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**Thesis for the Degree of Master of Engineering**

**Development of Game-Based Vidyanusa  
Mathematics Learning Systems Using  
Balanced Designing**

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**by**

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**Interdisciplinary Program of Information Systems**

**The Graduate School**

**Pukyong National University**

**February 2016**

**Development of Game-Based Vidyanusa  
Mathematics Learning Systems Using  
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**균형 잡힌 설계를 사용한 게임기반  
비다누사 수학 학습 시스템의 개발**

**Advisor: Prof. Man-Gon Park**

**by**

**Diena Rauda Ramdania**

**A thesis submitted in partial fulfillment of the requirements  
for the degree of**

**Master of Engineering**

**in the Department of Information Systems (Interdisciplinary Program),  
the Graduate School,  
Pukyong National University**

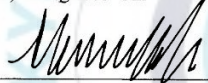
**February 2016**

Development of Game-Based Vidyanusa Mathematics  
Learning Systems Using Balanced Designing

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February 26, 2016

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## 균형 잡힌 설계를 사용한 게임기반 비다누사 수학 학습 시스템의 개발

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### 요약

학습에 기반한 게임 개발은 학생들이 경험을 얻고, 게임을 함으로써 학습자료들을 이해하고 문제를 해결하는 데에 있어 효과적인 학습방식중의 하나이다. 여기서 ‘재미’라는 요소는 학습할 때 게임 이용을 위한 계기가 되는 게임을 할 때 얻어지게 된다. 그러나 게임을 하는 학생들이 실제로 그들이 이러한 게임을 하는 동안 학습을 하게되는 지에 대한 의문이 생기게 된다.

비다누샤는 인도네시아의 Crayonpedia 교육 시스템에 의해 개발된 온라인 수학 교육 게임을 말하게 된다. 비다누샤의 학습 목표는 중학교 학생들이 수학을 배우는 데 있어 효율적인 학습을 할 수 있도록 하는 것이다. 비다누샤에 포함된 콘텐츠는 인도네시아 교육과정에 맞게 레벨 7, 8, 9 수준의 수학 과목을 포함하고 있다. 전체적으로 중학생 레벨 7, 8, 9를 위한 