponents shall carry out the following processes:

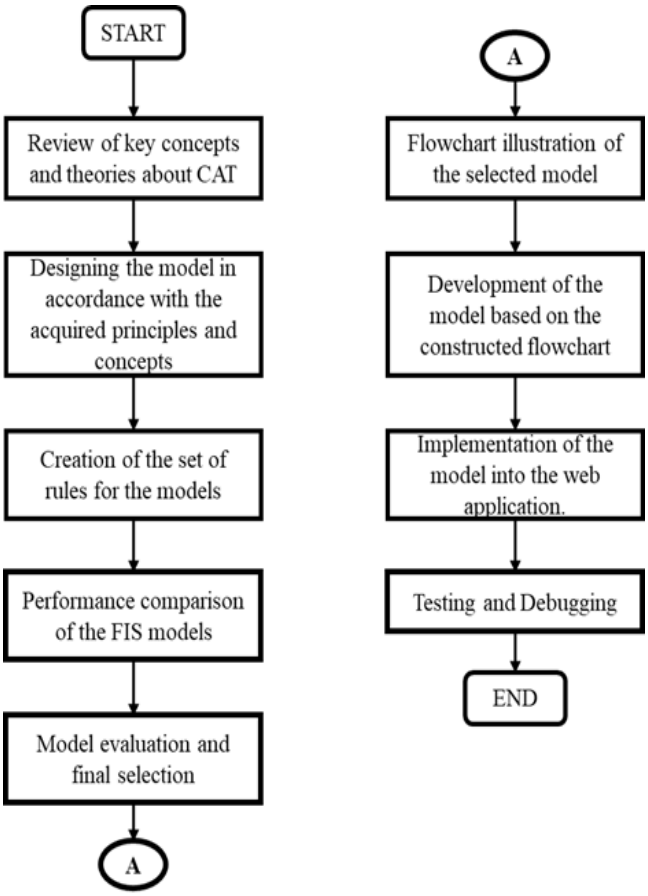


Figure 3.6 *Flowchart for Objective 2*

3.5.1 Review of key concepts and theories about Computerized Adaptive Testing (CAT)

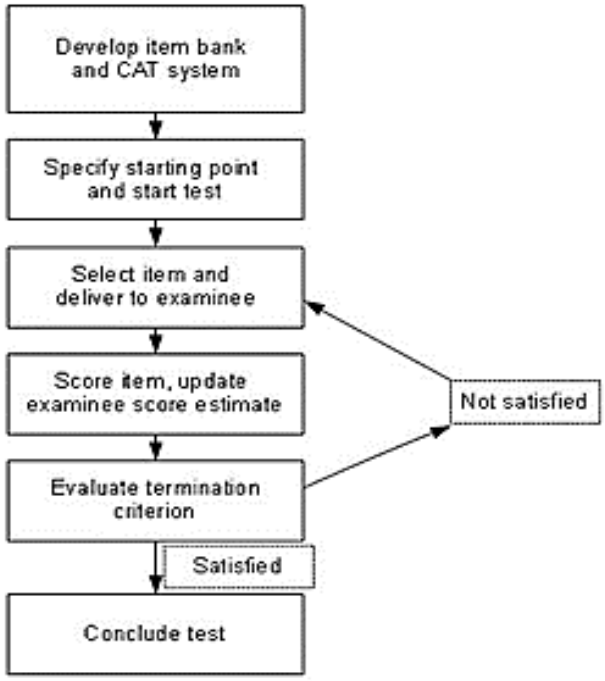


Figure 3.7 *Example flowchart of CAT algorithm*

The proponents will conduct research and assessment of the necessary principles, concepts, and theories needed to develop a FIS model to be utilized by the web application for item selection based on the pattern of user's performance. This will also help the proponents to select candidate algorithms that suit the suggested framework for the development of the model. In addition, the proponents will be utilizing the framework for the development of Computerized Adaptive Tests (CAT) shown in Figure 3.7 as a guiding reference. As discussed in [61], an important consideration in the item selection algorithm for CAT is determining the purpose of the test. An example of this is whether the test focuses on obtaining accurate point estimates of examinee ability (θ) or making broad decisions like classifying examinees

based on a cut score which will take a different approach in the development of the algorithm. These key concepts will help the proponents determine the proper approach to developing the FIS model.

3.5.2 Designing the model in accordance with the acquired principles and concepts

From the gathered information on the previous task, the proponents will design the chosen FIS model in accordance with the reviewed principles and concepts of Computerized Adaptive Tests (CAT). Specifically, the proponents will utilize the Fuzzy Inference System (FIS) using the Mamdani and Sugeno method with different membership functions. Models will be calibrated based on the suggested methods for the development of an item selection algorithm for a CAT and how it can be utilized on the developed web application.

3.5.3 Creation of the set of rules for the models

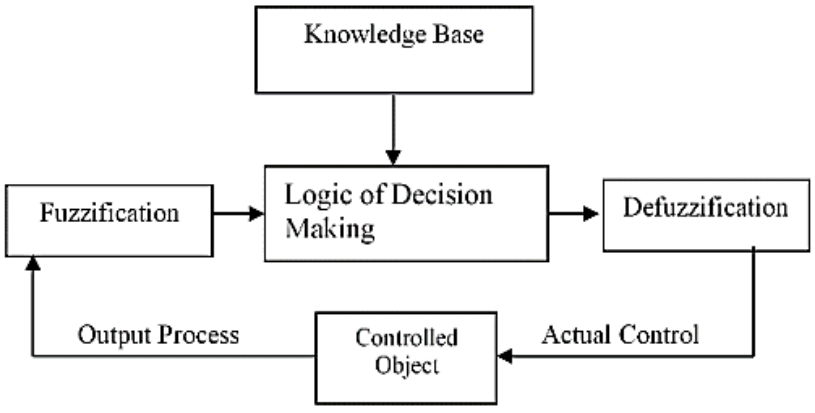


Figure 3.8 *Fuzzy Logic Control*

As shown in Figure 3.8, Fuzzy Logic Control (FLC) consists of four essential components. The four elements serve the following purposes [62]: (1) fuzzifier functions are utilized to convert crisp input signals to a fuzzy set using the fuzzifier operator. (2) the knowledge base consists of a database and a set of fundamental rules that establish fuzzy sets of input and output areas and organize them in the control rules. (3) decision making is fundamental to FLC, which can make human-like choices. Fuzzy implications and fuzzy inference techniques are utilized to infer fuzzy set actions. (4) defuzzification functions convert fuzzy set action inferences to actual actions. The fuzzy Inference System (FIS) model that will be used in the study, requires a set of rules to be used by the Knowledge Base. This set of rules is called the "rule base" which contains several fuzzy if-then rules [63]. In this study, the proponents will be formulating this set of fuzzy if-then rules, crisp input, and crisp output that is aligned with the game mechanics that will be implemented on the web application.

3.5.4 Performance comparison of the FIS models

After the set of fuzzy rules is established, the proponents will now apply these rules to the models. These sets of fuzzy if-then rules will be utilized by the model in order to determine the difficulty of the question based on the user's performance and ability. Also, the set of rules will help the model to determine what are the specific outputs it will be producing given a combination of input parameters defined by the proponents. Comparison and evaluation of the models will be performed to know which model is more accurate as an item selection algorithm for the system. The proponents

will consult professional/s to determine the specific tests and other evaluation methods to which both models are subjected.

3.5.5 Model evaluation and final selection

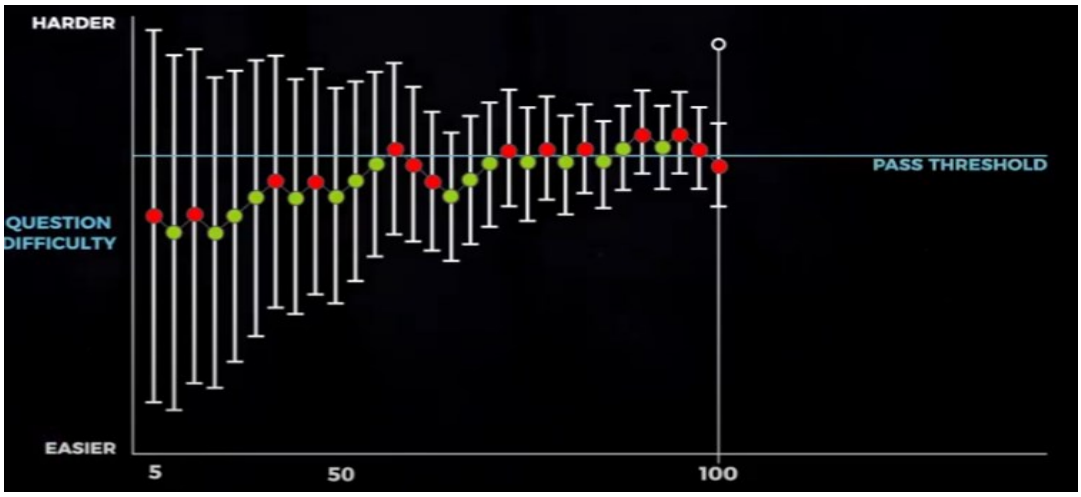


Figure 3.9 *Example Output Plot of the Model*

With the series of test comparisons and evaluations conducted among the Fuzzy Inference System (FIS) models as an adaptive item selection model for the web application, the model with better performance will be selected. An important consideration in this task is the accuracy of the model in giving the appropriate level of difficulty to the user based on his/her past performances. The algorithm shall depict the same functionality as shown in Figure 3.9. The level of difficulty of the next question decreases if the user answers the current question incorrectly and increases if the user answers the current question correctly. The same pattern applies until the user reaches a level of difficulty wherein the pass threshold lies, declaring that the user has already mastered a specific topic.

3.5.6 Flowchart illustration of the selected model

Before the development of the model, the proponents will construct a flowchart to map the functionality of the model. The diagram will help the proponents to determine what are the processes and decision-making that the model will be conducted to give the appropriate question with a certain level of difficulty based on the user's performance. The proponents will base the flowchart on the set of rules established for the model on the previous tasks. Moreover, additional parameters will be included in the model which employs the game mechanics of the web application. Creation of the reward system and termination criterion of the web application should be established in this task.

3.5.7 Development of the model based on the constructed flowchart

Using the constructed flowchart for the functionality of the model, the proponents will be developing the model based on the processes and decision-making plotted on the previous task. With the use of flow charts, the proponents will have a better visualization of how the input parameters yielded by the user travel through the system and know if the processes are consistent with the designed set of rules for the model.

3.5.8 Implementation of the model into the web application.

Using the flowchart mapped on the previous task, the proponents will now integrate the model into the web application. The algorithm for the other components

of the Computerized Adaptive Testing (CAT) and the gaming mechanics of the web application will be calibrated and adjusted based on the developed model of adaptive item selector algorithm.

3.5.9 Testing and Debugging

After implementing the model and finalizing the game mechanics of the system, the web application will be tested and debugged. This will assist the proponents in validating the produced model's functionality. Additional calibration and adjustment of the algorithm will be performed in this task if errors and bugs are discovered before, during, and after the testing of web application.

3.6 Effectivity of the Gamified LMS on the Engagement, Motivation, and Performance of the Users

In order to accomplish the third objective of this study, the proponents shall carry out the following processes:

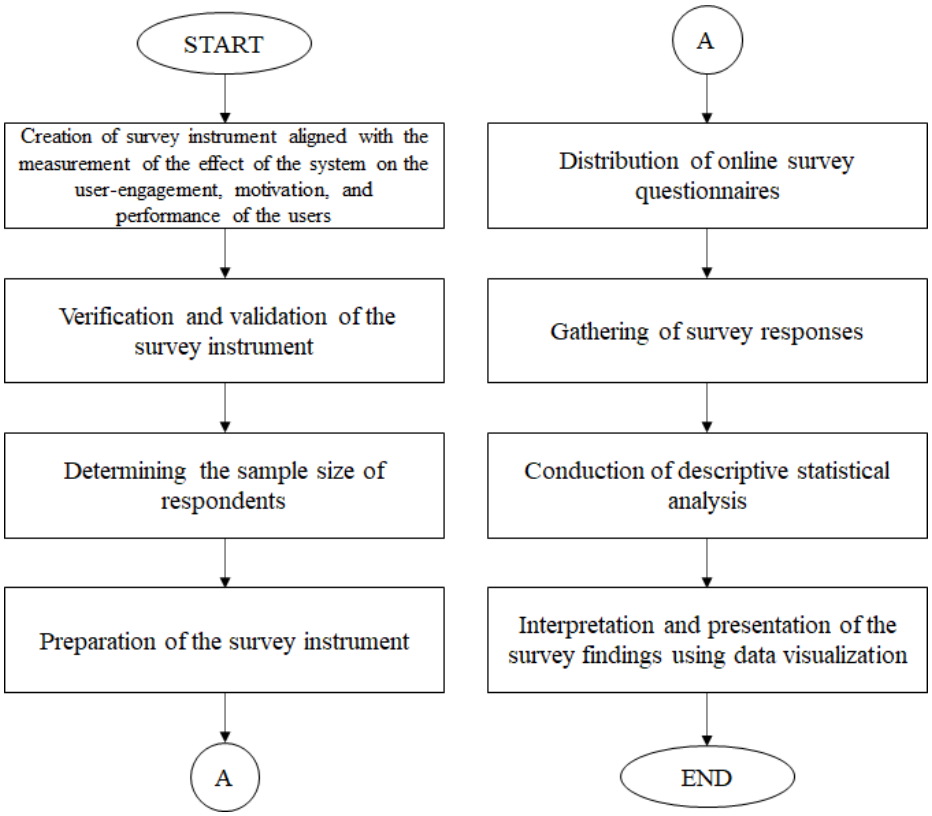


Figure 3.10 *Flowchart for Objective 3*

3.6.1 Development of the Survey Instrument Aligned with the Measurement of the Effect of the System on the User-Engagement, Motivation, and Performance of the Users

In this study, the proponents will use a structured questionnaire as the main data-gathering instrument. The survey will consist of three sections: (1) for the title of the study, introduction, and instruction; (2) for collecting socio-demographic data of the respondents such as name, email, and section; and (3) for collecting qualitative data on the participants' perception on the effect or their experiences on using the gamified LMS.

The survey to be presented should have a concise explanation of the purpose of the study and clear instructions on how to fill it. Twenty-seven (27) survey statements and five (5) open-ended questions aligned with the objective of the study will be constructed to measure the effect of the system on the user's engagement, motivation, and performance. Moreover, a five-point Likert scale (e.g., strongly agree, agree, neutral, disagree, strongly disagree) will be employed. In order to evaluate the effects of using the system of ECEdemy on the expert, fourteen (14) survey questions will also be developed.

3.6.2 Verification and Validation of the Survey Instrument

After the drafted survey instrument has been developed, it will undergo validation and verification. To establish the validity extent, suitability, and appropriateness of the questionnaire, the proponents will consult professional/s who will review and analyze whether the drafted survey instrument measures what it is intended to measure and who will ensure that the survey does not contain common errors such as leading, confusing, or double-barreled questions. If comments and suggestions were given, the proponents will have to revise the questionnaire accordingly and resubmit it with either minor corrections or major changes. Once the draft of the survey instrument has been approved, the proponents can now prepare the questionnaire for distribution.

3.6.3 Sample Size of Respondents

The respondents of this study will consist of at most one hundred (100) students, consisting of 4th year, 3rd year, and graduating Electronics Engineering (ECE) students from Technological University of the Philippines – Manila; as well as alumni who wish to take the board exam this year 2022 or next year.

The proponents will use a non-probability sampling technique, specifically the purposive and convenience sampling techniques to determine the respondents. Purposive sampling is a type of sampling technique wherein the respondents are chosen to be part of the sample with a specific purpose in mind. On the other hand, convenience sampling is where the respondents are selected because of their convenience and accessibility.

3.6.4 Survey Instrument Preparation

The proponents will create the survey instrument using Google Form after finalizing the validated survey questionnaire. The proponents may edit the Google Form Questionnaire in three ways: Question Field, in which the survey instrument is displayed; Topic Format, which refers to the way the questions are presented such us in the form of text, image, or video format; and Reply Format, which is the most common way of presenting a questionnaire based on the user's text input. With these in mind, the proponents will use the Reply Format for the Google form's content. It includes a short answer option for their credentials like respondents' names and email addresses (optional) and survey questionnaires with a five-point Likert scale to apply a linear scale.

3.6.5 Online Survey Questionnaires Distribution

After the creation of the form, it will be disseminated to the respondents for whom the questionnaire is intended to be. The proponents can send it through email or social media or embed it into the webpage. Upon exploring and testing the model, the respondents will have to evaluate their experience or perception of using the system based on the user's engagement, motivation, and performance through the provided form.

3.6.6 Collection of Survey Responses

To know the effect of the gamified LMS on user-engagement, motivation, and performance of the users, the data were collected through a self-made and adapted questionnaire administered to the selected respondents. After filling out the online survey in Google Form, the responses of the respondents will be recorded into the system and can be viewed through the website itself or Google Excel. The collected biographical data and corpus will be treated with utmost confidentiality.

3.6.7 Conduction of Descriptive Statistical Analysis

The raw data gathered in this study will be subjected to descriptive statistical analysis. Descriptive statistics will allow the proponents to describe and interpret the quantitative analysis of the data using data visualization when analyzing the significant effect of the gamified LMS on its users in terms of performance, motivation, and user engagement. Statistical tools such as the measures of tendency and dispersion will be

employed to characterize the different categories or sets of data. In this way, proponents may see patterns emerging from the collections of responses from the users.

3.6.8 Interpretation and Presentation of the Survey Findings using Data Visualization

After describing the samples using the statistical tools, the proponents can now characterize the data by converting it into its visual representation to make it clear and cohesive. The presentation of the summary of the data could be through the use of tables, charts, or graphs. In this way, proponents may see patterns emerging from the collections of responses from users and establish an understanding of the data.

3.7 Gannt Chart

Task	2021										2022					
	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Brainstorming and idealization of the topic																
Topic Consultation																
Gathering facts about the topic and researching on related studies/																

literature																
Chapter 1: The Problem and Its Setting																
Chapter 2: Review of Related Literature																
Chapter 3: Methodolo -gy																
Title Defense																
Prototypin g																
Progress Defense																
Chapter 4: Results and Discussion																
Pre-Final Defense																
Chapter 5: Summary of Findings, Conclusion , and Recommen dation																
Final Defense																

Chapter 4

RESULTS AND DISCUSSION

This chapter contains the presentation, analysis, and interpretation of data in order to answer the objectives of this project study. Conclusions were drawn based on the results obtained.

4.1 Project Technical Description

"Development of a Gamified Learning Management System for ECE Subjects Through Utilization of Fuzzy Inference System (FIS) Models for Effective Learning" aims to produce a gamified LMS that serves as a licensure exam reviewer tool containing a database of questions based on the ECE licensure exam.

The web application comprises of front-end and back-end development. Using Visual Studio Code, HTML, CSS, and JavaScript make up the frontend, while Django was utilized for the latter to configure the user database with account authorization, questions and answers database, and the quiz app itself. The proponents used the KaTeX support extension for Python Markdown, too. The integrated solutions can be used in Node.js to pre-render the expression and serve it as plain HTML.

In order to create the Mamdani and Sugeno Fuzzy Inference System (FIS) models, the proponents used a python built-in library called *Simpful*. *Simpful* supports Probabilistic, Mamdani and Sugeno reasoning of any order, parsing any complex fuzzy rules involving AND, OR, and NOT operators, using arbitrarily shaped fuzzy sets. In the membership functions, the inputs are User's Response and User's Streak while the output is the

Calibrated Item Question. A set of rules is created using the membership functions of the input and output.

4.2 Development of the Gamified LMS Web Application for ECE Licensure Exam

The proponents were able to construct, gather, and sort at least 4,000 possible questions to be included on the web application by using various review materials such as books, eBooks, and board exam reviewers based on the scope of the ECE licensure exam.

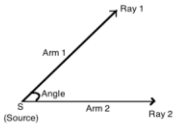
Question	Choices	Answer	Solution	Subject	Subtopic	Level
1. The union of two non-collinear rays with some common end point is called	A. Vertex B. Angle C. Degree D. Radius	B. Angle	An angle is the union of two noncollinear rays with a common endpoint. The common endpoint is called the vertex of the angle, and the rays are called the sides of the angle. https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	1
2. In an angle, the rays of the angle are known as	A. Arms B. Vertex C. Point of intersection D. Initial side	A. Arms	The two rays which have common initial point and form an angle between them are known as arms of angle.  https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	2
3. By rotating a ray from one position to another to make an angle, the original position is called	A. Initial side B. Terminal side C. Point of intersection D. Vertex	A. Initial side	We can interpret an angle by rotating a ray from one position to another. When we use this interpretation of an angle, the ray to begin with is called the initial side, and the final position of ray is called the terminal side. https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	1

Figure 4.1 *Preview of questions based on the scope of the ECE Licensure Exam: Math, ELEX, ESAT, and GEAS*

4.2.1 Answers and Solutions for each Question

Every question/problem gathered comes with a solution for the learner to further understand the course material. Although not all of them have solutions available, the proponents are able to provide them with the guidance of professors and/or Electronics Engineers (ECE).

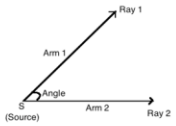
Question	Choices	Answer	Solution	Subject	Subtopic	Level
1. The union of two non-collinear rays with some common end point is called	A. Vertex B. Angle C. Degree D. Radius	B. Angle	An angle is the union of two noncollinear rays with a common endpoint. The common endpoint is called the vertex of the angle, and the rays are called the sides of the angle. https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	1
2. In an angle, the rays of the angle are known as	A. Arms B. Vertex C. Point of intersection D. Initial side	A. Arms	The two rays which have common initial point and form an angle between them are known as arms of angle.  https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	2
3. By rotating a ray from one position to another to make an angle, the original position is called	A. Initial side B. Terminal side C. Point of intersection D. Vertex	A. Initial side	We can interpret an angle by rotating a ray from one position to another. When we use this interpretation of an angle, the ray to begin with is called the initial side, and the final position of ray is called the terminal side. https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	1

Figure 4.2 *Preview of answers and solutions of the given problem*

4.2.2 Number of Difficulty Levels in Categorized Questions

The proponents decided to organize a 9-level difficulty of questions, consisting of at least 50 questions each level. Take note that there will be at least 1,000 initial questions for every major subject (MATH, ELEX, ESAT, and GEAS) to ensure that users are presented with a random assortment of questions each time the learners try to play a game. This will also be enough in order to pass or master each subtopic.

4.2.3 Tagging of the Questions

Tagging of questions is based on how time-consuming the solutions are and how complex the problems are to grasp, as comprehended by the proponents and later will be verified by the professors and/or engineers.

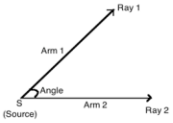
Question	Choices	Answer	Solution	Subject	Subtopic	Level
1. The union of two non-collinear rays with some common end point is called	A. Vertex B. Angle C. Degree D. Radius	B. Angle	An angle is the union of two noncollinear rays with a common endpoint. The common endpoint is called the vertex of the angle, and the rays are called the sides of the angle. https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	1
2. In an angle, the rays of the angle are known as	A. Arms B. Vertex C. Point of intersection D. Initial side	A. Arms	The two rays which have common initial point and form an angle between them are known as arms of angle.  https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	2
3. By rotating a ray from one position to another to make an angle, the original position is called	A. Initial side B. Terminal side C. Point of intersection D. Vertex	A. Initial side	We can interpret an angle by rotating a ray from one position to another. When we use this interpretation of an angle, the ray to begin with is called the initial side, and the final position of ray is called the terminal side. https://mcqlearn.com/math/g10/measurement-of-angles-mcqs.php	MATH - Trigonometry	Angle and Angle Measure	1

Figure 4.3 *Tagging of the questions based on their level of difficulty.*

4.2.4 Finalization of the Verified Questions with Corresponding Solutions and Creation of a Database using Django

The quiz component of the web application is done but still, the proponents are exploring additional features that could be employed to meet the functional requirements of the quiz application. Additionally, the proponents created a table for the database including the question and answer wherein each item can be appropriately tagged in the questions and answer database.

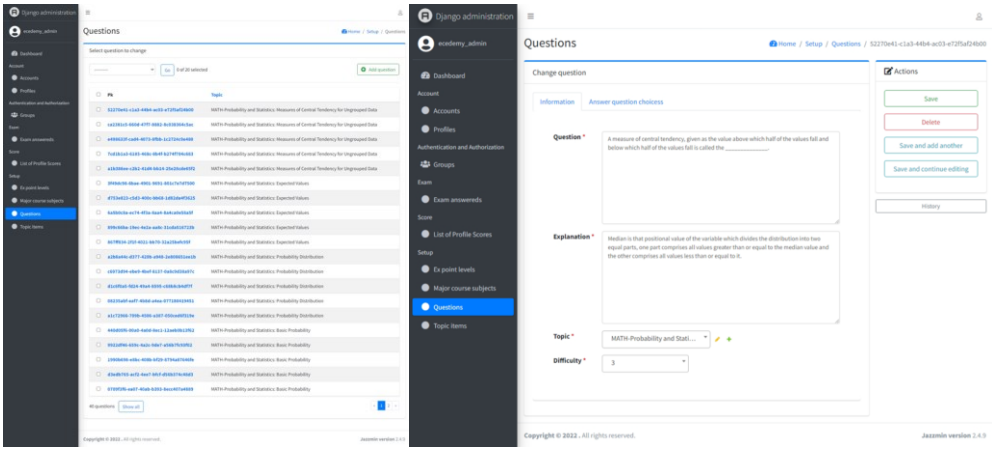


Figure 4.4 *Database for Questions and Answers in Admin Interface*

4.2.5 Wireframes of User Interface for Prototyping

Several user interface wireframes were designed and drafted for prototyping to establish a platform that incorporates gamification into a learning management system (LMS). The wireframes made for the said platform include the web pages for the login, registration, home, gameplay, profile, report, hall of fame, and overview of the progress as shown in the figures below.

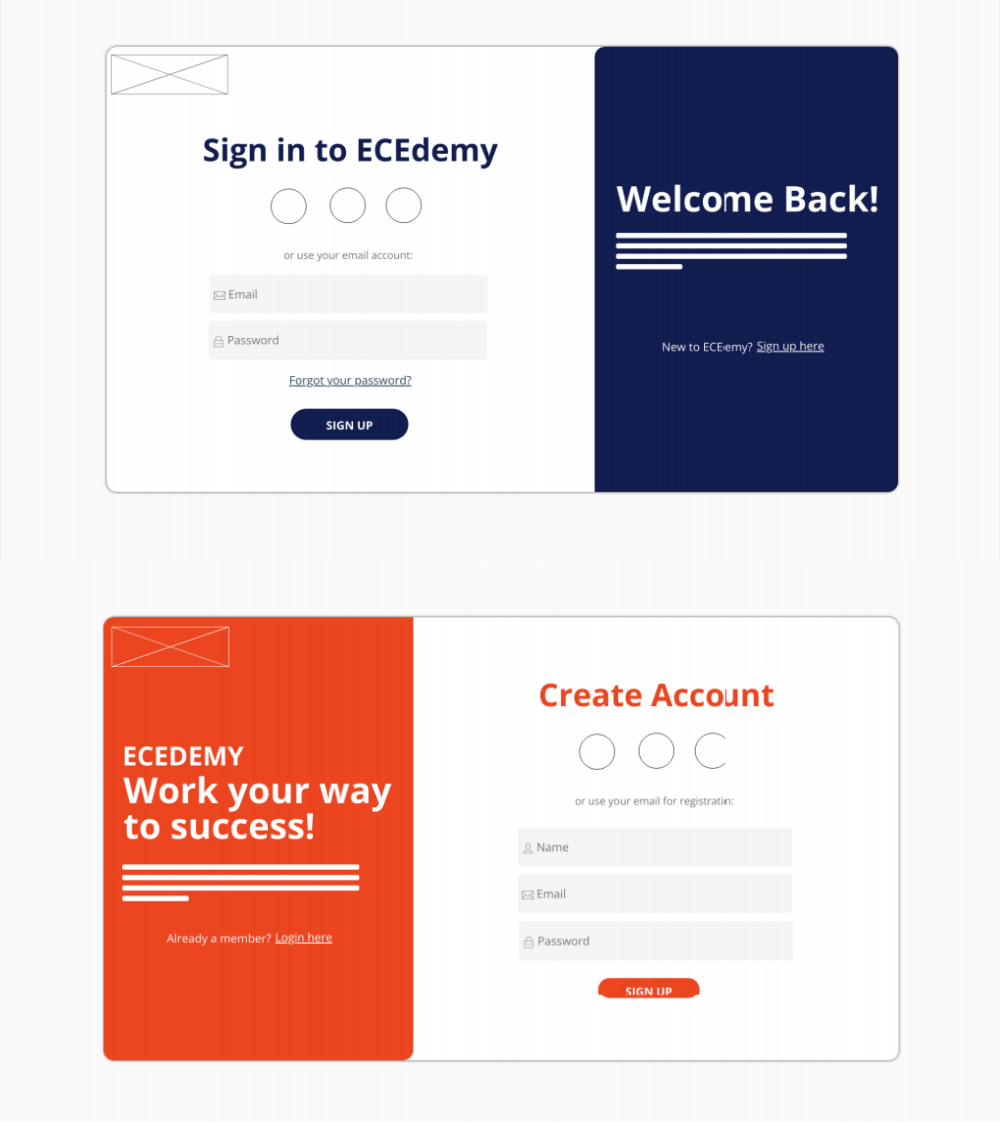


Figure 4.3 *Wireframe for Login and Register Page*

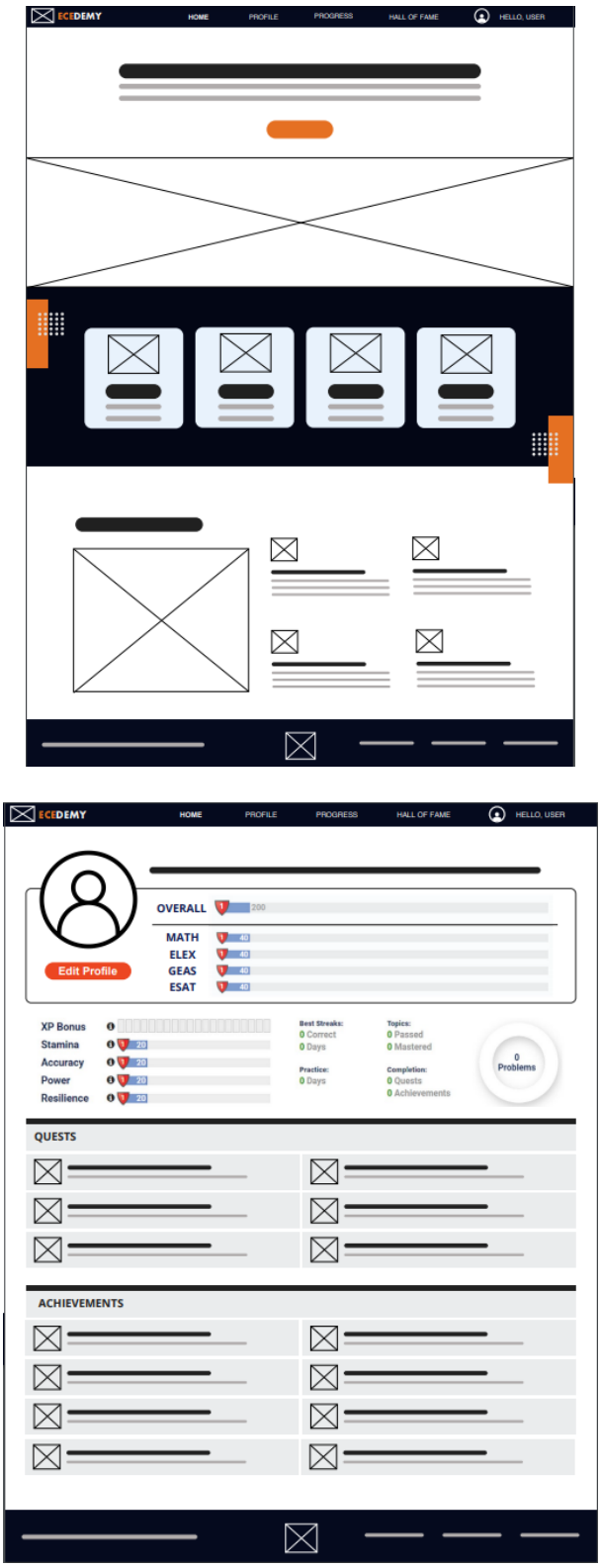


Figure 4.4 *Wireframe for Homepage and Profile Page*

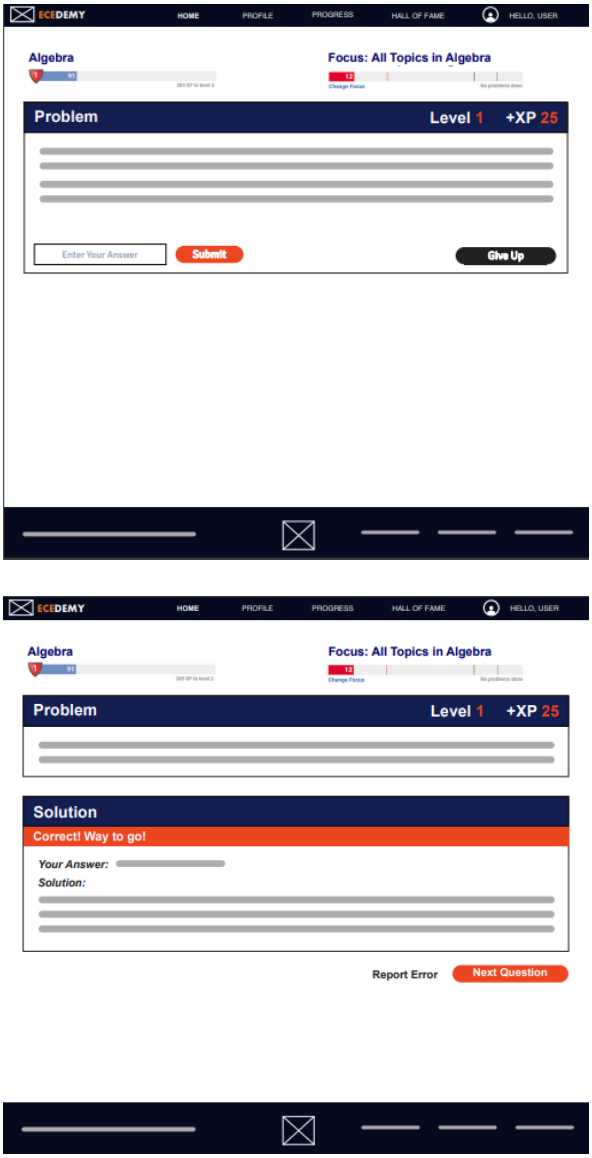


Figure 4.5 *Wireframe for Play Page (Problem and Solution)*

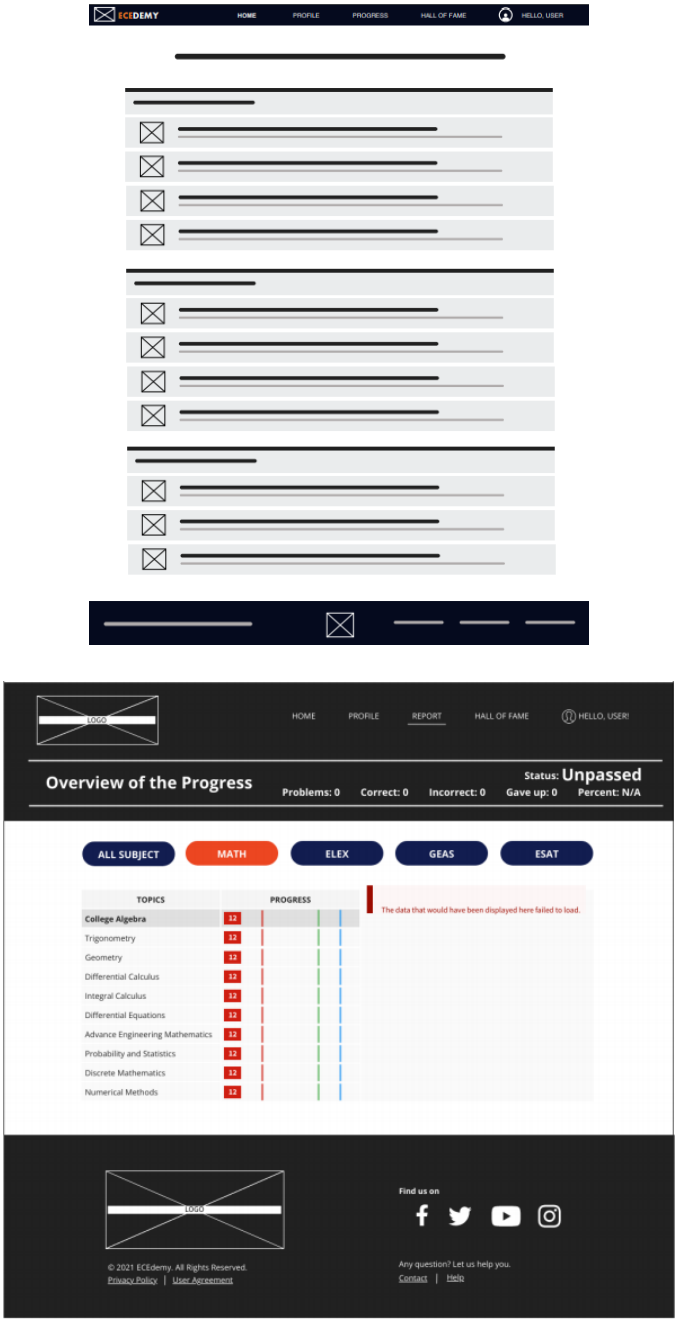


Figure 4.6 *Wireframe for Leaderboards and Overview of the Progress Page*

4.2.6 Coded Web Pages and Design of the Web Application

The proponents were able to develop the web pages required for establishing the platform by utilizing Visual Studio Code as the primary programming software.

The frontend of the gamified learning management system (LMS) was prototyped and built using HTML5 to structure the web pages and their contents, CSS to design the system's web pages, and JavaScript to make the web pages interactive. On the backend, the proponents used Django, an open-source Python web framework, to create a website that is quick to develop, pragmatic, maintainable, has a clean design, and is secure. The codes as well as the built web pages were shown below.

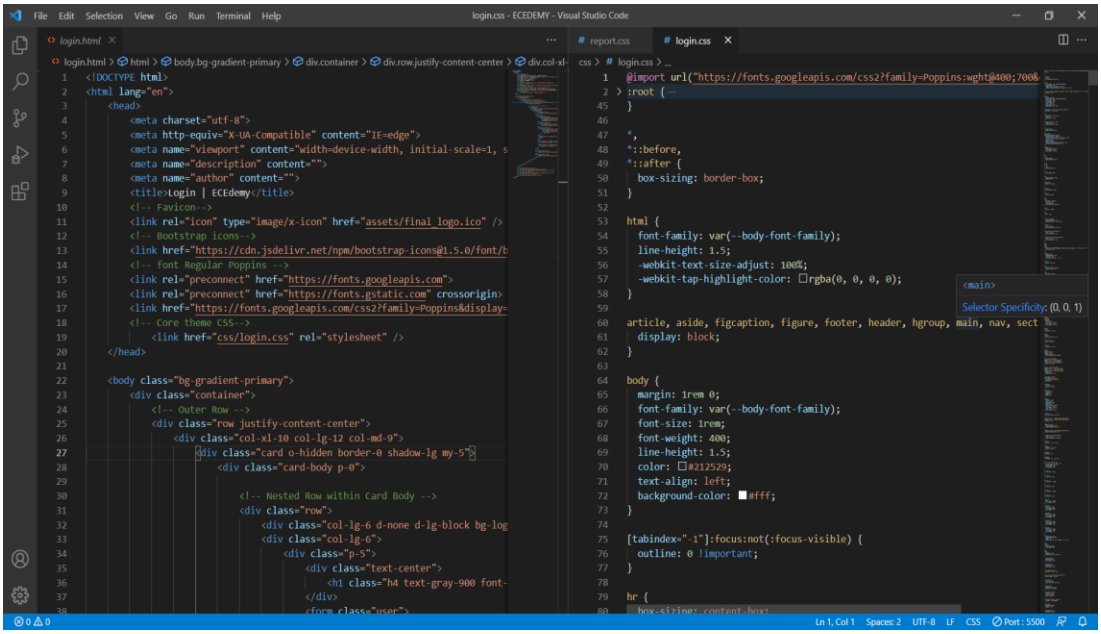


Figure 4.7 *HTML and CSS Codes for Login Page*

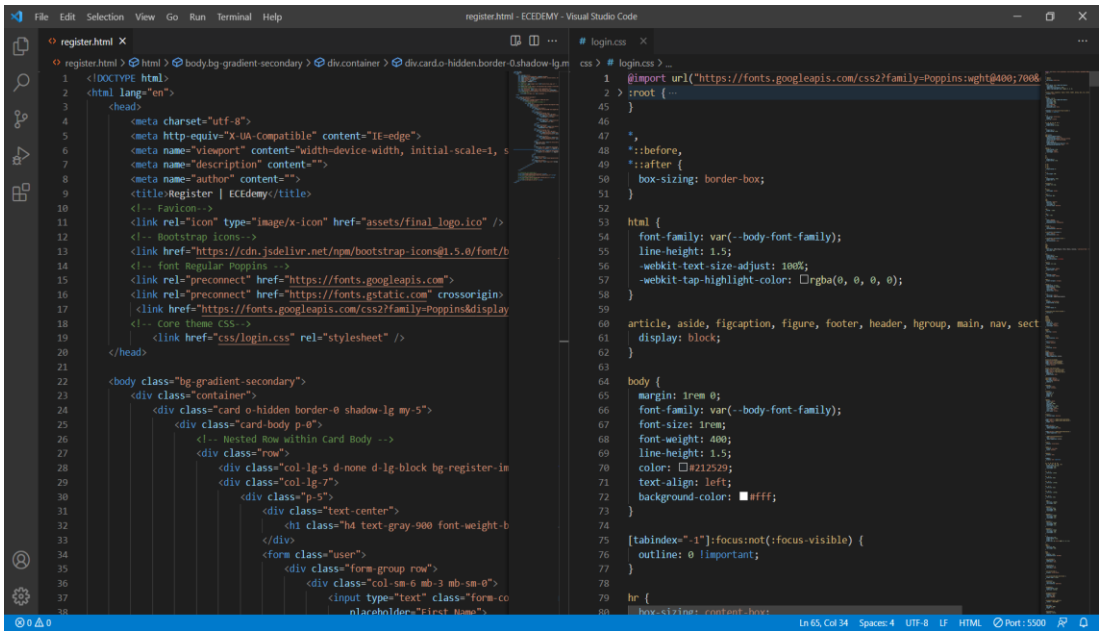


Figure 4.8 *HTML and CSS Codes for Register Page*

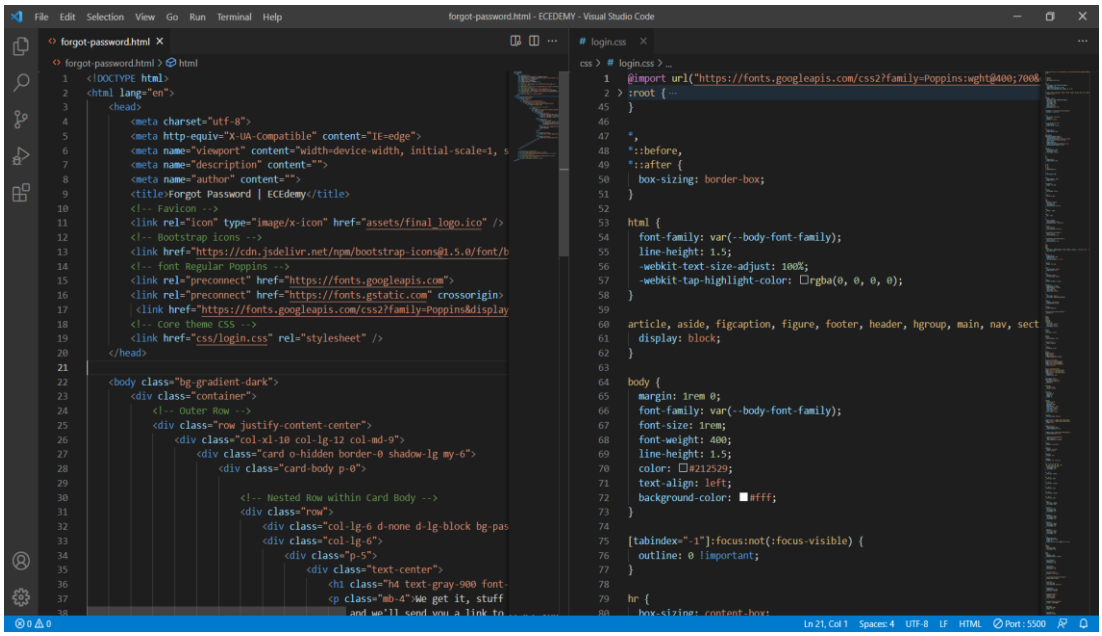


Figure 4.9 *HTML and CSS Codes for Forgot Password Page*

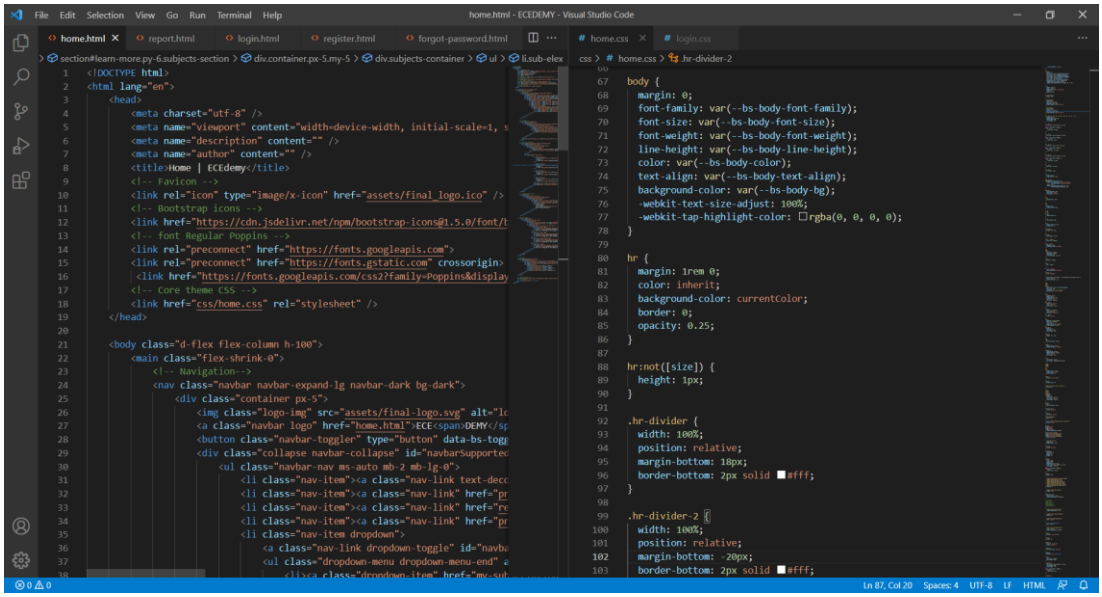


Figure 4.10 *HTML and CSS Codes for Home Page*

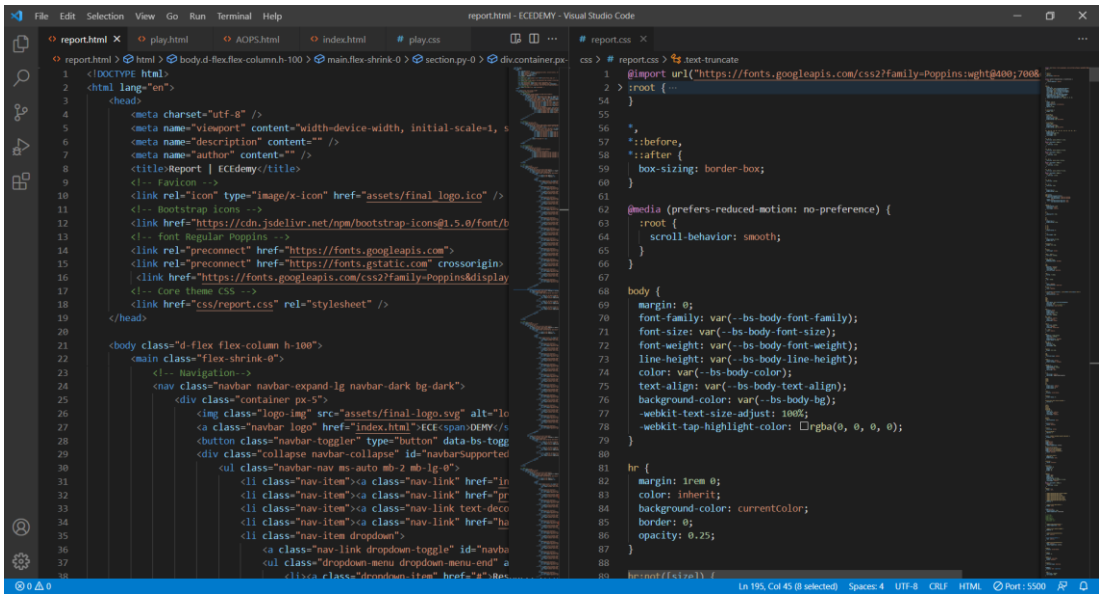


Figure 4.11 *HTML and CSS Codes for Progress Report Page*

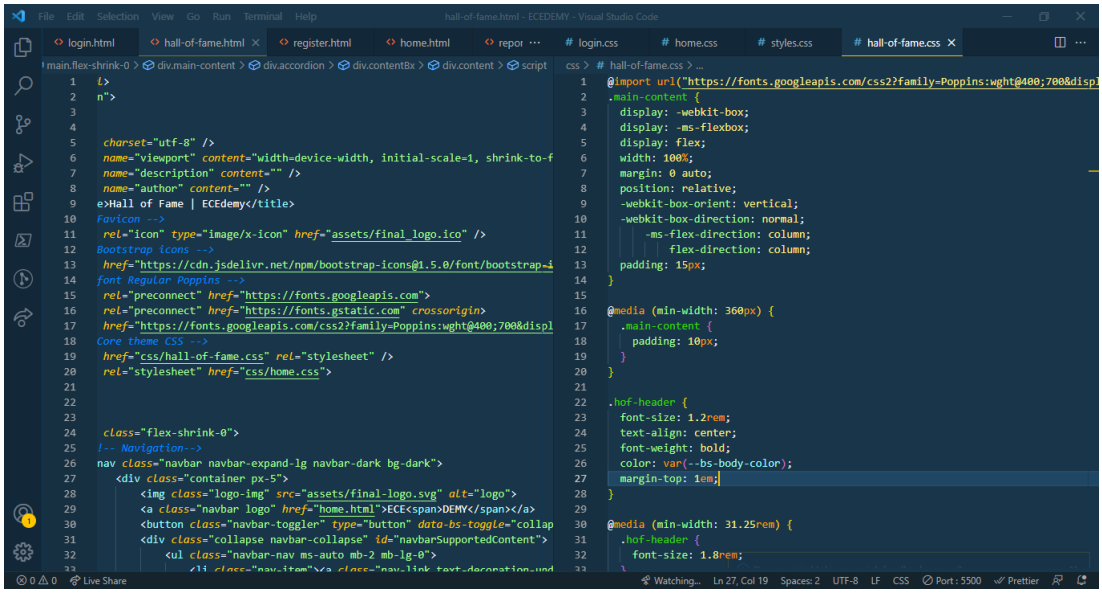


Figure 4.12 *HTML and CSS Codes for Hall of Fame Page*

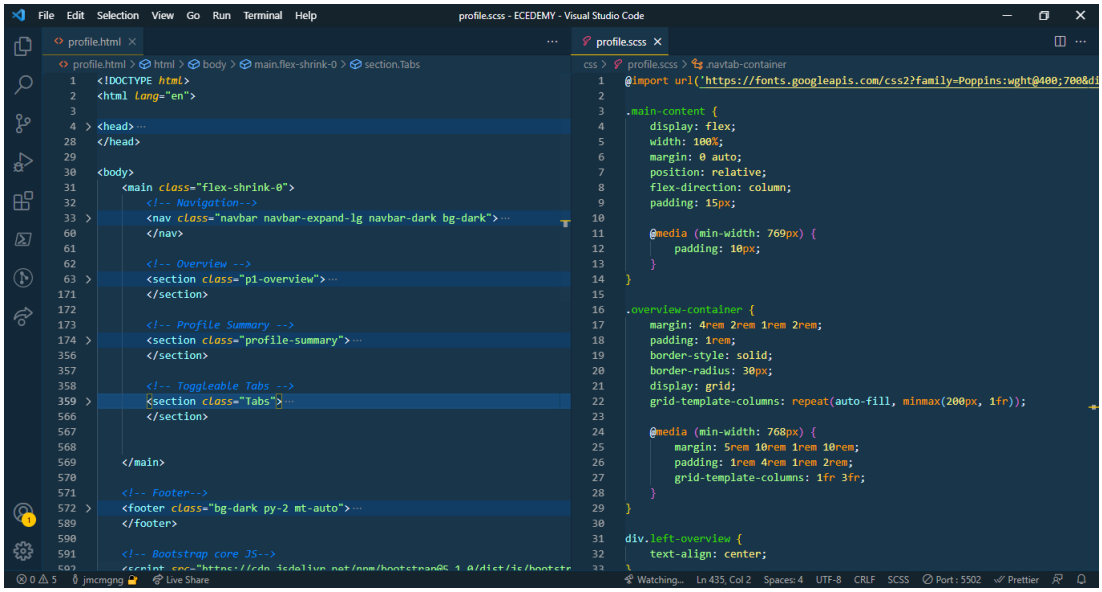


Figure 4.13 *HTML and CSS Codes for Profile Page*

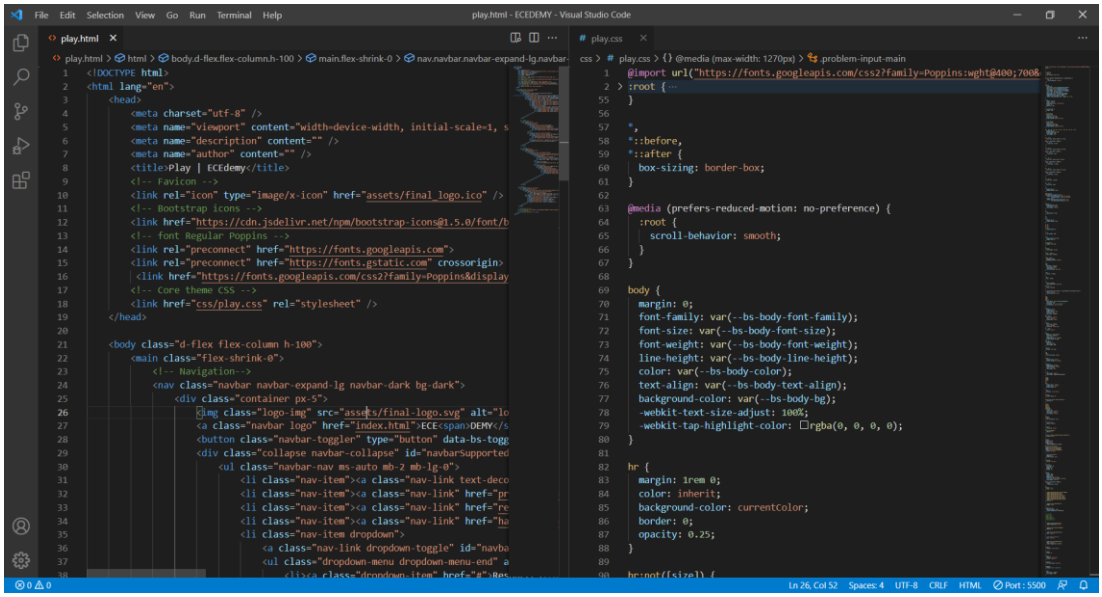


Figure 4.14 *HTML and CSS Codes for Play (Question) Page*

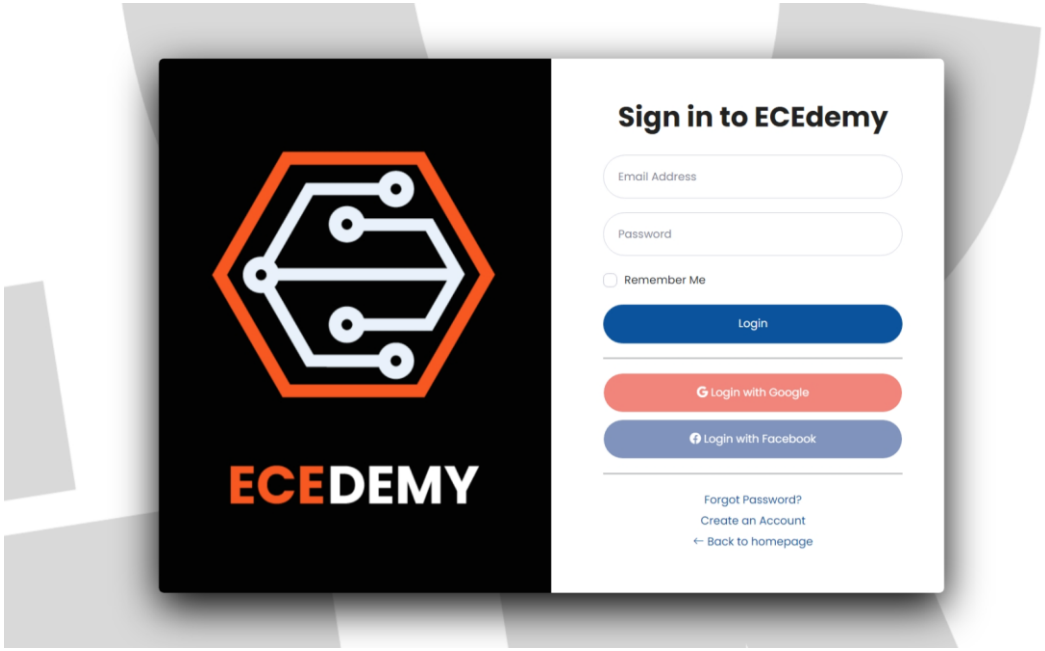


Figure 4.15 *Web Pages Created: Login Page*

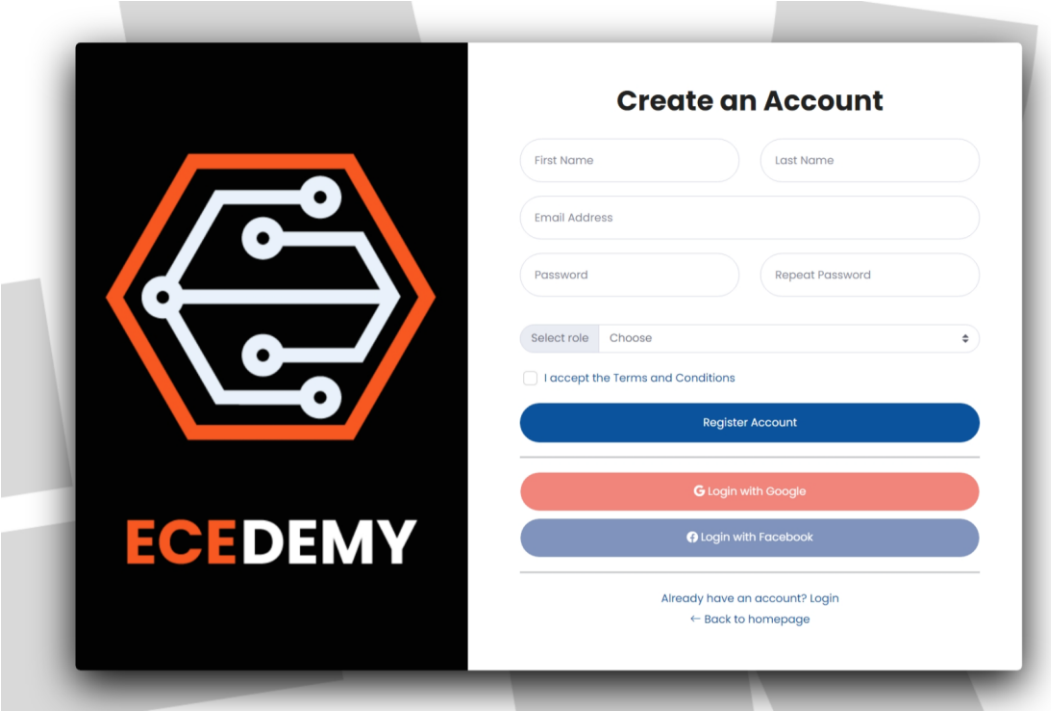


Figure 4.16 *Web Pages Created: Register Page*

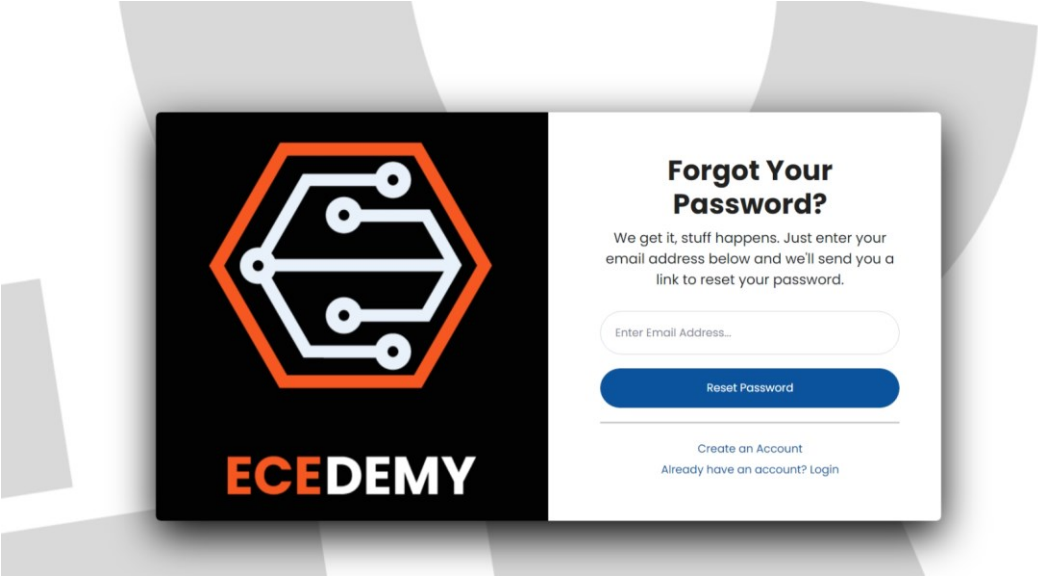


Figure 4.17 *Web Pages Created: Forgot Password Page*

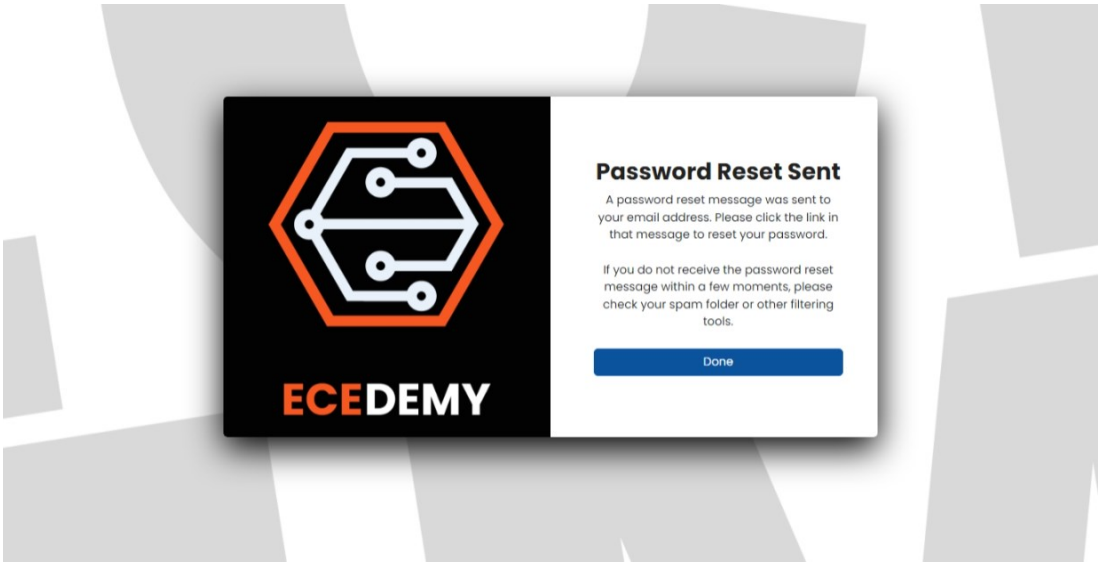


Figure 4.18 *Web Pages Created: Password Reset Sent*

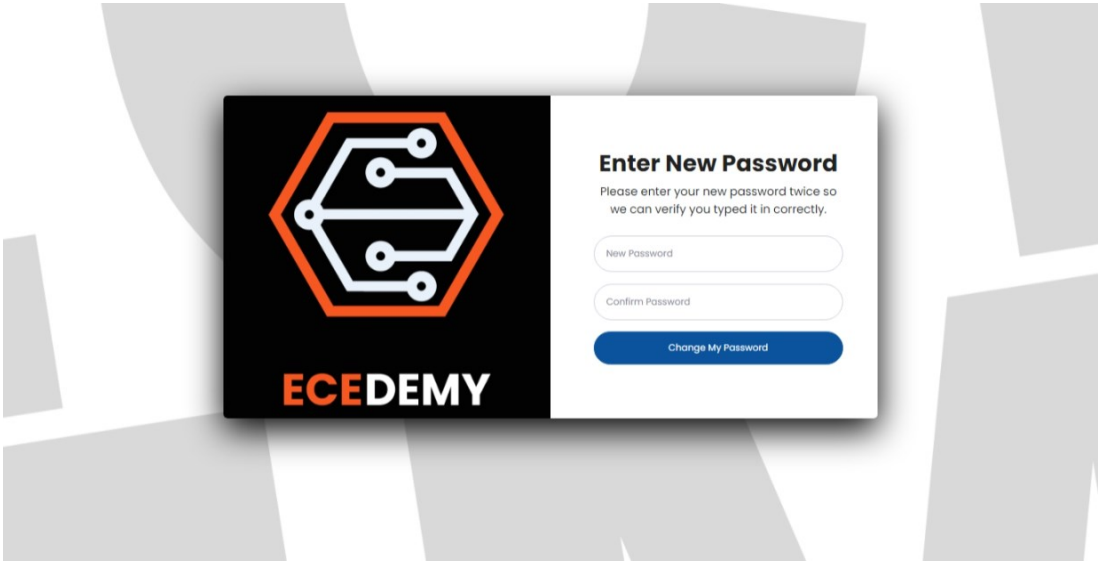


Figure 4.19 *Web Pages Created: Enter New Password*

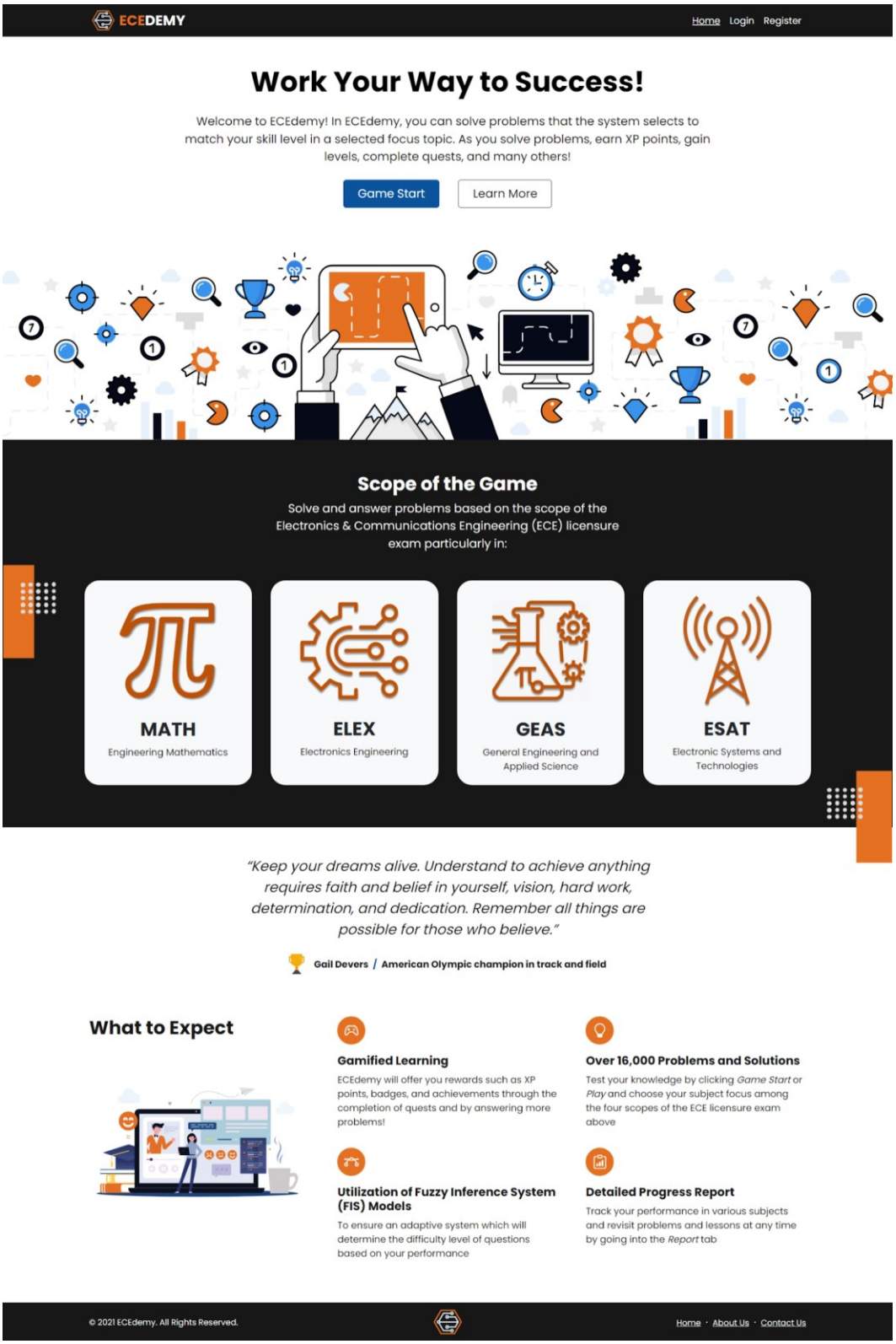


Figure 4.20 *Web Pages Created: Home Page*

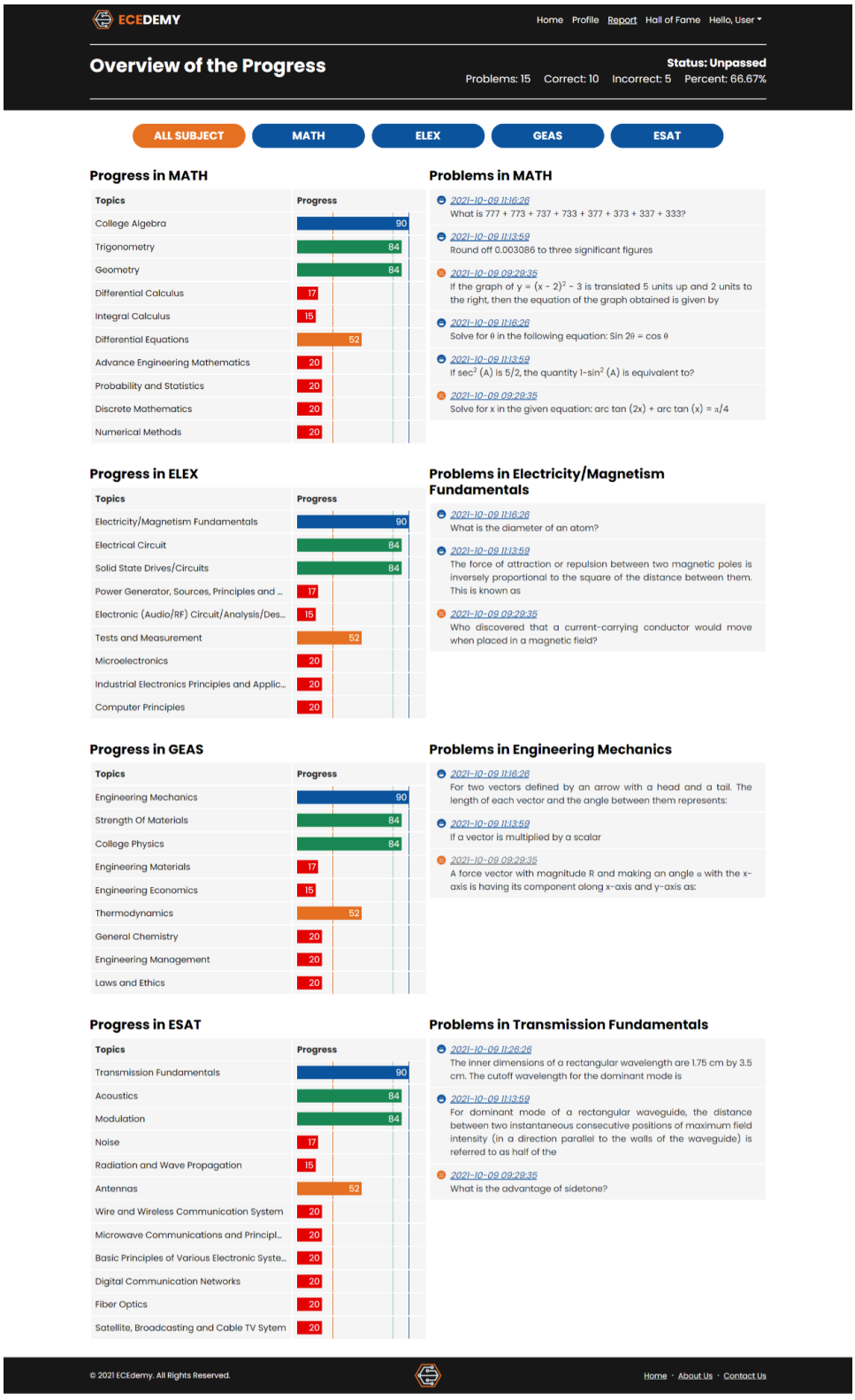


Figure 4.21 *Web Pages Created: Progress Report Page - Subject Focus*

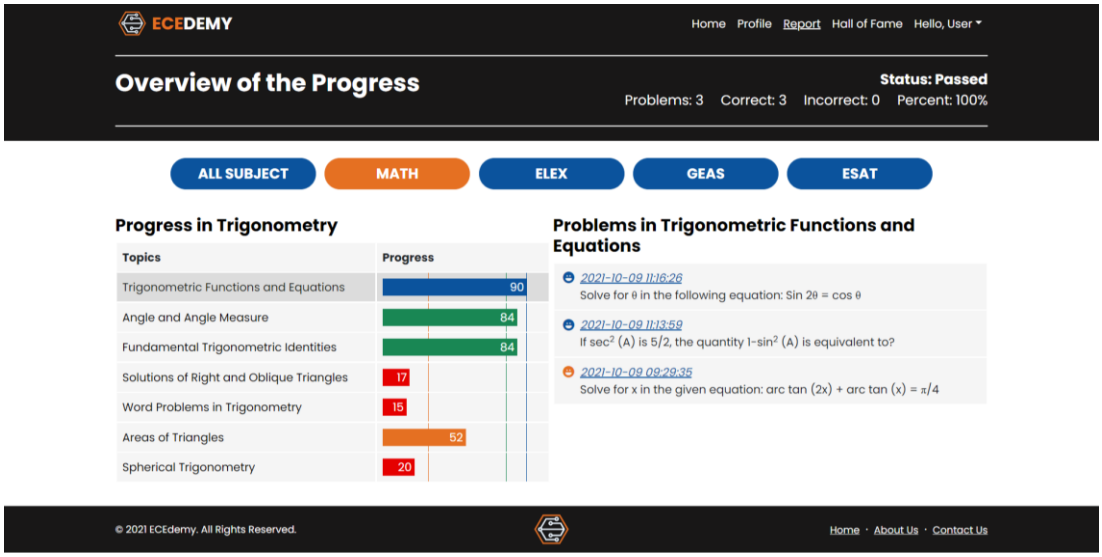


Figure 4.22 *Web Pages Created: Progress Report Page - Subtopic*

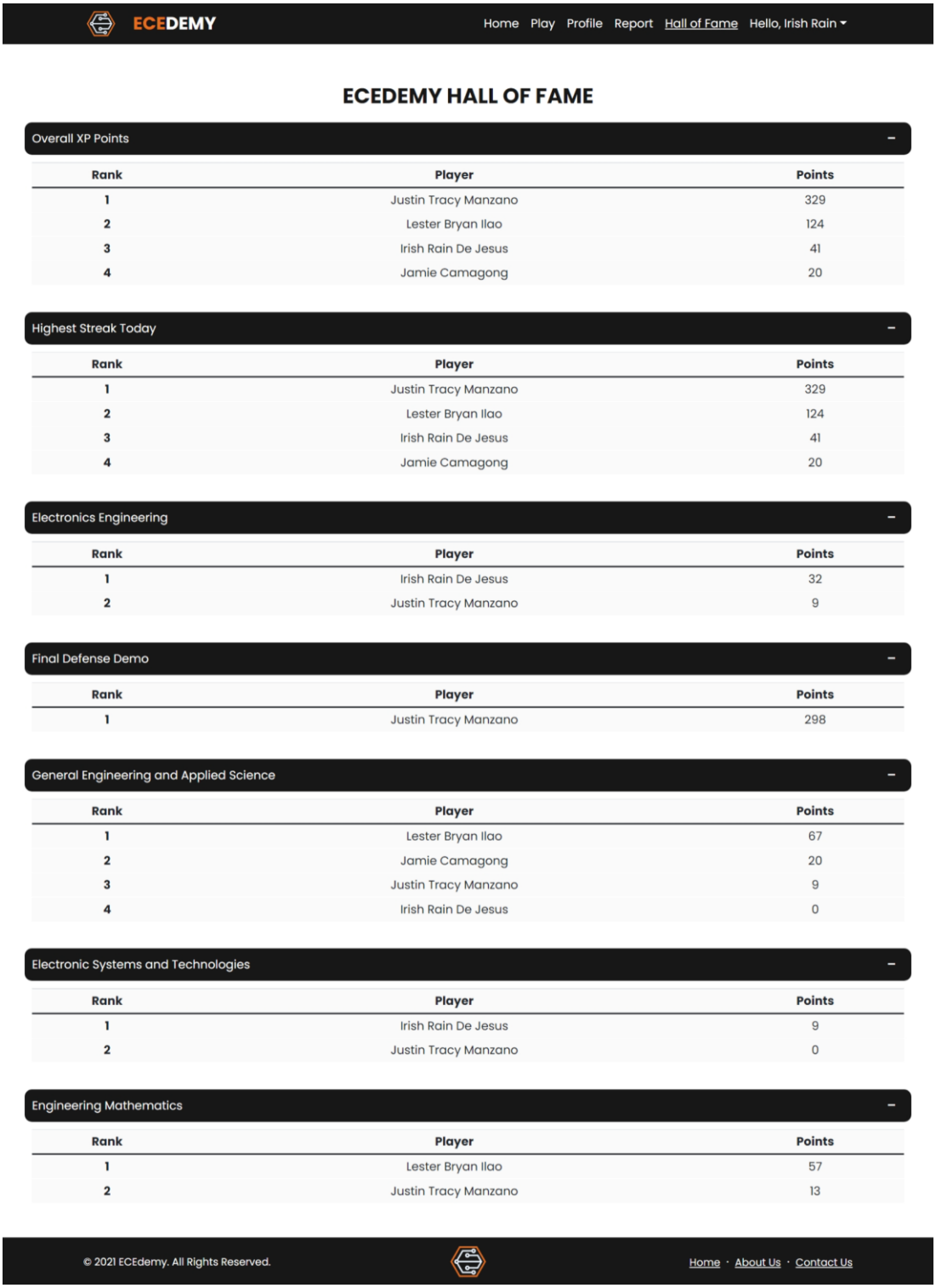


Figure 4.23 *Web Pages Created: Hall of Fame Page*

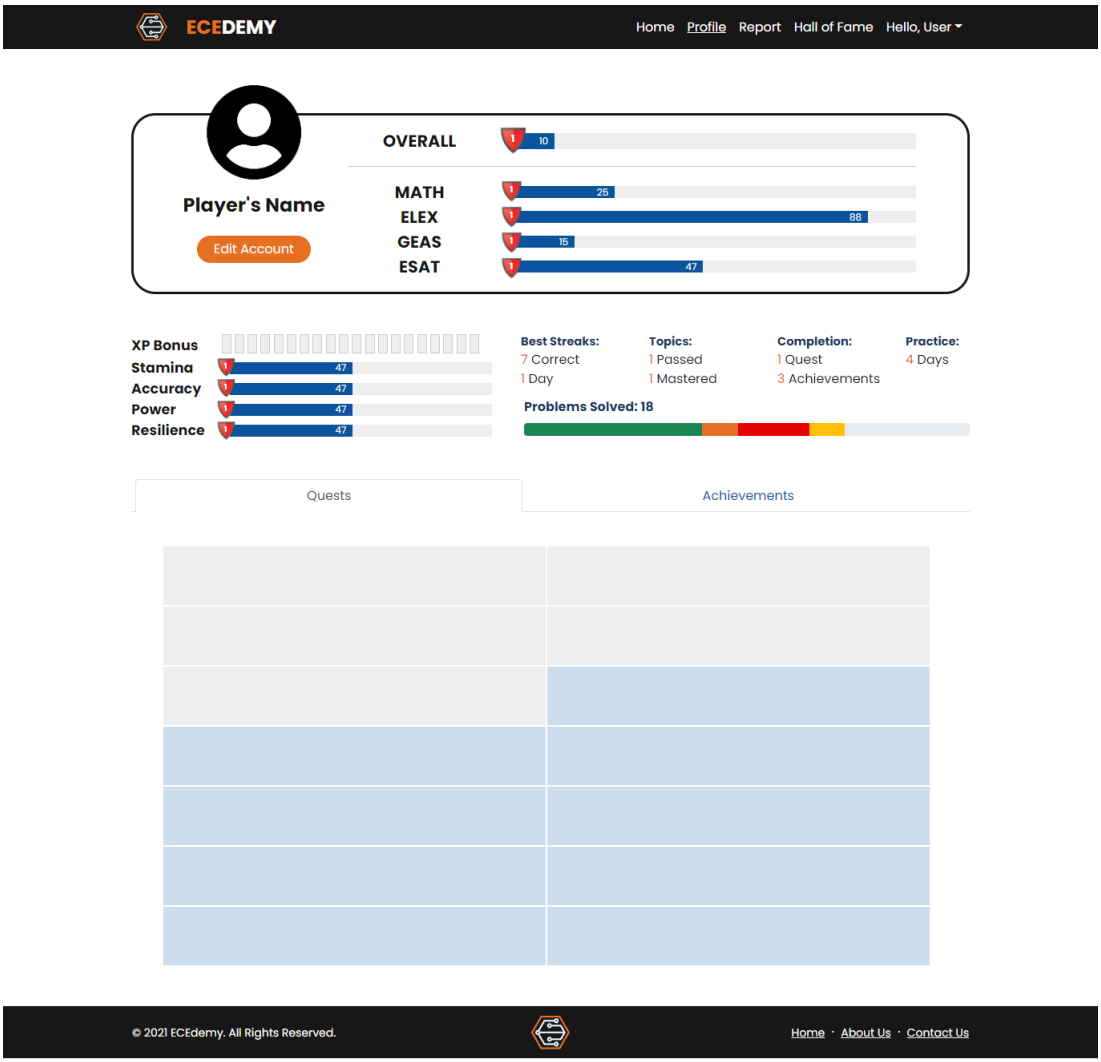


Figure 4.24 *Web Pages Created: Profile Page*

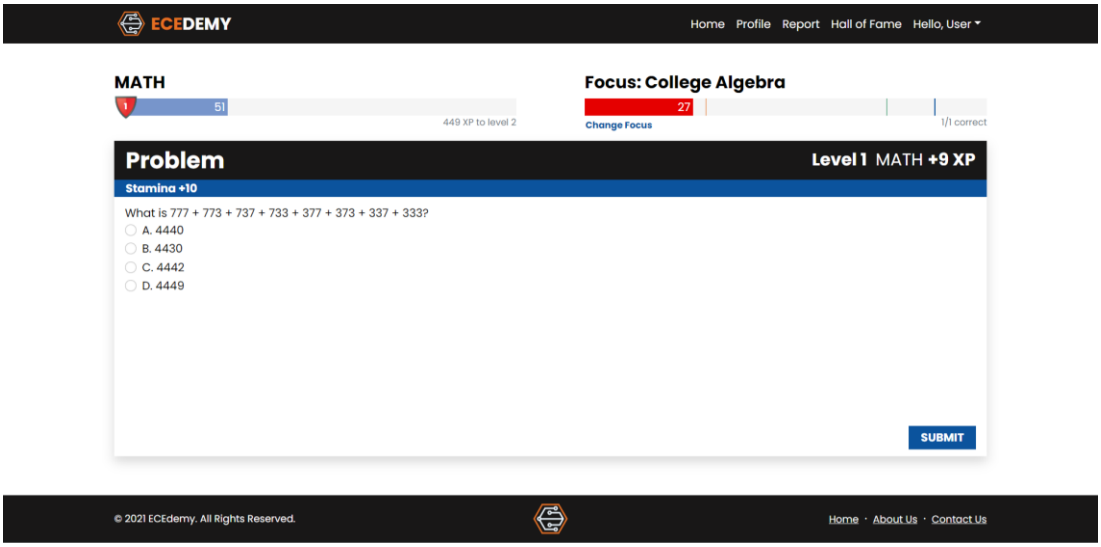


Figure 4.25 *Web Pages Created: Play (Question) Page*

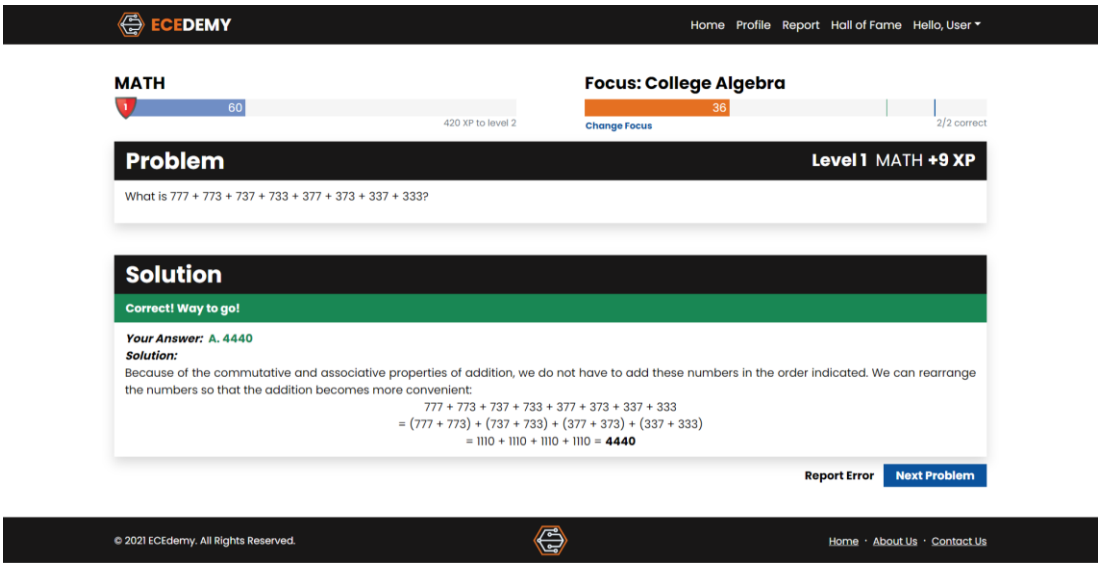


Figure 4.26 *Web Pages Created: Play (Solution) Page*

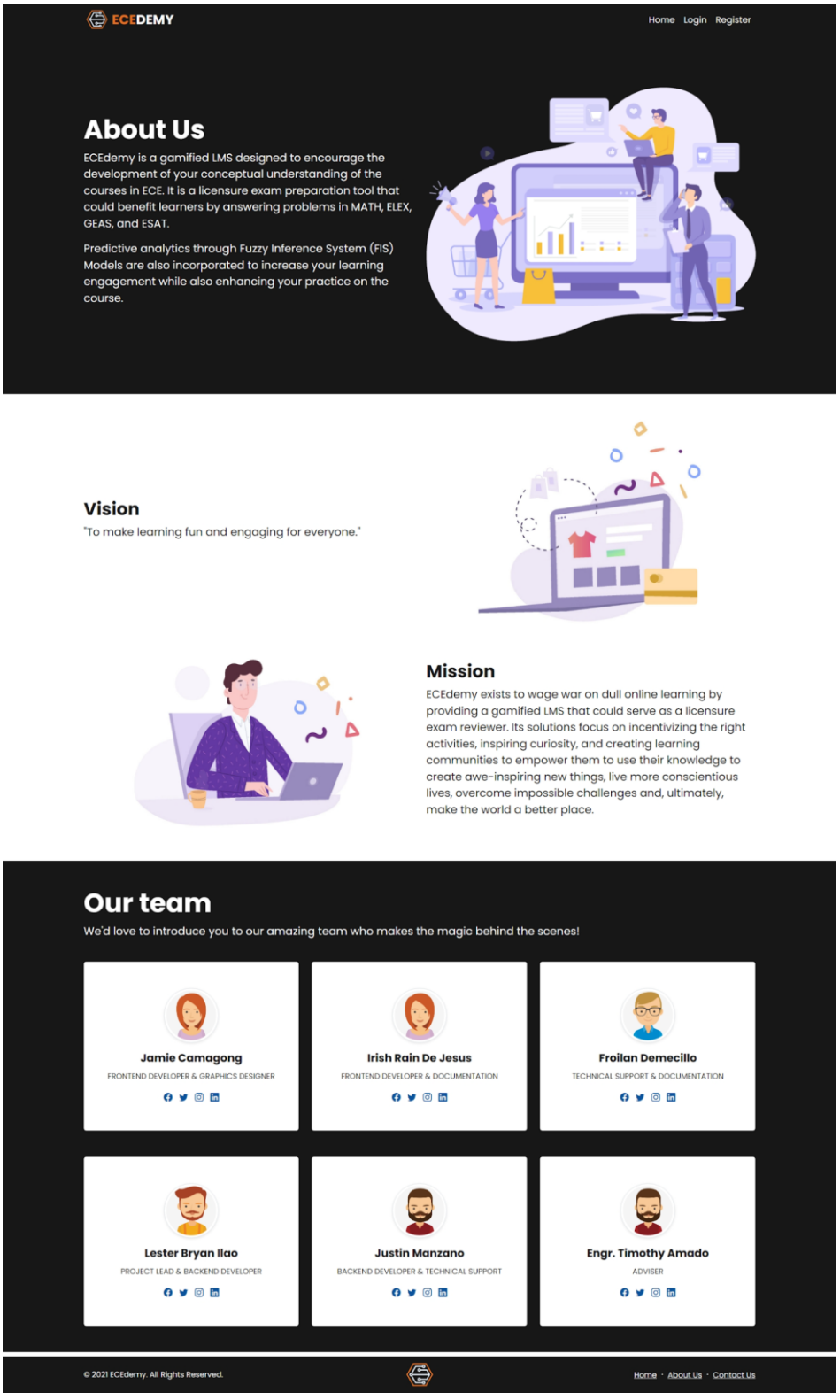


Figure 4.27 *Web Pages Created: About Us*

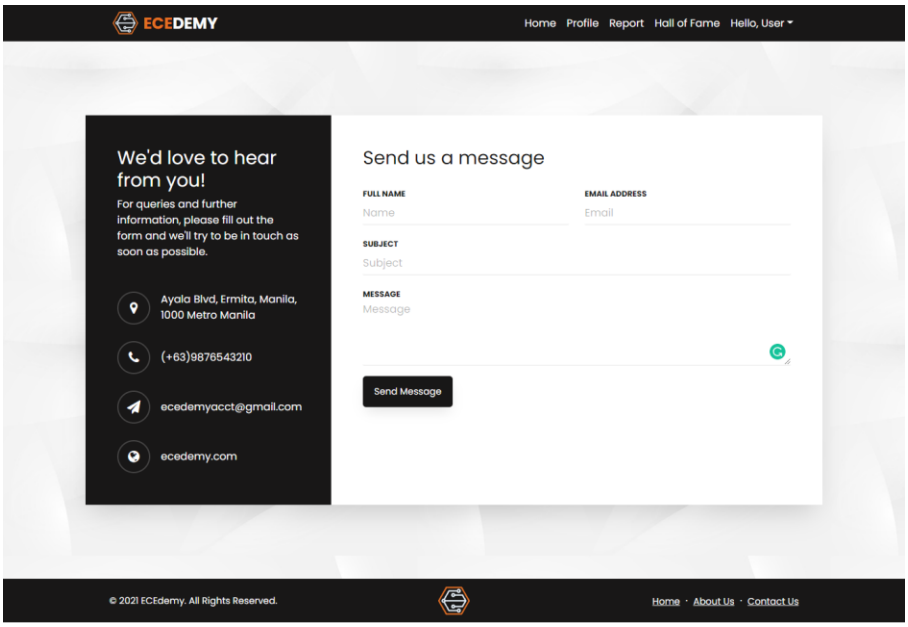


Figure 4.28 *Web Pages Created: Contact Us*

4.2.7 User Database

Using Django, the proponents were able to employ a database to store all the data entered by the users into the web application.

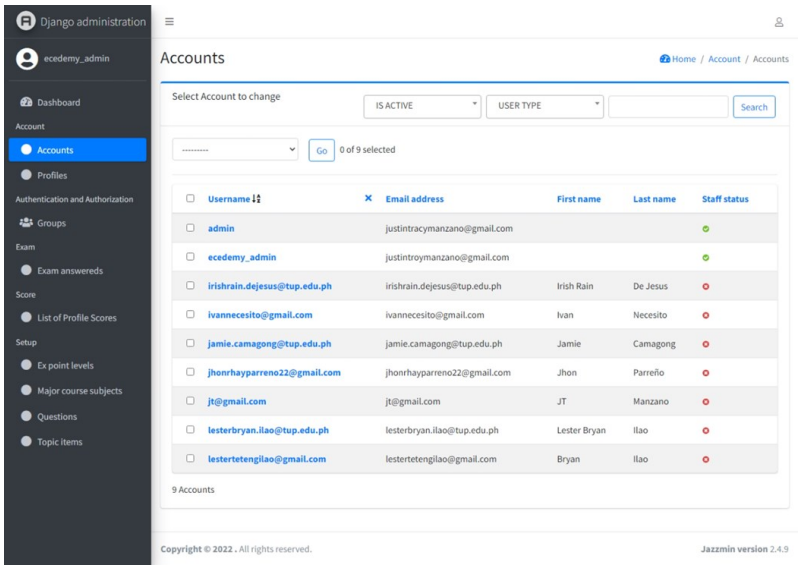


Figure 4.29 *User Database in Admin Interface*

4.2.8 Game Mechanics and Elements on the Web Application

The following game mechanics were implemented by the proponents for the learning management system (LMS):

Multiple Choice (A, B, C, D) - The user must select the correct answer from the provided choices of the ECEdemy.

Single Attempt - The user can only answer the question once. The first answer entered will be the recorded attempt of the user. If the answer is correct, the user will be rewarded with the corresponding XP of the question to be added on which major subject it is under., otherwise no XP will be awarded,

Experience Points (XP) to Reach per Level in Major/Core Subjects		
Lvl	**(XP) Level**	**XP Needed**
1	**0**	**0**
2	**300**	**300**
3	**600**	**300**
4	**900**	**300**
5	**1200**	**300**
6	**1500**	**300**
7	**1800**	**300**
8	**2100**	**300**
9	**2400**	**300**
n	**…**	**…**

Table 4.1 *Experience Points (XP) to Reach per Level*

Equivalent Experience Points (XP) per Question Difficulty	
Lvl	**Pattern (Formula) Options**
	[4*lvl+1]
1	5
2	9
3	13
4	17
5	21
6	25
7	29
8	33
9	37
Streak = 5 consecutive correct answers	

Table 4.2 *Equivalent Experience Points (XP) per Question Difficulty*

The following tables show the achievements and quests that will be included in the gamification feature of the learning management system. As shown, each achievement and quest were given a corresponding name, badge, and definition. These gamification badges are collectible achievements that are earned by fulfilling the badge criteria which are displayed on the profile page of the user.

Achievements (38)		
Name	**Badge**	**Definition**
SUPER SAIYAN		Master all topics in all subjects (Mathematics, Electronics, General Engineering and Applied Science, and Electronics System and Technologies).
SAIYAN		Pass all topics in all subjects (Mathematics, Electronics, General Engineering and Applied Science, and Electronics System and Technologies).
Math Victory		Pass all the topics under mathematics (MATH).
ELEX Victory		Pass all the topics under the Electronics Engineering (ELEX).
GEAS Victory		Pass all the topics under General Engineering and Applied Science (GEAS).
ESAT Victory		Pass all the topics under the Electronics System and Technologies (ESAT).

Math Master		Mastered all the topics under Mathematics (MATH).
ELEX Master		Mastered all the topics under Electronics Engineering (ELEX).
GEAS Master		Mastered all the topics under General Engineering and Applied Science (GEAS).
ESAT Master		Mastered all the topics under the Electronics System and Technologies (ESAT).
Math Grind I		Answer at least 100 questions under MATH (any topic) correctly.
Math Grind II		Answer at least 500 questions under MATH (any topic) correctly.
Math Grind III		Answer at least 1000 questions under MATH (any topic) correctly.

ELEX Grind I		Answer at least 100 questions under ELEX (any topic) correctly.
ELEX Grind II		Answer at least 500 questions under ELEX (any topic) correctly.
ELEX Grind III		Answer at least 1000 questions under ELEX (any topic) correctly.
GEAS Grind I		Answer at least 100 questions under GEAS (any topic) correctly.
GEAS Grind II		Answer at least 500 questions under GEAS (any topic) correctly.
GEAS Grind III		Answer at least 1000 questions under GEAS (any topic) correctly.
ESAT Grind I		Answer at least 100 questions under GEAS (any topic) correctly.

ESAT Grind II		Answer at least 500 questions under GEAS (any topic) correctly.
ESAT Grind III		Answer at least 1000 questions under GEAS (any topic) correctly.
Slayer I		Correctly answer a level 8 problem on your first try.
Slayer II		Correctly answer a level 9 problem on your first try.
Slayer III		Correctly answer a level 10 problem on your first try.
Busy Bee		Correctly answer 100 problems in one week.
Archimedes		Reach level 10 in Mathematics (MATH).

Faraday		Reach level 10 in Electronics Engineering (ELEX).
Galileo		Reach level 10 in General Engineering and Applied Science (GEAS).
Graham Bell		Reach level 10 in Electronics System and Technologies (ESAT).
Shannon		Reach an overall level of 10.
Quad Kill		Reach level 10 in all four different subjects.
There is a prize for this		Gain two overall levels without completing any quests or achievements.
Best Week Ever		Top a weekly hall of fame list.

All Time Great		Appear on the all-time hall of fame list.
Johnny Quest		Complete three different quests that were all assigned and completed in a 24-hour period.
Quest Master		Complete 25 different quests.
Overachiever		Obtain 25 achievements.

Table 4.3 Achievements to be included in the Gameplay of ECEdemy

Quests (37)		
Name	**Badge**	**Definition**
Climb Up!		Gain an overall level
MATH Climber		Gain an overall level in Mathematics (MATH)

ELEX Climber		Gain an overall level in Electronics Engineering (ELEX)
GEAS Climber		Gain an overall level in General Engineering and Applied Science (GEAS)
ESAT Climber		Gain an overall level in Electronics System and Technologies (ESAT)
MATH Champ I		Correctly answer a question in all topics in MATH
MATH Champ II		Correctly answer 3 questions in all topics in MATH
MATH Champ III		Correctly answer 5 questions in all topics in MATH
ELEX Champ I		Correctly answer a question in all topics in ELEX

ELEX Champ II		Correctly answer 3 questions in all topics in ELEX
ELEX Champ III		Correctly answer 5 questions in all topics in ELEX
GEAS Champ I		Correctly answer a question in all topics in GEAS
GEAS Champ II		Correctly answer 3 questions in all topics in GEAS
GEAS Champ III		Correctly answer 5 questions in all topics in GEAS
ESAT Champ I		Correctly answer a question in all topics in ESAT
ESAT Champ II		Correctly answer 3 questions in all topics in ESAT

ESAT Champ III		Correctly answer 5 questions in all topics in ESAT
Jack of All Trades		Correctly answer a question in all of the ECEdemy subjects.
Are you XPerienced? I		Gain a total of 1000 overall experience points.
Are you XPerienced? II		Gain a total of 1500 overall experience points.
Are you XPerienced? III		Gain a total of 2000 overall experience points.
Power Attack		Correctly answer the next 5 problems with power XP.
Lucky Sevens I		Correctly answer 7 questions you have not seen before.
Lucky Sevens II		Correctly answer 77 questions you have not seen before.

Third Time's the Charm		Pass 3 topics that you have not passed before.
Perfect Run I		Correctly answer 3 questions in a row on the first try.
Perfect Run II		Correctly answer 5 questions in a row on the first try.
Perfect Run III		Correctly answer 7 questions in a row on the first try.
Perfect Run IV		Correctly answer 8 questions in a row on the first try.

Perfect Run V		Correctly answer 10 questions in a row on the first try.
Frequent Flyer I		Work on ECEdemy for 3 days in a row.
Frequent Flyer II		Work on ECEdemy for 5 days in a row.
Frequent Flyer III		Work on ECEdemy for 7 days in a row.
Still Got It I		Correctly answer 10 review problems
Still Got It II		Correctly answer 15 review problems
Still Got It III		Correctly answer 20 review problems

Rockin' a Hard Place		Correctly answer 5 new questions in a row on the Hard difficulty setting (levels 7-10)

Table 4.4 *Quests to be Included in the Gameplay of ECEdemy*

4.3 Utilization of Fuzzy Inference System (FIS) Models in the categorization of questions depending on the level of difficulty.

4.3.1 Reviewed key concepts and theories about Computerized Adaptive Testing (CAT)

In order to create the Mamdani and Sugeno Fuzzy Inference System (FIS) models, the proponents used a python built-in library called *Simpful*. *Simpful* is a Python library for fuzzy logic reasoning, designed to provide a simple and lightweight Application Programming Interface (API), as close as possible to natural language. *Simpful* supports Probabilistic, Mamdani and Sugeno reasoning of any order, parsing any complex fuzzy rules involving AND, OR, and NOT operators, using arbitrarily shaped fuzzy sets.

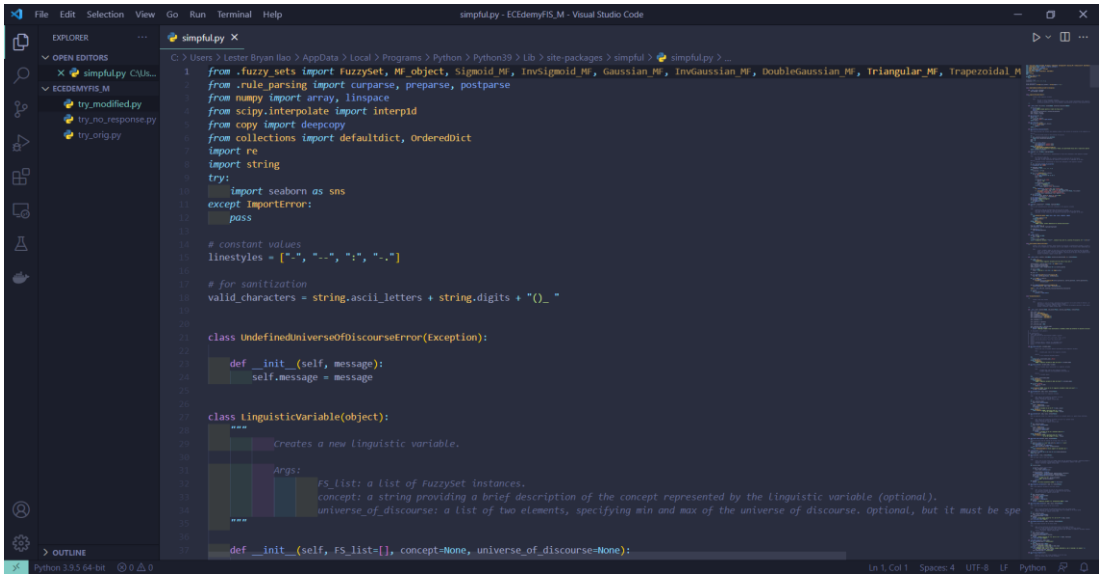


Figure 4.30 *Snapshot of Simpful module*

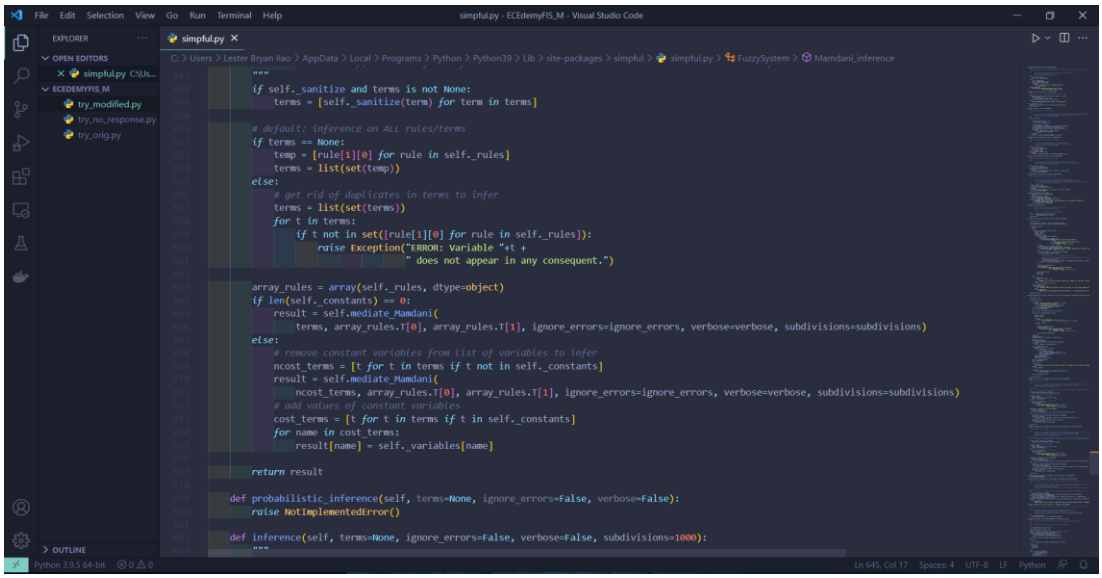


Figure 4.31 *Snapshot Mamdani Inference Function on Simpful module*

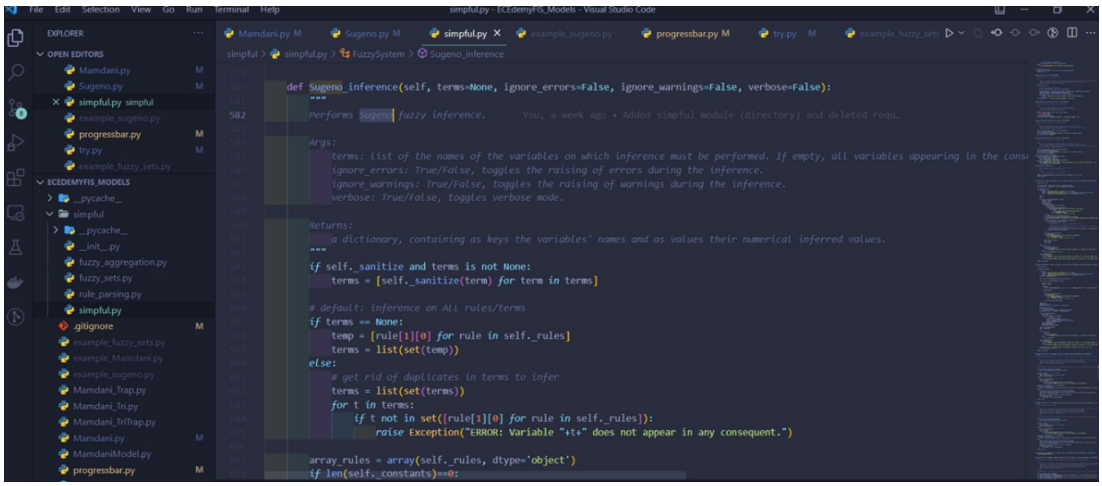


Figure 4.32 *Snapshot Sugeno Inference Method on Simpful module*

4.3.2 Designed the model in accordance with the acquired principles and concepts

Rule No.	Input					Output		
	User's Response		User's Streak			Calibrated Item Question		
	Wrong	Right	Losing	Non-streak	Winning	Easier	Retain	Harder
1	1		1			1		
2	1			1			1	
3	1				1		1	
4		1	1				1	
5		1		1			1	
6		1			1			1

Table 4.5 *Designed Model in Accordance with the Acquired Principles and Concepts*

4.3.3 Created set of rules for the Fuzzy Inference System (FIS) models

One of the requirements in order to design the model is to create the set of rules needed which will serve as the criteria in calibrating the questions to be given to the user based on his/her performance. Shown below is the table for a set of rules to be used both by the Mamdani and Sugeno Fuzzy Inference System (FIS) model.

Listed below are the drafted membership functions and set of rules to be used for the Mamdani and Sugeno Fuzzy Inference System (FIS) models. In the membership functions, the inputs are User's Response and User's Streak while the output is the Calibrated Item Question. Using the membership functions of the input and output, a set of rules is created.

Membership Functions

- Input

  - User's Response (UR)

    = WRONG or CORRECT

  - User's Streak (US)

    = WINNING, NON-STREAK OR DEFAULT, LOSING

- Output

  - Calibrated Item Question (CIQ)

    = EASIER, RETAIN or HARDER

Set of Rules

If UR is Wrong and US is LOSING, then CIQ is EASIER

If UR is Wrong and US is NONSTREAK, then CIQ is RETAIN

If UR is Wrong and US is WINNING, then CIQ is RETAIN

If UR is Correct and US is LOSING, then CIQ is RETAIN

If UR is Correct and US is NONSTREAK then CIQ is RETAIN

If UR is Correct and US is WINNING, then CIQ is RETAIN

4.3.4 Performance Comparison of the FIS models

By applying the formulated set of rules to the candidate algorithms, the proponents were able to compare the performance of each FIS model namely the triangular method, trapezoidal method, tri-trap method, gaussian method, and double gaussian method in terms of their response and streak to the user membership function as well as their calibrated item question membership function.

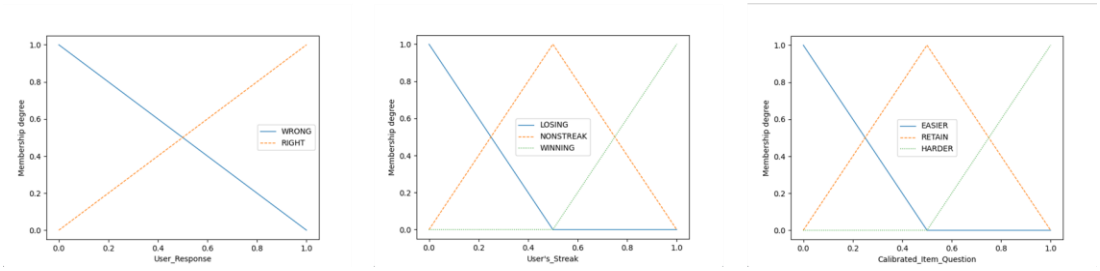


Figure 4.33 (a) *Snapshot of User's Response Membership Function using Triangular Method;* ***(b)*** *Snapshot of User's Streak Membership Function using Triangular Method;* ***(c)*** *Snapshot of Calibrated Item Question Membership Function using Triangular Method*

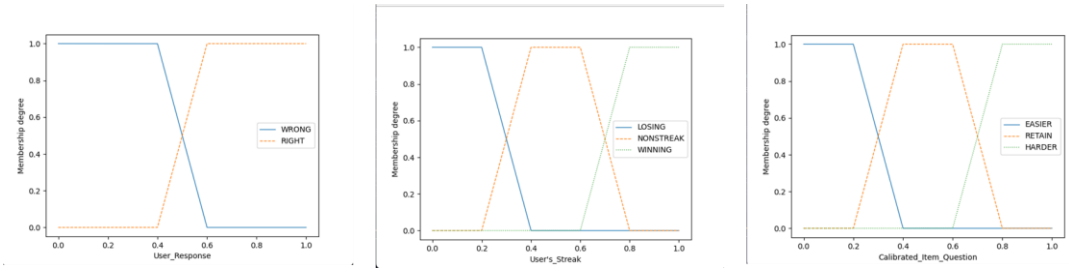


Figure 4.34 (a) *Snapshot of User's Response Membership Function using Trapezoidal Method;* ***(b)*** *Snapshot of User's Streak Membership Function using*

Trapezoidal Method; ***(c)*** *Snapshot of Calibrated Item Question Membership Function using Trapezoidal Method*

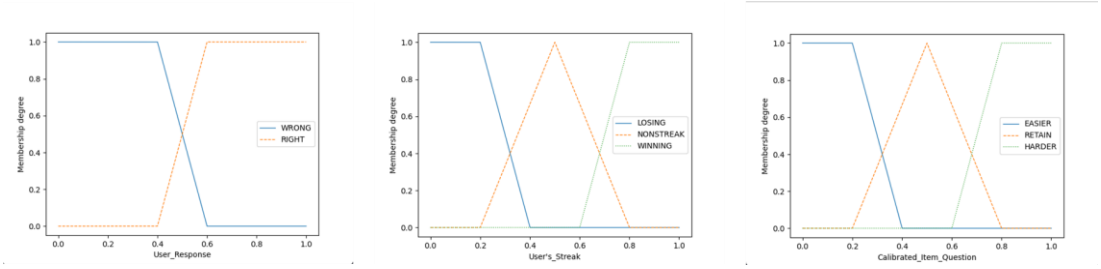


Figure 4.35 (a) *Snapshot of User's Response Membership Function using Tri-Trap Method;* ***(b)*** *Snapshot of User's Streak Membership Function using Tri-Trap Method;* ***(c)*** *Snapshot of Calibrated Item Question Membership Function using Tri-Trap Method*

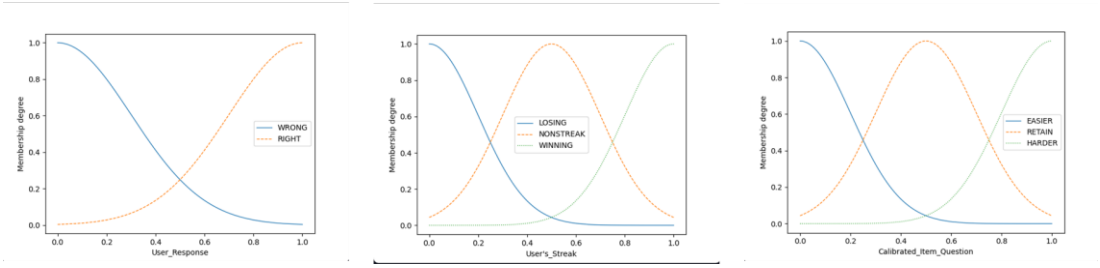


Figure 4.36 (a) *Snapshot of User's Response Membership Function using Gaussian Method;* ***(b)*** *Snapshot of User's Streak Membership Function using Gaussian Method;* ***(c)*** *Snapshot of Calibrated Item Question Membership Function using Gaussian Method*

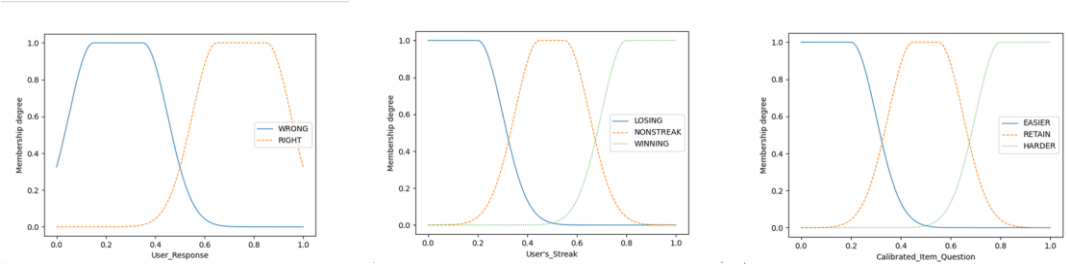


Figure 4.37 (a) *Snapshot of User's Response Membership Function using Double Gaussian Method;* ***(b)*** *Snapshot of User's Streak Membership Function using Double Gaussian Method;* ***(c)*** *Snapshot of Calibrated Item Question Membership Function using Double Gaussian Method*

4.3.5 Evaluation and Selection of the FIS models

For Mamdani Method:

where,

0 = wrong response

1 = correct response

+ 1/0 = current response

Mamdani Method Model					
	Wrong Response				
Membership Function	(0000)+0	(0001)+0	(0011)+0	(0111)+0	(1111)+0
Triangular	0.1663	0.4119	0.4904	0.5000	0.5000
Trapezoidal	0.1553	0.1553	0.5000	0.5000	0.5000
Triangular-Trapezoidal	0.1553	0.1553	0.5000	0.5000	0.5000
Gaussian	0.2027	0.3860	0.4949	0.5000	0.5000
Double Gaussian	0.2029	0.2511	0.4421	0.5000	0.5000
	Correct Response				
Membership Function	(0000)+1	(0001)+1	(0011)+1	(0111)+1	(1111)+1
Triangular	0.5000	0.5000	0.5096	0.5881	0.8367
Trapezoidal	0.5000	0.5000	0.5000	0.8447	0.8447
Triangular-Trapezoidal	0.5000	0.5000	0.5000	0.8447	0.8447
Gaussian	0.5000	0.5000	0.5051	0.3140	0.7973
Double Gaussian	0.5000	0.5000	0.5578	0.7489	0.7971

Table 4.6 *Outputs of Mamdani Method Models*

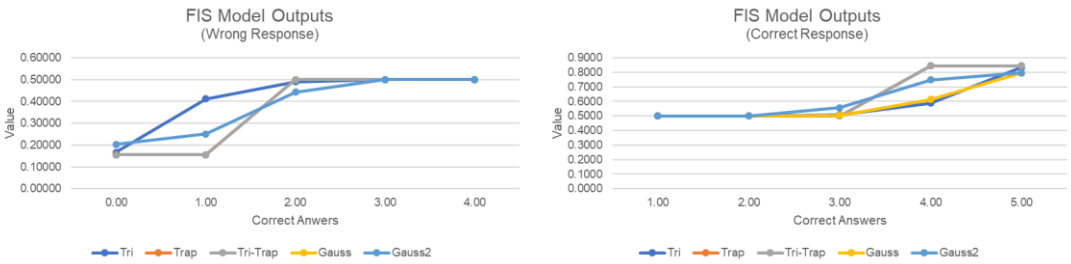


Figure 4.38 *Outputs of Mamdani Method Models based on the (a) Wrong Response and (b) Correct Response*

For Sugeno Method:

where,

0 = wrong response

1 = correct response

+ 1/0 = current response

Sugeno Method Model					
	Wrong Response				
Membership Function	(0000)+0	(0001)+0	(0011)+0	(0111)+0	(1111)+0
Triangular	0.0000	0.0000	0.5000	0.5000	0.5000
Trapezoidal	0.0000	0.0000	0.5000	0.5000	0.5000
Triangular-Trapezoidal	0.0000	0.0000	0.5000	0.5000	0.5000
Gaussian	0.0246	0.0596	0.4368	0.4965	0.5019
Double Gaussian	0.0000	0.0596	0.3530	0.4996	0.5000
	Correct Response				
Membership Function	(0000)+1	(0001)+1	(0011)+1	(0111)+1	(1111)+1
Triangular	0.5000	0.5000	0.5000	1.0000	1.0000
Trapezoidal	0.5000	0.5000	0.5000	1.0000	1.0000
Triangular-Trapezoidal	0.5000	0.5000	0.5000	1.0000	1.0000
Gaussian	0.4981	0.5035	0.5632	0.8226	0.9754
Double Gaussian	0.5000	0.5004	0.6470	0.9404	0.9999

Table 4.7 *Outputs of Sugeno Method Models*

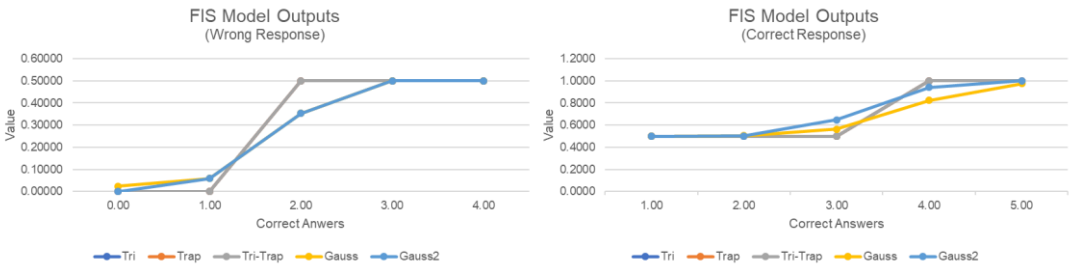


Figure 4.39*Outputs of Mamdani Method Models based on the (a) Wrong Response and (b) Correct Response*

4.3.6 Flowchart of the Model as an Adaptive Item Selector for the Web Application

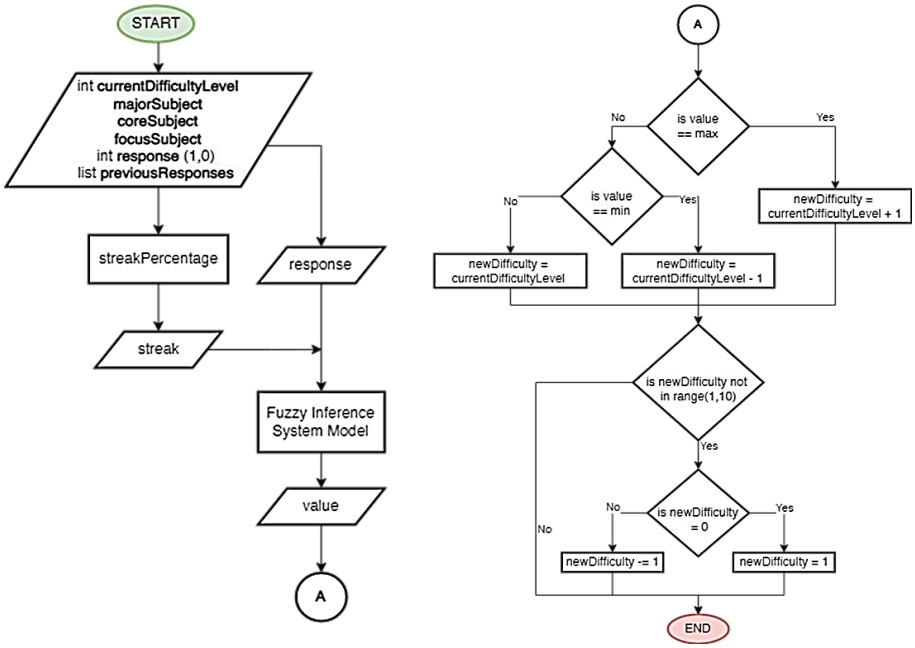


Figure 4.40 *Flowchart of the FIS System Model used as an Adaptive Item Selector*

4.3.7 Development and Implementation of Models Based on the Developed Flowchart

Figure 4.41 *Snapshot of the Implementation of Mamdani and Sugeno Method*

4.4 Effectivity of the Gamified LMS on User-Engagement, Motivation, and Performance of the Users

4.4.1 Development of the Survey Instrument Aligned with the Measurement of the Effect of the System on the User-Engagement, Motivation, and Performance of the Users

The proponents will use a structured questionnaire as the main data-gathering instrument, disseminated through Google forms. The survey consists of three sections: (1) the title of the study, introduction, and instruction; (2) socio-demographic data collection of the respondents such as name, email, and section; and (3) quantitative and qualitative data collection on the participants' perception on the effect of the gamified LMS on their engagement, motivation, and their performance.

After exploring and testing the web application, the proponents will measure its effect using a survey instrument consisting of 27 statements and 5 open-ended questions to assess their engagement, motivation, and their performance.

The survey to be presented should have a concise explanation of the purpose of the study and clear instructions on how to fill it, while employing a five-point Likert scale (e.g., strongly agree, agree, neutral, disagree, strongly disagree). For additional information and supporting details, the proponents may also conduct an interview with some of their respondents.

4.4.2 Deployment Plan

There will be at most one hundred (100) students, consisting of 4th year, 3rd year, and graduating Electronics Engineering (ECE) students from Technological University of the Philippines – Manila; as well as alumni who wish to take the board exam this year 2022 or next year.

The proponents will use a non-probability sampling technique to determine the respondents, specifically the purposive and convenience sampling techniques. Purposive sampling is a type of sampling technique wherein the respondents are chosen to be part of the sample with a specific purpose in mind. On the other hand, convenience sampling is where the respondents are selected because of their convenience and accessibility.

The filled-out survey forms of the respondents will be recorded into the system and can be viewed through the website itself or Google Excel. The collected biographical data and corpus will be treated with utmost confidentiality.

4.5 Project Limitation and Capabilities

The system was built to develop a reviewer tool in preparation for the upcoming licensure exam for ECE students. The capabilities of this study were as follows:

1. ECEdemy is an online learning tool that is accessible to ECE students.
2. The questions in the system are based on the new Table of Specifications by PRC 2022.
3. Solutions containing equations are integrated without the use of images through TeX coding.
4. Predictive analytics through the Mamdani Fuzzy Inference System Model with a Triangular type of membership function is implemented in the system.
5. Computer Adaptive Testing (CAT) and gamification are incorporated to help improve the users' educational experience.

The limitations of the study are as follows:

1. Internet access is necessary when using the application.
2. It will not provide video lectures for any topics it covers. Hence, video solutions are also not provided to the learners and will only be available in a text format.
3. Attaching and importing image/s on the problem/solution is not yet possible as it is unstructured data and the system focused more on importing structured data
4. The scope of the gamified LMS is only limited to the subjects covered in Electronics Engineering Licensure Examination.

4.6 Data and Results

4.6.1 FIS Models

Using the Mamdani and Sugeno Method of Fuzzy Inference System with 5 types of membership functions, the proponents were able to develop 10 item selection models which are subjected to performance (accuracy) and runtime (speed) tests.

The performance (accuracy) test was done by running the models with 5 predetermined inputs of different combinations. The 0s represent wrong answers while 1s represent correct answers and the "+" sign represents the most recent response of the user. Table 4.8 and 4.9 shows that among the 10 models, 5 types of membership function result in a unique value for 0 out of 5 correct answers and 5 out of 5 correct answers, namely Triangular-Mamdani, Gaussian-Mamdani, Double Gaussian-Mamdani, Gaussian-Sugeno, and Double Gaussian-Sugeno. This means that these models were able to determine if the next question to be given to the user will yield a lower difficulty if they have 5 losing streaks or higher difficulty if they have a 5 winning streaks.

Mamdani Method Model					
	Wrong Response				
Membership Function	(0000)+0	(0001)+0	(0011)+0	(0111)+0	(1111)+0
Triangular	0.1663	0.4119	0.4904	0.5000	0.5000
Trapezoidal	0.1553	0.1553	0.5000	0.5000	0.5000
Triangular-Trapezoidal	0.1553	0.1553	0.5000	0.5000	0.5000
Gaussian	0.2027	0.3860	0.4949	0.5000	0.5000
Double Gaussian	0.2029	0.2511	0.4421	0.5000	0.5000
	Correct Response				
Membership Function	(0000)+1	(0001)+1	(0011)+1	(0111)+1	(1111)+1
Triangular	0.5000	0.5000	0.5096	0.5881	0.8367
Trapezoidal	0.5000	0.5000	0.5000	0.8447	0.8447
Triangular-Trapezoidal	0.5000	0.5000	0.5000	0.8447	0.8447
Gaussian	0.5000	0.5000	0.5051	0.3140	0.7973
Double Gaussian	0.5000	0.5000	0.5578	0.7489	0.7971

Table 4.8 *Outputs of Mamdani Method Models*

Sugeno Method Model					
	Wrong Response				
Membership Function	(0000)+0	(0001)+0	(0011)+0	(0111)+0	(1111)+0
Triangular	0.0000	0.0000	0.5000	0.5000	0.5000
Trapezoidal	0.0000	0.0000	0.5000	0.5000	0.5000
Triangular-Trapezoidal	0.0000	0.0000	0.5000	0.5000	0.5000
Gaussian	0.0246	0.0596	0.4368	0.4965	0.5019
Double Gaussian	0.0000	0.0596	0.3530	0.4996	0.5000
	Correct Response				
Membership Function	(0000)+1	(0001)+1	(0011)+1	(0111)+1	(1111)+1
Triangular	0.5000	0.5000	0.5000	1.0000	1.0000
Trapezoidal	0.5000	0.5000	0.5000	1.0000	1.0000
Triangular-Trapezoidal	0.5000	0.5000	0.5000	1.0000	1.0000
Gaussian	0.4981	0.5035	0.5632	0.8226	0.9754
Double Gaussian	0.5000	0.5004	0.6470	0.9404	0.9999

Table 4.9 *Outputs of Sugeno Method Models*

For the runtime (speed), the test was done by running the models with 5, 10, 50, 100, 500, 1000 simulated inputs under 100 repetitions. From that, the runtime of each model was averaged and recorded as shown in this table. Here, generally, we can see that the Mamdani models are faster than the Sugeno models. Among the Mamdani models, the Triangular type has the fastest average on different volumes of simulated input ranging from 3.83ms to 4.53ms.

Mamdani Method Model						
	Run Time (ms)					
Membership Function	**5**	**10**	**50**	**100**	**500**	**1000**
Triangular	3.83	3.85	3.88	3.93	4.23	4.53
Trapezoidal	4.13	4.20	4.24	4.34	4.56	4.86
Triangular-Trapezoidal	4.10	4.14	4.15	4.17	4.44	4.69
Gaussian	9.41	9.46	9.47	9.49	9.69	9.94
Double Gaussian	16.48	16.73	16.59	16.57	16.60	17.04

Table 4.10 *Runtime of Mamdani Method Models*

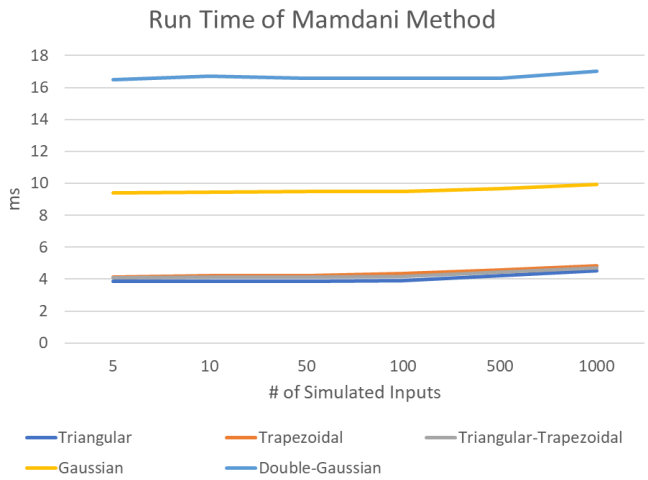


Figure 4.42 *Runtime of Mamdani Method Models*

Sugeno Method Model						
	Run Time (ms)					
Membership Function	**5**	**10**	**50**	**100**	**500**	**1000**
Triangular	13.94	13.61	16.30	16.33	16.05	17.91
Trapezoidal	13.05	14.19	13.59	13.28	15.53	17.99
Triangular-Trapezoidal	13.09	13.48	13.59	13.24	15.77	20.57
Gaussian	13.80	13.96	15.90	13.97	17.20	18.54
Double Gaussian	13.58	13.86	14.00	14.32	15.47	18.89

Table 4.11 *Runtime of Sugeno Method Models*

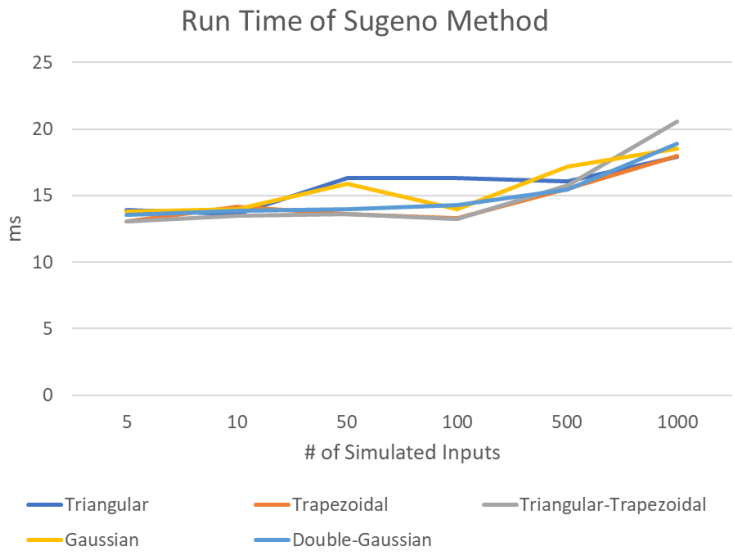


Figure 4.43 *Runtime of Sugeno Method Models*

With this, considering both performance and runtime of the models, the Mamdani method with Triangular type of membership function was chosen to be integrated to the web application.

4.6.2 Descriptive Statistical Analysis of the Gathered Data

The development and evaluation of the gamified LMS was conducted to satisfy the objectives of this research study. One hundred (100) students, including alumni, 4th year, 3rd year, and graduating Electronics Engineering (ECE) students from Technological University of the Philippines – Manila, answered the survey questionnaire.

For the analysis, the proponents have calculated descriptive statistics (means, standard deviation, and frequencies) to measure its effectiveness on its users. The means were interpreted as follows: Strongly disagree in the point range of 1.00 - 1.80,

Disagree 1.81 - 2.60, Neutral 2.61 – 3.40, Agree 3.41 - 4.20, and Strongly agree 4.21 - 5.00.

Likert-Scale	Description	Interval
Strongly Disagree	1	1.00 – 1.80
Disagree	2	1.81 – 2.60
Neutral	3	2.61 – 3.40
Agree	4	3.41 – 4.20
Strongly Agree	5	4.21 – 5.00

Table 4.12 *Interpretation of 5-Point Likert Scale Measurements*

Statements	N	Mean	Standard Deviation
Gamified elements (e.g., XP points, badges, leaderboards, levels, etc.) keep me committed to the game.	100	4.670	0.514
I like how I'm rewarded with XP points or leveling up every time I answer a question correctly.	100	4.730	0.468
I feel excited every time I open the web application.	100	4.480	0.745
I wanted to explore all the options because it was very challenging.	100	4.610	0.665
I wanted to complete the game.	100	4.610	0.751
ECEdemy is great for killing time productively.	100	4.620	0.632
Being in a competition keeps my excitement alive.	100	4.540	0.702

Table 4.13 *Descriptive Statistics on the Effectiveness of ECEdemy on User-Engagement*

After performing descriptive statistics on the gathered data for the effect of the gamified LMS on user-engagement, all of the statements had a mean above 4.20. The majority of participants strongly agree with the effectiveness of the gamified LMS based on their engagement. It also shows that users like being rewarded with XP points for every item they answer, as it has the highest mean of 4.73 and the lowest standard deviation of 0.468 (see Table 4.13).

Statements	N	Mean	Standard Deviation
Seeing my XP points, badges, rank on leaderboards, levels, etc. inspires me to try harder.	100	4.670	0.514
I feel challenged every time a new question appears.	100	4.550	0.626
ECEdemy inspires my curiosity, making me intrigued by the lessons.	100	4.550	0.672
The solutions provided encourage me to correctly answer similar problems next time.	100	4.730	0.529
I like to do better than other students in ECEdemy.	100	4.450	0.821
I would describe the gameplay as very interesting.	100	4.530	0.731
It is important that I earn a high score in the game.	100	4.470	0.784
Earning XP points, badges, and ranking on the leaderboard improves my commitment to the review process.	100	4.600	0.569
ECEdemy encourages me to study on a regular basis.	100	4.460	0.744

Table 4.14 *Descriptive Statistics on the Effectiveness of ECEdemy on Motivation of Users*

Table 4.14 shows the descriptive statistics on the effectiveness of the gamified LMS on user motivation. All of the statements on the table had a mean value greater

than 4.20, indicating that the majority of participants strongly agree that ECEdemy has a significant impact on user motivation. The fourth statement, which states that the solutions provided encourage its users to correctly answer similar problems, has the highest mean among the group, with 4.730.

Statements	N	Mean	Standard Deviation
ECEdemy improves my productivity.	100	4.490	0.703
The use of ECEdemy enables me to better prepare for the examination.	100	4.580	0.572
I am able to learn easily by answering problems in ECEdemy.	100	4.530	0.674
I felt my learning experience is customized according to my needs.	100	4.540	0.717
Performing well in the game has improved my self-confidence.	100	4.480	0.745
ECEdemy enables me to apply and practice my knowledge.	100	4.660	0.555
Using ECEdemy enhances my learning performance.	100	4.590	0.588

The system helps me have a clear understanding of the concepts.	100	4.520	0.611
I was so into this game that I lost track of time.	100	4.210	0.967
I can fully understand the problems, thanks to the solutions.	100	4.610	0.567
Personalized set of questions aids me to learn efficiently.	100	4.580	0.606

Table 4.15 *Descriptive Statistics on the Effectiveness of ECEdemy on the Performance of Users*

The descriptive statistics performed on the effectiveness of the gamified LMS on the performance of the users are exhibited in Table 4.15. Again, all of the statements on the table had a mean greater than 4.20, indicating that the majority of participants strongly agree that ECEdemy has a significant impact on user performance. The majority of ECEdemy users agreed that it helped them in applying and practicing their knowledge, as indicated by the highest mean of 4.660.

Statements	N	Mean	Standard Deviation
The website can perform under anticipated user	7	4.429	0.535
The website can handle expected	7	4.429	0.535

load over a long period of time			
The website can perform under sudden changes in load.	7	4.571	0.535
The website can handle a large volume of data	7	4.429	0.787
The website can maintain performance in various load levels	7	4.286	0.756

Table 4.16 *Descriptive Statistics on the Performance Efficiency of ECEdemy for Experts*

After performing descriptive statistics on the gathered data for the performance efficiency of ECEdemy, all of the statements showed a mean that is above 4.20. Statement 1 to 5 garnered a mean of 4.429, 4.429, 4.571, 4.429, and 4.286 respectively. Hence, the majority of the participants strongly agree that the gamified LMS performs well (see Table 4.16).

Statements	N	Mean	Standard Deviation
The website can run properly in different browsers	7	4.714	0.488
The website can perform in different networks.	7	4.714	0.488

Table 4.17 *Descriptive Statistics on the Compatibility of ECEdemy for Experts*

Table 4.17 shows the descriptive statistics performed on the compatibility of the gamified LMS based on its users. Both statements showed the same results with a mean of 4.714 and a standard deviation of 0.488. Hence, the users strongly agree that the website can perform properly in different browsers and in different networks.

Statements	N	Mean	Standard Deviation
The website's functions produce minimal or no bugs.	7	4.571	0.535
The website can respond to user requests for usage.	7	4.714	0.488
The website can perform properly after adding and/or removing some functions.	7	4.286	0.756

Table 4.18 *Descriptive Statistics on the Reliability and Portability of ECEdemy for Experts*

Table 4.18 shows the descriptive statistics performed on the reliability and portability of the gamified LMS. All of the statements showed an average higher than 4.20. Hence, the users strongly agree that the website can respond to user requests for usage, can perform properly after adding and/or removing some functions, and its functions produce minimal or no bugs.

Statements	N	Mean	Standard Deviation
The website has minimal or no vulnerabilities.	7	4.143	0.690
The website can stand against hostile behaviors, eg. denial-of-service attacks, virus infection and proliferation.	7	4.429	0.535
The website can protect users' data information.	7	4.571	0.787

Table 4.19 *Descriptive Statistics on the Security of ECEdemy for Experts*

Lastly, descriptive statistics performed on the security of the gamified LMS is shown in Table 4.19. The first statement got a mean of 4.143 and a standard deviation of 0.690 hence, the users agree that the website has minimal or no vulnerabilities. While they strongly agree that it can stand against hostile behaviors and protect users' data information as the corresponding statements receive a 4.429 and 4.571 mean, respectively.

4.6.3 Analysis and Visualization of the Gathered Data for Open-Ended Questions

For the last part of the survey questionnaire, open-ended questions have been included to better understand the voice of the respondents. Analyzing open-ended questions efficiently and empathizing with the users will reveal information that are not even considered by the respondents and to have a deeper, qualitative data. Gathered data

that are part of the same theme are first categorized and grouped, even if they're worded differently. After recording the individual responses, categories are organized in descending order from left to right. This will be helpful in visually representing the data through a bar chart.

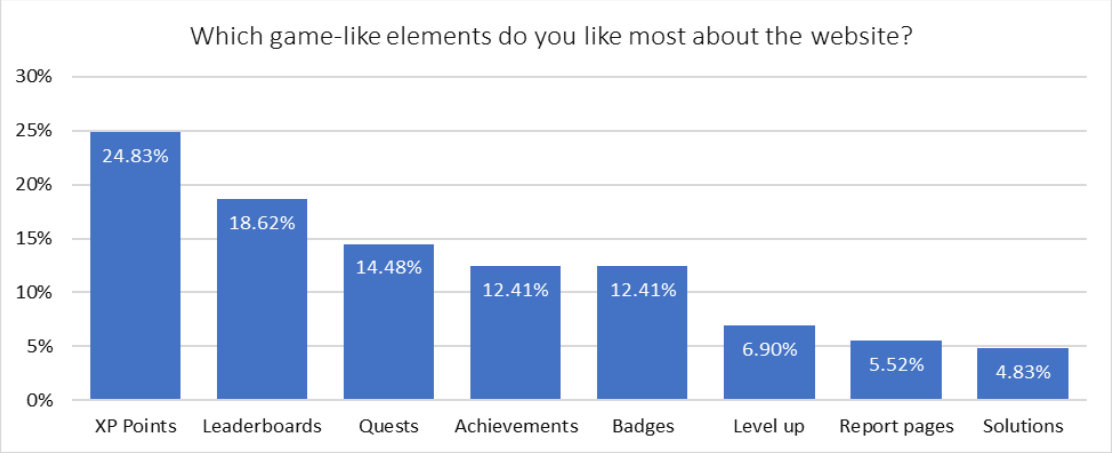


Figure 4.44 *Descriptive Statistics on Most Liked Game Elements of the Users*

Figure 4.44 shows the descriptive statistics performed on which game-like elements do they like most about the website. With 24.83%, results demonstrate that they liked XP points among all the other game elements, followed by leaderboards with 18.62%, and quests with 14.48%. Based on their explanation, XP Points made them feel rewarded and motivated for every question that they answered correctly; while the leaderboards inspire them to get more points and move up the ranks since they display all participants and their rankings.

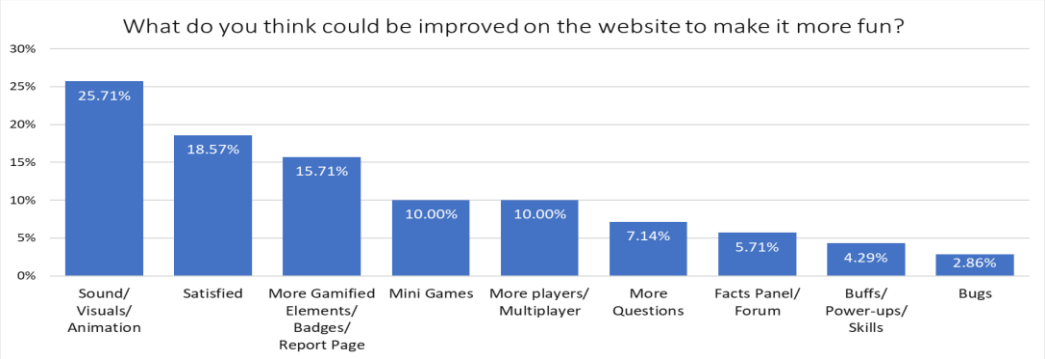


Figure 4.45 *Descriptive Statistics on Improvements to Make the Website More Fun*

Figure 4.45 shows the descriptive statistics performed on what do they think could be improved on the website to make it more fun. With 25.71%, users suggested that the web app should add sounds, interactive visuals, and animation to ECEdemy. Although 18.57% of users already find it fun and interesting (satisfied), they also suggested replacing static images with animation to make it even more engaging, as well as making the user interface give a 'game vibes' first impression. These are followed by adding more gamified elements such as badges and report page with 15.71%, as well as mini games and multiplayer option with 10.00%.

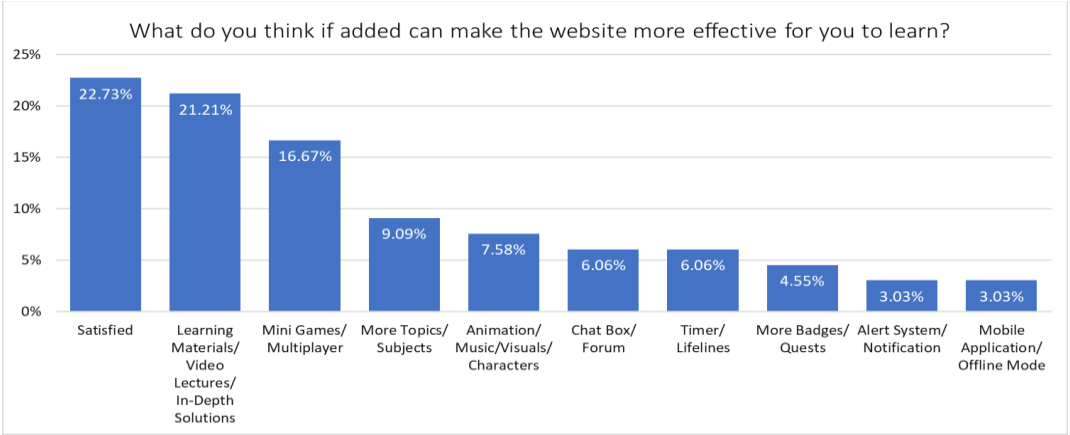


Figure 4.46 *Descriptive Statistics on Improvements to Make Learning More Effective*

Figure 4.46 shows the descriptive statistics performed on what they think if added can make the website more effective for them to learn. Results demonstrate that 22.73% of users are already satisfied with ECEdemy, while 21.21% suggested adding learning materials, video lectures, and in-depth solutions, 16.67% on mini games/multiplayer, and 9.09% on adding more topics/subjects. Based on the respondents, creating a tab for review materials such as pdf books and lecture videos can be helpful before and after taking a quiz. More interactive quests, quiz game with a friend, and a timer are also advised to make learning more effective since there will be a time limit on an actual licensure exam.

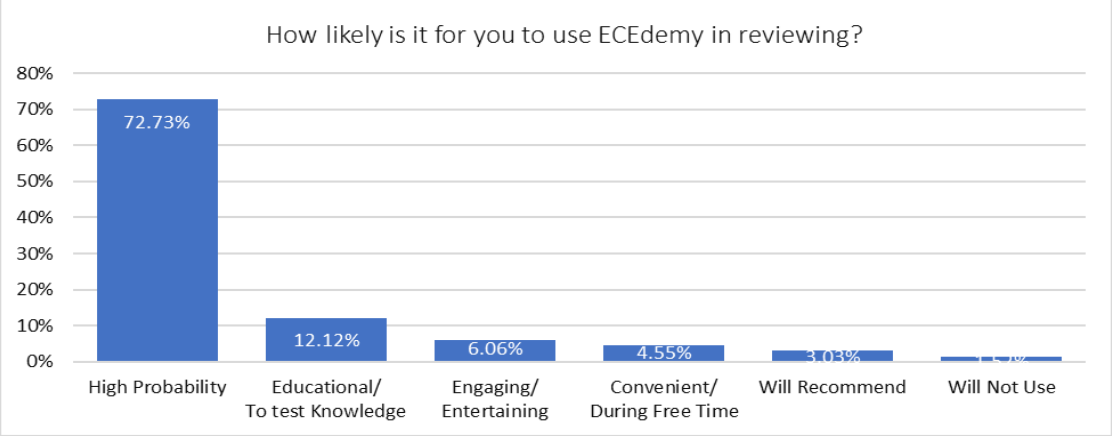


Figure 4.47 *Descriptive Statistics on the Likeliness to use ECEdemy in Reviewing*

Figure 4.47 shows the descriptive statistics on how likely users will use ECEdemy to review for the ECE licensure exam. Evidently, 72.73% of respondents mentioned that there is a high probability that they will use the web app, while 3.03% will recommend, and 1.52% will not use. For their reason, they said that ECEdemy is very helpful as a complementary tool specifically for objective type questions since they can easily retain information while having fun in between breaks. It is also a gamechanger in terms of

reviewing/studying since instead of just reading and memorizing continuously, they can play a game once in a while to challenge themselves while also being reviewed simultaneously. It is very convenient, and introduces a new way to learn, too.

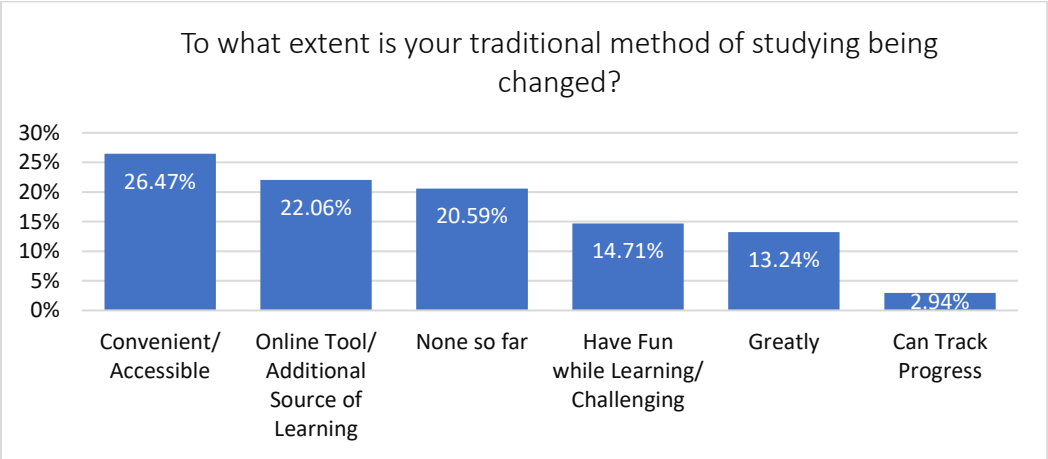


Figure 4.48 *Descriptive Statistics on the Extent their Traditional Method of Studying is Changed*

Furthermore, Figure 4.48 shows the descriptive statistics performed to what extent is their traditional method of studying being changed. 26.47% of respondents stated that their traditional method of studying is changed since ECEdemy is convenient and accessible, making learning much easier and fun. Reasons include helping them find problem sets easier instead of searching several eBooks from the internet, enabling them to review readily anywhere even in traffic or waiting in line, and learning how to study smart, not harder. While 22.06% mentioned that the web app can be an online tool or additional source of learning, followed by 20.59% who answered none so far.

Chapter 5

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of the study and conclusions drawn based on the results discussed. Recommendations were also made for future project improvement.

5.1 Summary of Findings

This study entitled the "Development of a Gamified Learning Management System for ECE Subjects Through Utilization of Fuzzy Inference System (FIS) Models for Effective Learning" aimed to develop a gamified learning management system (GLMS) that can serve as a licensure exam preparation tool. This project is expected to help the ECE students improve their understanding of various subject courses under the curriculum of ECE as adding a gamification functionality to LMS in the form of badges, points, achievements, and leaderboards can create a learning environment in which learners are motivated, intrigued, engaged, and eager to learn.

The main objective of this study is to develop a web-based learning management system (LMS) for Electronics Engineering (ECE) subjects that incorporates game elements and employs a predictive analytics model called Fuzzy Inference System (FIS). The said model imposes an accurate set of rules in categorizing questions based on their difficulty level and item selection based on user performance patterns. The proponents used Django as their primary programming language.

Accordingly, this research compares the performances of Mamdani-type and Sugeno-type fuzzy inference system models. Each proposed model's performance was

measured using simulated inputs with different combinations of correct and incorrect answers to check their accuracy, while the algorithm's speed was tested by getting their average runtime. Results have shown that the triangular type of membership function of Mamdani-type FIS model has the highest accuracy and the fastest speed on different volumes of simulated input ranging from 3.83ms to 4.53ms among the ten models. Thus, it was selected as the final model implemented in the system.

The proponents measured the effect of the gamified LMS on user-engagement, motivation, and performance of the users, and revealed that most student respondents strongly agreed with the statements about the effectiveness of technology, with means ranging from 4.210 to 4.730. Regarding user engagement, the proponents discovered that most users enjoy being rewarded with XP points for correctly answering questions. It revealed that when users see their XP points, badges, rank on leaderboards, and game levels, it inspires them to try harder and significantly impacts their motivation. As for the user-performance, most respondents stated that the ECEdemy allows them to apply and practice their knowledge.

The experts achieved nearly the same results as the users by using means corresponding to strongly agree and agree - ranging from 4.143 to 4.714. Consequently, most experts think that ECEdemy works well because it can respond well to user requests, works well after adding and/or taking away some functions, has few or no bugs, can handle hostile behavior, and keep users' data safe.

In addition, qualitative data were gathered to produce a richer and more comprehensive understanding of the study. This method revealed that, of all the elements implemented in the technology, 24.83% of users preferred the XP points the most because

they made them feel rewarded and motivated for each correctly answered question. 25.71% of users suggested that the web app incorporate sounds, interactive visuals, and animation into the LMS. Furthermore, 22.73% of users stated that they are already satisfied with ECEdemy, and 72.73% stated that they would likely use the web app for reviewing in the future. Finally, 26.47% of respondents stated that ECEdemy had changed their traditional method of studying because it is convenient and accessible, making learning much more manageable and fun.

5.2 Conclusions

In developing a web-based gamified Learning Management System (LMS), ECEdemy, solutions were incorporated without using an image by utilizing a KaTeX support extension for Python Markdown. Making use of Django in building the backend can create a user database with account authorization, a questions and answers database, and the quiz app itself.

Based on the findings and results of the study, the proponents were able to determine that the Mamdani method (with a Triangular type of membership function) Fuzzy Inference System algorithm has the highest accuracy and speed among the ten models that have been tested. The proponents also measured the effect of the gamified LMS on user engagement, motivation, and performance of users by using descriptive statistics. Most student respondents strongly agreed with the technology's effectiveness, garnering high means ranging from 4.210 to 4.730. It revealed that most users like being rewarded with XP points for correctly answering questions. In addition, seeing their XP points, badges, leaderboard rank, and game levels motivate them to work harder during the

game while improving their performance by applying and practicing their knowledge. Moreover, experts agree that the web app is efficient, compatible, secure, reliable, and portable by garnering high means ranging from 4.143 to 4.714.

5.3 Recommendations

To further improve the research and advancement of the study, the following suggestions were drawn:

1. Construct and/or gather at least 12,000 more questions to ensure that all topics are covered based on the scope of the ECE licensure exam.
2. Search for a method on how to easily verify and validate the pool of questions, as well as the solutions provided by the proponents.
3. Make an android app or a mobile view version of the web application to make ECEdemy more accessible and convenient to users.
4. Find ways to easily import questions and solutions with images to the system.
5. Deploy the system for at least a month to further measure its effect on the users' engagement, motivation, and performance.
6. Look for other hosting sites that provide better/same services but at a lower rate.
7. Develop a gamified learning management system utilizing JavaScript Frameworks for efficiency and TensorFlow for computer adaptive testing

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APPENDIX A - Literature Matrix

Table A Summary of Related Studies on Predictive Analytics, Learning Management System, and Gamified Learning Management System

Title	Author/s	Year	Key Features
Predictive Analytics			
Improved Fuzzy Modelling to Predict the Academic Performance of Distance Education Students [41]	Osman Yildiz, Abdullah Bal, and Sevinc Gulsecen	2013	The data consisted of five inputs and one output: three were collected through Moodle which were recency, frequency, and monetary, while the other two were the results of the quiz and midterm exam. A fuzzy inference system was modeled to predict distance education students' year-end academic performance. After modeling a classical fuzzy, it was remodeled in accordance with expert opinion, then was optimized via genetic algorithm.
Ability Estimation in CAT with Fuzzy Logic [43]	Dana V. Balas-Timar, Valentina E. Balas	2009	Five technical components in building a Computerized Adaptive Testing (CAT): calibrated item pool, starting point or entry level, item selection

			algorithm, scoring procedure, and termination criterion. A new approach called Fuzzy Item Response Model (FIRM) was proposed, combining item response theory (IRT) with fuzzy theory in estimation of abilities or competences. Each informational function of the item from the calibrated base (linguistic variable for FL) considered is modelled in MATLAB environment (Fuzzy Toolbox) using two fuzzy sets-linguistic terms. Linguistic variables such as discrimination, difficulty, probability, and response were used upon entering the system, then the rate of acceptance with its linguistic terms as the output.
Adaptive Testing System Modeled	Armando Hernandez	2007	Exploring new items to obtain is made by using vague or fuzzy terms instead of probabilistic assignations normally used in adaptive evaluators with 1PL,

Through Fuzzy Logic [44]			2PL, or 3PL models, although it could be based on a student historical record and the answer to previous questions. Adaptive testing acts in a fuzzy way instead of a probabilistic one. It is possible to build a CAT by using a fuzzy model as an item administrator.
Computer Adaptive Testing for an Intelligent E-Learning Platform [45]	Julian Ricardo Mahecha D'Maria	2014	The proposed CAT model includes 1PL, 2PL and 3PL models from Item Response Theory in its selection process. The development of the model is presented including its three versions: Basic Model, Question History Model and Topic History Model. The final version of the model includes two historical arrays (question history record and topic historical record) that tackle some key issues found in the trials.

Computerized Adaptive Test based o`n Sugeno Fuzzy Inference System [46]	W. Ridwan, I. Wiranto and R. D. R. Dako	2020	Sugeno Fuzzy Inference Systems (SFIS) was designed to measure the ability of examinees on the Computerized Adaptive Test (CAT) system. Input fuzzy consists of four variables: (1) item difficulty level (bi), with three levels, namely easy, medium, and difficult; (2) question discrimination (ai), with two levels, namely satisfactory and good; (3) probability of the examinees to correctly answer the question (pi), with two levels, namely min and max; and (4) participant's response or answer (ri), if the correct answer is worth 1, whereas if the wrong answer is 0. Fuzzy output is divided into five levels, namely Very Low (VL), Low (L), Average (Av), Great (G), and Excellent (Ex).

An Empirical Evaluation of the Slip Correction in the Four Parameter Logistic Models with Computerized Adaptive Testing [47]	Balázs Barna and Szabina Fodor	2018	The precision of the 4PL IRT model is higher than the 3PL model under both administration settings. The goal of the examination is to correctly determine the examiners' actual ability. In addition to prior simulation trials, the 4PL IRT model might reduce estimation errors owing to missing items early on, as well as the model might enhance measurement accuracy and efficiency. It was also claimed that using the 4PL model meant sacrificing accuracy for all scores in order to decrease the effect of one of two errors on scores for the highly competent. Furthermore, the 4PL IRT model could not only alleviate the difficulties of ability underestimate caused by early thoughtless errors in practical circumstances, but it could also increase measurement efficiency.

Learning Management System (LMS):			
Developing An LMS-Based Cross-Platform Web Application for Improving Vocational High School Students' Competitiveness in ASEAN Economic Community [48]	Hary Suswanto,Ahmad Mursyidun Nidhom,Andika Bagus Nur Rahma Putra,Jehad A.H. Hammad	2017	The thesis classified the learning methods into four domains. The first was (1) live synchronous instruction, which took place in the classroom while students approached the start of their apprenticeship. Three additional techniques for learning, including (2) virtual synchronous, (3) self-paced asynchronous, and (4) interactive asynchronous learning, were applied online and established throughout the Learning Management System.
A Web-Based Learning Management System with Automatic Assessment Resources [50]	Janine G. Moura,Leônidas O. Brandão, and Anarosa A. F. Brandão	2007	PHP, JavaScript, and MySQL were used to build LMS. The learning material is organized in components, which enables reusability. Course, lecture, topic, exercise, illustration, and text are the components. A course denotes a topic that is covered as part of a program. A lesson is a set of exercises designed to

			teach a specific topic over a specified period of time. A topic is a subtopic inside a lesson's subject. The events that comprise a lesson are exercises, illustrations, and documents.
Learning Management System (LMS) Success: An Investigation Among the University Students [52]	Seyed Mohammadbagher Jafari, Suha Fouad Salem, Mohaddece Sadat Moaddab, Sharif Omar Salem	2015	DeLone and McLean information system success model was utilized in this research. This model consists of six variables: (1) system quality, (2) information quality, (3) service quality, (4) use/intention to use, (5) user satisfaction and (6) net benefits
Gamified Learning Management System:			
Engaging Engineering Students with Gamification [53]	Gabriel Barata, Sandra Gama, Joaquim Jorge, Daniel Gonçalves	2013	Added experience points (XP), levels, leaderboards, challenges, and badges, which seem to be some of the most consensual game elements used in gamification. The leaderboard displays enrolled students by row, sorted in descending

			order by level and XP. All statistical differences between groups were checked using a nonparametric MannWhitney's U test.
An Empirical Study on the Use of Gamification on IT Courses at Higher Education [54]	Balázs Barna and Szabina Fodor	2017	The research used Moodle version 2.5.1 which was built in PHP and supported relational databases such as MySQL, PostgreSQL, or Microsoft SQL Server as well as Object-Oriented databases like Oracle. Five gamification elements are chosen to be implemented on the e-Learning system: leaderboard, score, title, badge, and completion track Based on this experiment, removing the gamification environment from the existing e-Learning system causes more impact compared to adding it.
The Effects of Gamification on Engineering Lab Activities [55]	Eunsik Kim, Ling Rothrock, and Andris Freivalds	2016	Websites with Gamification (GM) and Non-Gamification (NG) were established in which students could create their own multiple-choice

			questions (MCQs) and answer the questions authored by classmates. Frequency analysis and two-sample t-test were conducted to determine the numbers of students who joined the websites and to determine the significance of the differences in website activities between the two groups for each phase, respectively. The students' performance was compared based on the students' scores on the general knowledge test, midterm, and final exam. There is a positive effect of gamification on student learning in engineering lab activities.
'Make-It-ECE', a Mathematics Learning Management System (LMS) for Engineering	Maila R. Angeles, Custer C. Deocaris,Celso B. Co and Shearyl U. Arenas	2014	Make it EC-E (MiE) is a learning management system (LMS) intended to complement the mathematics assessment of prospective engineers taking the Philippine National Licensure Board exam.

Students in the Philippines [56]			The construction of this thesis was driven by architecture. The user interface layer, the device layer, and the data storage layer have all been defined. The front end is a graphical user interface (GUI) for both students and teachers. JavaScript and HTML were used. The website is divided into the following sections: Lecture Notes (LN), Learning Activities (LA), Assessment Exam (AE), Forum, and Login/Logout History. The LN is predefined according to the content of ABET-certified ECE courses. The LN is focused on the mathematics courses offered in the ECE program at TIP, including trigonometry, geometry, calculus, differential equations, and algebra.

Web-based Rapid Authoring Tool for LMS Quiz Creation [57]	Sugi Yuuichi, Kita Toshihiro, YasunamiSeisuke and Nakano Hiroshi	2006	Web-based learning management systems and course management systems offer an interactive platform that is efficient and instructive for online instructors and students. Self-exams or auto-graded quizzes are effective tools for determining the level of comprehension and determining which sections need additional study. HTML, (2) PHP, and (3) AJAX (Asynchronous and JavaScript + XML) were used in this research.

APPENDIX B – Survey Instrument

Gamified LMS for ECE Subjects Survey						
Introduction: The study entitled "**Development of a Gamified Learning Management System for ECE Subjects Through Utilization of Fuzzy Inference System (FIS) Models for Effective Learning**" aims to produce a gamified LMS that serves as a licensure exam preparation tool for ECE students. This survey questionnaire will then measure the effect of using ECEdemy in terms of the users' engagement, motivation, and performance.						
Instruction: Please rate whether you strongly disagree or strongly agree. Check one response of the following statements. Rate **1** – if Strongly Disagree, **2** – Disagree, **3** – Neither Agree nor Disagree, **4** – Agree, 5 – if Strongly Agree						
Survey Statements	**Rating**					
	1	**2**	**3**	**4**	**5**	
Engagement						
1. Gamified elements (e.g., XP points, badges, leaderboards, levels, etc.) keep me committed to the game.						
2. I like how I'm rewarded with XP points or leveling up every time I answer a question correctly.						
3. I feel excited every time I open the web-application.						
4. I wanted to explore all the options because it was very challenging.						
5. I wanted to complete the game.						
6. ECEdemy is great for killing time productively.						
7. Being in a competition keeps my excitement alive.						
Motivation						
8. Seeing my XP points, badges, rank on leaderboards, levels, etc. inspires me to try harder.						
9. I feel challenged every time a new question appears.						
10. ECEdemy inspires my curiosity, making me intrigued by the lessons.						
11. The solutions provided encourage me to correctly answer similar problems next time.						
12. I like to do better than other students in ECEdemy.						
13. I would describe the gameplay as very interesting.						
14. It is important that I earn a high score in the game.						
15. Earning XP points, badges, and ranking on the leaderboard improves my commitment to the review process.						
16. ECEdemy encourages me to study on a regular basis.						
Performance						
17. ECEdemy improves my productivity.						

18. The use of ECEdemy enables me to better prepare for the examination.					
19. I am able to learn easily by answering problems in ECEdemy.					
20. I felt my learning experience is customized according to my needs.					
21. Performing well in the game has improved my self-confidence.					
22. ECEdemy enables me to apply and practice my knowledge.					
23. Using ECEdemy enhances my learning performance.					
24. The system helps me have a clear understanding of the concepts.					
25. I was so into this game that I lost track of time.					
26. I can fully understand the problems, thanks to the solutions.					
27. Personalized set of questions aids me to learn efficiently.					

Free Response:

1. Which game-like elements do you like most about the website? (XP Points, badges, quests, achievements, leaderboards, report page, etc)
2. What do you think could be improved on the website to make it more fun?
3. What do you think if added can make the website more effective for you to learn?
4. How likely is it for you to use ECEdemy in reviewing?
5. To what extent is your traditional method of studying being changed?

APPENDIX C – Documentation

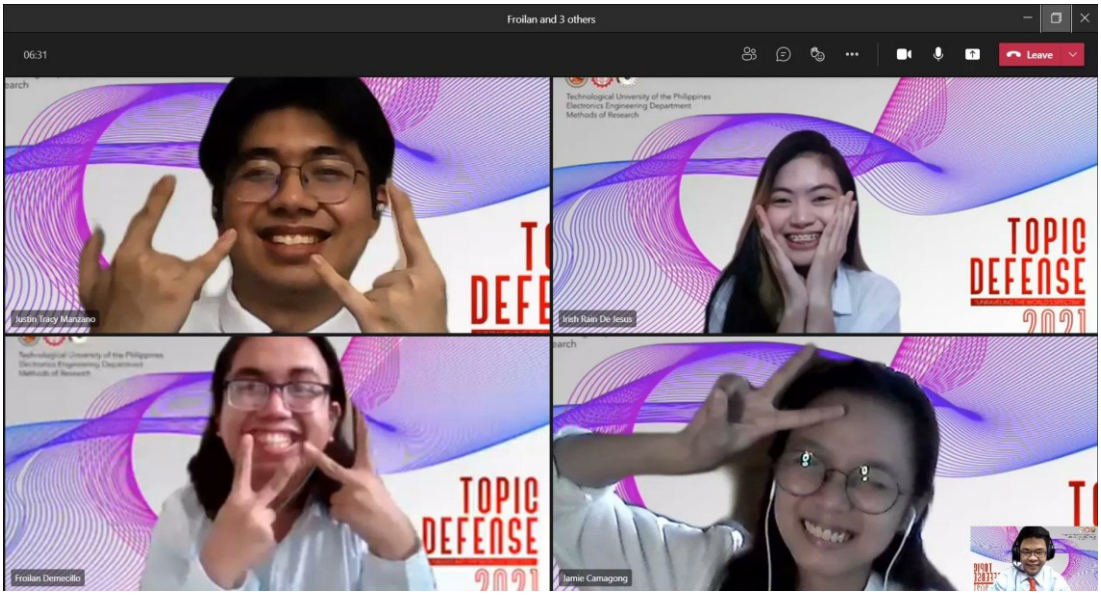


Image 1: *Topic Defense*

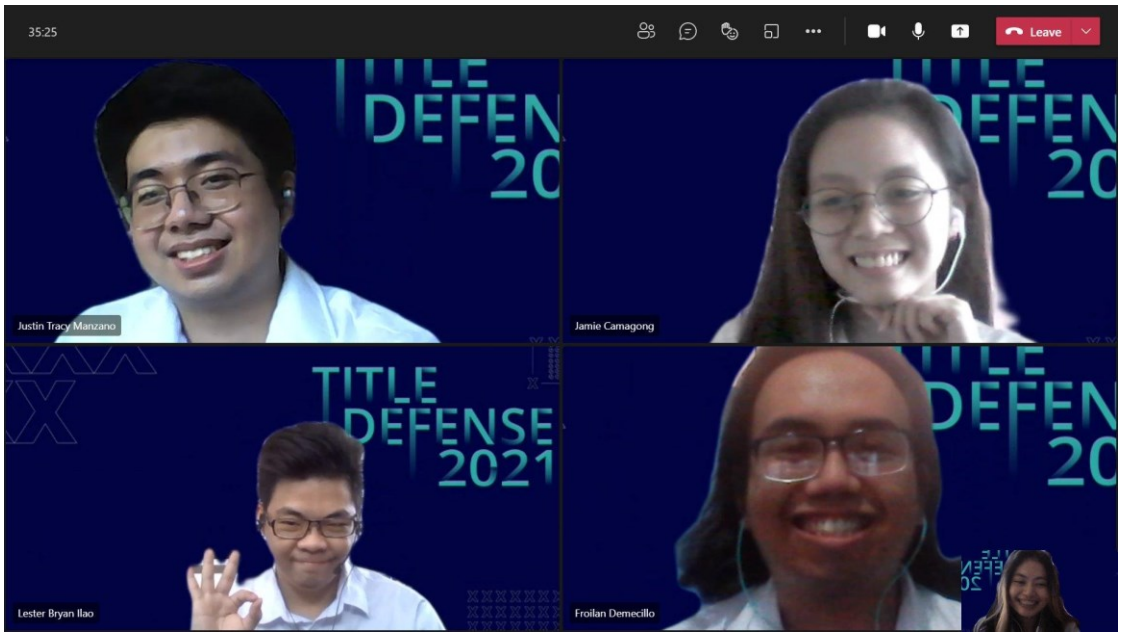


Image 2: *Title Defense*

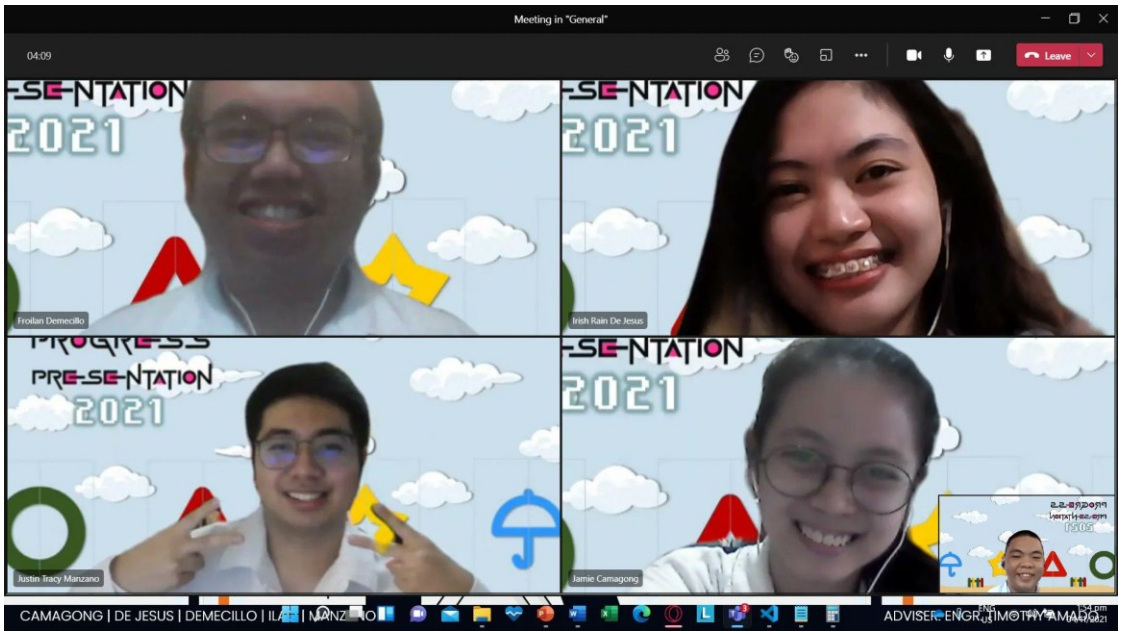


Image 3: *Progress Defense*

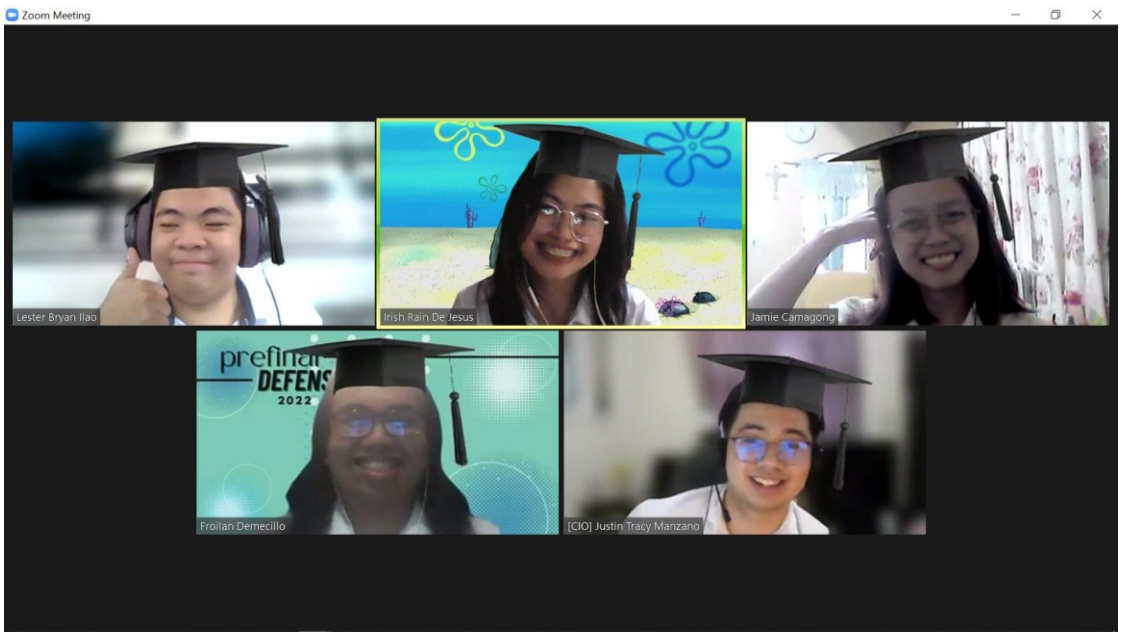


Image 4: *Prefinal Defense*

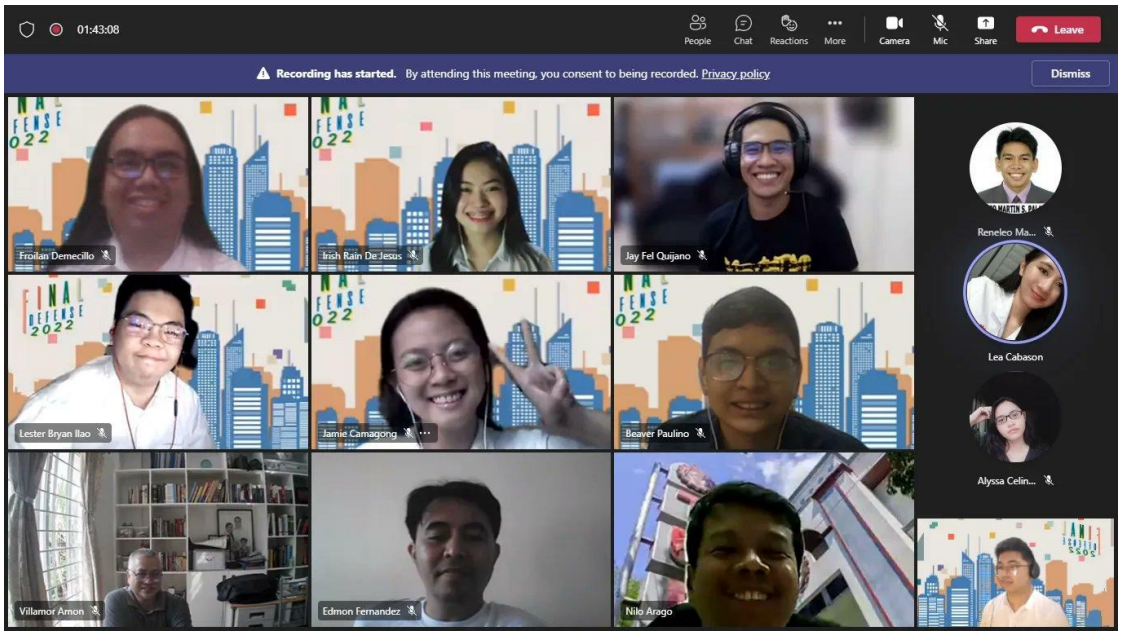


Image 5: *Final Defense (with Panelists)*

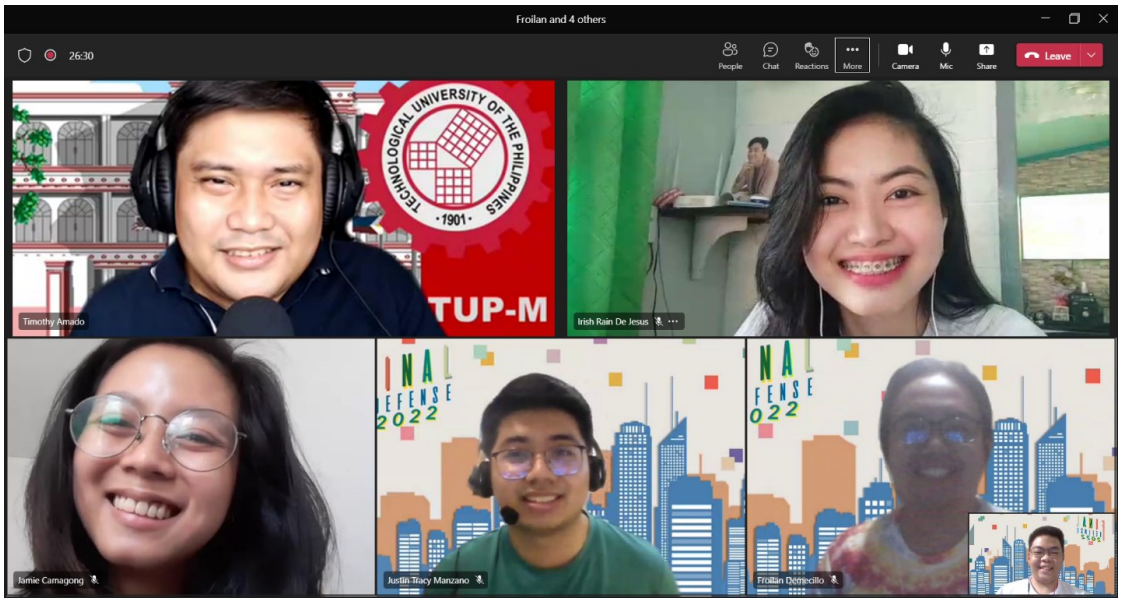


Image 6: *Team ECEdemy with Engr. Amado*

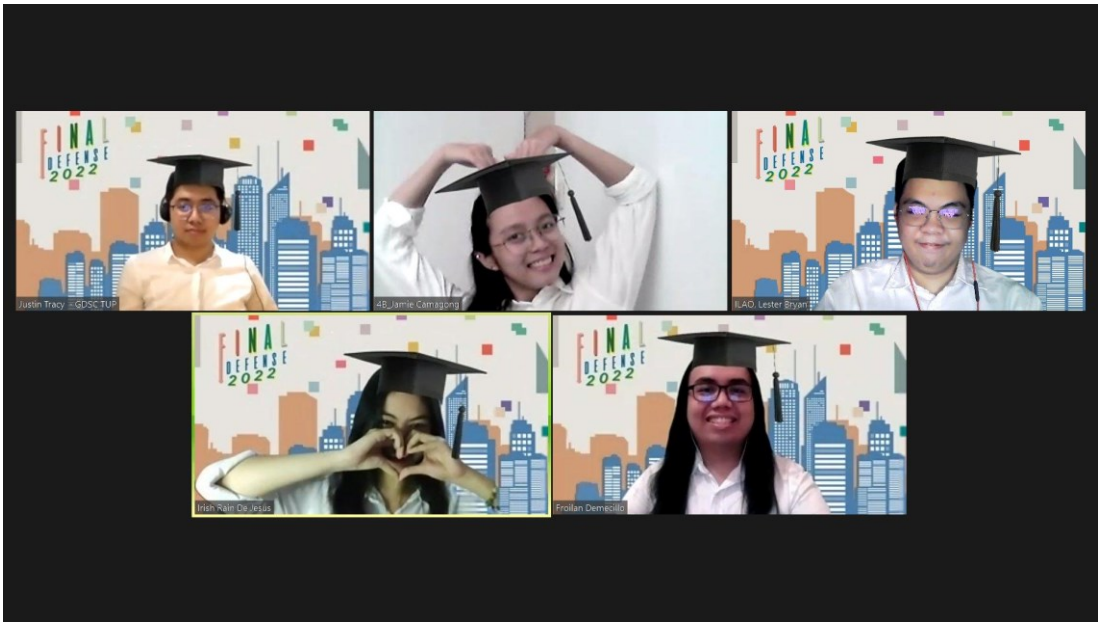


Image 7: *Manifesting (Final Defense)*

Image 8*: Manifested! Graduation August 26, 2022*

APPENDIX D – Curriculum Vitae

CAMAGONG, JAMIE L.
Lot 63 Blk 36 Annapolis St. Metro South Village,
Biclatan, General Trias, Cavite
Contact No.: 09354987350
Email Address: jamiecamagong@gmail.com

CAREER OBJECTIVE

- To work with passion and contribute to organizational success by maximizing my skills, knowledge, and competency relating to my field of study while developing new skills and gaining real-world experience.

PERSONAL SKILLS

- Simulation and Design Software
  - Multisim
  - Cisco Packet Tracer
  - Design Spark PCB
  - Figma
  - Adobe Illustrator, Photoshop, and XD
- Technical Skills
  - Basic Electronics and Communication
  - Troubleshooting and soldering
  - Postman API
- Programming Languages
  - Basic knowledge in Programing: Python, R, JavaScript, HTML, and CSS
  - Node.JS and Angular
  - MATLAB / GNU Octave
  - Oracle DB basics
  - Basic Database Management (SQL)
- Computer Skills
  - Microsoft Office Suite
  - Computer System and Services

WORK EXPERIENCE

- **Finastra**
  Technical Solutions Consultant Intern (February 2022 – July 2022)
  Makati, Metro Manila

- **International Business & Economic Forum (IBEForum)**
  Data Scientist Intern (August 2021)
  Bangalore, India

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES

Bachelor of Science in Electronics Engineering
Ayala Blvd. Ermita, Manila
AY: 2018 – Present

SECONDARY : ROGATIONIST COLLEGE
Km 52 Emilio Aguinaldo Hwy, Silang, 4118 Cavite
SY: 2016 – 2018

AMADEO NATIONAL HIGH SCHOOL
Crisanto M. De Los Reyes Ave, Amadeo, Cavite
SY: 2012 – 2016

PRIMARY : JAVALERA ELEMENTARY SCHOOL
Crisanto M. De Los Reyes Ave, General Trias, Cavite

SY: 2006 – 2012

AFFILIATIONS

June 2018 – Present **Organization of Electronics Engineering Students (OECES)**

Member
College of Engineering
Technological University of the Philippines

August 2021 – Present **Organization of Electronics Engineering Students (OECES)**

Creative Works and Design Committee, Graduating Class Division
College of Engineering
Technological University of the Philippines

June 2018 – Present **Institute of Electronics Engineering Students of the Philippines – Manila Student Chapter (IECEP – MSC)**
Member

June 2017 – April 2018 **Science, Technology, Engineering, and Mathematics (STEM) Society**
Treasurer
Rogationist College

ACHIEVEMENTS

- Graduated with Honors (Senior High) – Rogationist College (2016 – 2018)
- TESDA National Certificate (NCII) Passer – Computer Systems Servicing (2018)
- Best in Conduct and Diligence Awardee (2016 – 2018)
- Elected as the General Treasurer of the STEM Society (2017 – 2018)
- 3rd Place District Level – Feature Writing in English (2010)
- Participant in the Division Schools Press Conference (DSPC) – (2011)

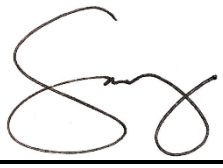
SEMINARS

- **Establishing Networks and Possibilities: Achieving higher frequencies for Excellence through Technology**
  Technological University of the Philippines – Manila
  April 7, 2022
- **SEMICON: Unravelling Limitless Solutions to Infinite Advanced Technologies**
  Technological University of the Philippines – Manila
  April 26, 2022
- **ON-AIR: Exploring Different Channels Towards Greater Amplitude**
  Technological University of the Philippines – Manila
  April 29, 2022
- **Power On: Amplifying Knowledge and Career Opportunities in the Field of Power Electronics**
  Technological University of the Philippines – Manila
  May 28, 2022
- **Vision Capsule: Biomedical Field in the Eye of Electronics Engineering**
  Technological University of the Philippines – Manila
  May 28, 2022

CHARACTER REFERENCES

Engr. Timothy M. Amado
Head, Electronics Engineering Department
Technological University of the Philippines - Manila
Ayala Blvd. Ermita, Manila

I hereby certify that the above information is true and correct to the best of my knowledge and ability.



Applicant's Signature

DE JESUS, IRISH RAIN S.
5 Kaimito St. Bilog, Balangkas, Valenzuela City
Contact No.: 09569143138
Email Address: irishraindejesus@gmail.com

CAREER OBJECTIVE

- To contribute to team success through hard work, attention to detail, and excellent organizational skills. Have a clear understanding of cloud computing, communications, ICT, and microprocessor. Motivated to learn, grow, and excel in your company.

PERSONAL SKILLS

- **Simulation and Design Software**
  - Multisim
  - Cisco Packet Tracer
  - Design Spark PCB
  - Figma
  - Adobe Photoshop, Premiere, & InDesign
- **Technical Skills**
  - Cloud Computing
  - Microsoft Azure
  - Citrix Cloud & Workspace
  - JIRA Service Desk
  - Active Directory
  - Windows & Linux Servers
  - Amazon Web Services (AWS)
  - Front-End Development
  - Graphic Design
  - Basic Electronics & Communication
  - Troubleshooting and soldering
- **Programming Languages**
  - Basic knowledge in Python Programing, R, HTML, and CSS
  - MATLAB / GNU Octave
- **Computer Skills**
  - Microsoft Office Suite

WORK EXPERIENCE

- **Finastra**
  Associate Technical Solutions Consultant (Sept 2022 – Present)
  Technical Solutions Consultant Intern (Aug 2021 – June 2022)
  Ruby Road, Ortigas Center, Pasig City, Metro Manila
- **Business Permit and Licensing Office**
  Encoder/Customer Service/All Around Employee (SPES)
  Obando, Bulacan

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES

Bachelor of Science in Electronics Engineering
Ayala Blvd. Ermita, Manila
AY: 2018 – Present

SECONDARY : SAN DIEGO PAROCHIAL SCHOOL
Polo, Poblacion, Valenzuela City
SY: 2016 – 2018

OBANDO NATIONAL HIGH SCHOOL
Obando, Bulacan
SY: 2012 – 2016

PRIMARY : OBANDO CENTRAL SCHOOL
Obando, Bulacan
SY: 2006 – 2012

AFFILIATIONS

June 2018 – Present **Organization of Electronics Engineering Students (OECES)**

Member
College of Engineering
Technological University of the Philippines

June 2018 – Present **Institute of Electronics Engineering Students of the Philippines**
Member
Manila Student Chapter (IECEP – MSC)

ACHIEVEMENTS

- San Diego Parochial School, With High Honors (Salutatorian) – AY 2017-2018
- Obando National High School, With High Honors (Salutatorian) – AY 2015-2016
- Obando Central School, Class Valedictorian – AY 2011-2012
- Dean's Lister – AY 2020-2022
- President's Lister – 1st Sem, 2021-2022
- Participant in 2021 Eccentrify: The ECE Quizzers' Cup
- TUP-Manila ROTC Medics – AY 2018-2019
- CHED-Tulong Dunong Scholar (2018-Present)
- Top 2: Electronic Circuits Analysis and Design
- Top 5: Electronic Devices and Circuits
- Top 6: Advanced ECE Mathematics
- Editor-in-Chief: SANUERA English School Publication – AY 2015-2016

- School Press Conference: Photojournalism, Regional Level Participant (2015)
- Award for Research and Innovation – Gold (2018), Senior High School
- Supreme Student Government Officer (2011-2018)

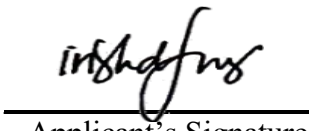
SEMINARS

- **Fundamentals of Cloud Computing & Exploring Azure DevOps**
  IECEP Manila Student Chapter (IECEP – MSC)
  November 2021
- **TechEx – Fundamentals of Data Science**
  IECEP Manila Student Chapter (IECEP – MSC)
  October 2020
- **SEIPI's Microelectronics and Semiconductor Testing Webinar**
  Semiconductor and Electronics Industries in the Philippines Foundation, Inc.
  September 2021
- **Establishing Networks and Possibilities: Achieving Higher Frequencies for Excellence through Technology**
  Technological University of the Philippines – Manila
  April 2022
- **NEXT LEVEL: Artificial Intelligence Trends in the 21st Century**
  IECEP Manila Student Chapter (IECEP – MSC)
  March 2022

CHARACTER REFERENCES

Engr. Timothy M. Amado
Head, Electronics Engineering Department
Technological University of the Philippines - Manila
Ayala Blvd. Ermita, Manila

I hereby certify that the above information is true and correct to the best of my knowledge and ability.



Applicant's Signature

DEMECILLO, FROILAN N.
L5 E East Fresno St. California Vill. San Bartolome Q.C.
Contact No.: +639178047598
Email Address: froilan.demecillo@tup.edu.ph

CAREER OBJECTIVE

- To obtain a suitable position in a firm where I can make the most of use of all knowledge and skills I have acquired through my educational life and help the organization to reach on the peak and thus prolong my career.

PERSONAL SKILLS

- Simulation and Design Software
  - Multisim
  - Cisco Packet Tracer
- Technical Skills
  - Basic Electronics and Communication
  - Troubleshooting and soldering
- Programming Languages
  - Basic knowledge in JavaScript and R
  - MATLAB / GNU Octave
  - Basic Database Management (SQL)
- Computer Skills
  - Microsoft Office Suite

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES

Bachelor of Science in Electronics Engineering
Ayala Blvd. Ermita, Manila
AY: 2018 – Present

SECONDARY : COLLEGE OF ST. CATHERINE QUEZON CITY
362 Quirino Highway, Quezon City, Philippines
SY: 2012 – 2018

PRIMARY : LEOPOLDO B. SANTOS ELEMENTARY SCHOOL
Dominador St., T. S. Cruz Subd., Brgy. Baesa, Quezon City

SY: 2006 – 2012

AFFILIATIONS

June 2018 – Present	**Organization of Electronics Engineering Students (OECES)** Member College of Engineering Technological University of the Philippines
2020 – 2021	**Organization of Electronics Engineering Students (OECES)** Vice President for Sports, Culture and Arts Technological University of the Philippines
June 2018 – Present	**Institute of Electronics Engineering Students of the Philippines – Manila Student Chapter (IECEP – MSC)** Member
2018 – Present	IECEP Volleyball Team Member Technological University of the Philippines
2018 – 2019	TUP Kalinangan Singers Member Technological University of the Philippines
2016 – 2018	CSCQC Senior Police President
2008 – 2018	Sipnayan Club (Junior High School and Senior High School) President
2007 – 2008	Choir Club Member
2006 – 2007	Supreme Pupil Government Auditor
2015 – 2016	Citizenship Advancement Training Color Commander

ACHIEVEMENTS

- Consistent honor student (Elementary to 1st Year College)
- Winnie Castelo Awardee
- Model Color Commander (Citizenship Advancement Training)
- Consistent Outstanding Leader of the Year (Sipnayan Club)
- Most Outstanding Senior Police
- Math Wizard of the Year (Senior High School)

- 1st place in Table Tennis and Champion in Badminton Doubles (SHS)
- 1st place in Volleyball at Institute of Electronics Engineers of the Philippines

SEMINARS

- **Establishing Networks and Possibilities: Achieving higher frequencies for Excellence through Technology**
  Technological University of the Philippines – Manila
  April 7, 2022
- **Preventing Backdoors: Application of Random Number Generators in Cryptography**
  Technological University of the Philippines – Manila
  April 23, 2022

- **SEMICON: Unravelling Limitless Solutions to Infinite Advanced Technologies**
  Technological University of the Philippines – Manila
  April 26, 2022

- **ON-AIR: Exploring Different Channels Towards Greater Amplitude**
  Technological University of the Philippines – Manila
  April 29, 2022

- **Digital Fabrication and Modelling Technologies: An Introduction To Computer Controlled Manufacturing**
  Technological University of the Philippines – Manila
  May 14, 2022

- **What's Next: Amplifying ECE Career Opportunities Post Pandemic**
  Technological University of the Philippines – Manila
  May 21, 2022

- **Power On: Amplifying Knowledge and Career Opportunities in the Field of Power Electronics**
  Technological University of the Philippines – Manila
  May 28, 2022

- **Vision Capsule: Biomedical Field in the Eye of Electronics Engineering**
  Technological University of the Philippines – Manila
  May 28, 2022

- Fantastic Thesis and Where to Find Them
- COS Graduate Research Lecture Series
- Fundamentals of Data Science (IEEE)
- Role of Artificial Intelligence to Traffic Management (IEEE)
- Role of Machine Learning in Smart Manufacturing (IEEE)
- CCNA Introduction and Technical Seminar (TOP ECE Review Center)

CHARACTER REFERENCES

Engr. Timothy M. Amado
Head, Electronics Engineering Department
Technological University of the Philippines - Manila
Ayala Blvd. Ermita, Manila

I hereby certify that the above information is true and correct to the best of my knowledge and ability.

Applicant's Signature

ILAO, LESTER BRYAN F.
9316 Sampaguita St. Guadalupe Nuevo, Makati City
Contact No.: +639999762512
Email Address: lestertetengilao@gmail.com

CAREER OBJECTIVE

- To advance my learning, knowledge, and skills by obtaining a challenging position in a reputable company and make use of my technical skills to achieve goals of a company that focuses on software engineering and data management.

PERSONAL SKILLS

- Simulation and Design Software
  - Multisim
  - Cisco Packet Tracer
- Technical Skills
  - Basic Electronics and Communication
  - Troubleshooting and soldering
- Programming Languages
  - Python
  - SQL
  - MATLAB
  - Java
- Data Science Big Data & Machine Learning
  - A/B Testing
  - ETL
  - Data Science pipeline (data cleansing, wrangling, visualization, modelling)
  - Python (e.g: Scikit-learn, NumPy, Pandas, Matplotlib, Seaborn)
- Web Development Technologies
  - Heroku
  - Django Framework
  - Flask Framework
  - Git, HTML, CSS, and Javascript

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES

Bachelor of Science in Electronics Engineering
Ayala Blvd. Ermita, Manila
AY: 2018 – Present

SECONDARY : ASIA PACIFIC COLLEGE

3 Humabon Place, Magallanes, Makati City 1212 Ph
SY: 2016 – 2018

PITOGO HIGH SCHOOL
Negros St. Pitogo, Makati City 1213
SY: 2012 – 2016

PRIMARY **:** SAN JOSE ELEMENTRAY SCHOOL
J. Felipe St. Guadalupe Nuevo, Makati City
SY: 2006 – 2012

AFFILIATIONS

June 2018 – Present **DOST Scholars Club**
Member
Technological University of the Philippines

June 2018 – Present **Organization of Electronics Engineering Students (OECES)**
Member
College of Engineering
Technological University of the Philippines

August 2019 – 2020 **Organization of Electronics Engineering Students (OECES)**
Technical Committee, Graduating Class Division
College of Engineering
Technological University of the Philippines

June 2018 – Present **Institute of Electronics Engineering Students of the Philippines – Manila Student Chapter (IECEP – MSC)**
Member

2021 – Present **Google Developer Students Clubs**
Member
Technological University of the Philippines

ACHIEVEMENTS

- Received Department of Science and Technology (DOST) Merit Scholarship
- Department of Information and Communications Technology (DICT) through the Modern Academics Convergence Hub (MACH), Certification of Course Completion (December 2021 – March 2022)
- University of Michigan – Coursera, Certification of Course Completion (February 2022)
- DataCamp – Certificate of Course Completion

TRAININGS AND SEMINARS

- **Omdena**
  OmdenaSchool, Intern
  February 2022

- **StackTrek**
  Talent Acceleration Program (TAP), Trainee
  February 2022

- **The Sparks Foundation**
  Graduate Rotational Internship Program (GRIP), Intern
  February 2022

- **AWS Academy and AWS Re/start**
  AWS Cloud Practitioner, Intern
  February 2022

- **When Data Meets Social Good**
  Analytics Association of the Philippines (AAP)
  November 5, 2022

- **Automated Machine Learning Workflows with Sage Maker Pipelines**
  EdukasyonPH
  February 3, 2022

- **Data Analytics in Action**
  Smarter Philippines through Data Analytics, Research and Development, Training and Adoption (SPARTA)
  March 2, 2022

- **Establishing Networks and Possibilities: Achieving higher frequencies for Excellence through Technology**
  Technological University of the Philippines – Manila
  April 7, 2022

- **Preventing Backdoors: Application of Random Number Generators in Cryptography**
  Technological University of the Philippines – Manila
  April 23, 2022

- **SEMICON: Unravelling Limitless Solutions to Infinite Advanced Technologies**
  Technological University of the Philippines – Manila
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- **ON-AIR: Exploring Different Channels Towards Greater Amplitude**

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  Technological University of the Philippines – Manila
  May 28, 2022

- **Vision Capsule: Biomedical Field in the Eye of Electronics Engineering**
  Technological University of the Philippines – Manila
  May 28, 2022

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Head, Electronics Engineering Department
Technological University of the Philippines - Manila
Ayala Blvd. Ermita, Manila

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.

Applicant's Signature

MANZANO, JUSTIN TRACY Q.
Numancia Residences, Urbiztondo St. Binondo Manila
Contact No.: 09772848199
Email Address: justintracymanzano@gmail.com

CAREER OBJECTIVE

- To work with passion and contribute to organizational success by maximizing my skills, knowledge, and competency relating to my field of study while developing new skills and gaining real-world experience.

PERSONAL SKILLS

- Simulation and Design Software
  - Multisim
  - Cisco Packet Tracer
- Technical Skills
  - Basic Electronics and Communication
  - Troubleshooting and soldering
- Programming Languages
  - Basic knowledge in Python Programing and R
  - MATLAB / GNU Octave
  - Basic Database Management (SQL)
- Data Science & Web Development Technologies
  - ETL
  - Data Science pipeline (data cleansing, wrangling, visualization modelling)
  - Django Framework
  - Flask Framework
  - Git, HTML, CSS, and JavaScript
- Big Data & Machine Learning
  - Heroku
  - Python

EDUCATIONAL ATTAINMENT

TERTIARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES
Bachelor of Science in Electronics Engineering
Ayala Blvd. Ermita, Manila
AY: 2018 – Present

SECONDARY : TECHNOLOGICAL UNIVERSITY OF THE PHILIPPINES
Senior Highschool – STEM Mechatronics Engineering
Ayala Blvd. Ermita, Manila
SY: 2016 – 2018

PHILIPPINE NORMAL UNIVERSITY
Junior Highschool
Taft Avenue Ermita Manila
SY: 2012 – 2016

PRIMARY : **P**EDRO GUEVARRA ELEMENTARY SCHOOL
Numancia St. San Nicolas Manila
SY: 2006 – 2012

AFFILIATIONS

June 2018 – Present **Organization of Electronics Engineering Students (OECES)**
Member
College of Engineering
Technological University of the Philippines

June 2018 – Present **Institute of Electronics Engineering Students of the Philippines – Manila Student Chapter (IECEP – MSC)**
Member

August 2021 - Present **Google Developer Student Clubs – TUP Manila**
Chief Innovation Officer, Co-Founder

SEMINARS

- **Establishing Networks and Possibilities: Achieving higher frequencies for Excellence through Technology**
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  April 7, 2022

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  May 14, 2022

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  Technological University of the Philippines – Manila
  May 28, 2022

- **Vision Capsule: Biomedical Field in the Eye of Electronics Engineering**
  Technological University of the Philippines – Manila
  May 28, 2022

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Head, Electronics Engineering Department
Technological University of the Philippines - Manila
Ayala Blvd. Ermita, Manila

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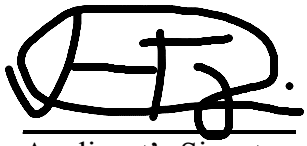

Applicant's Signature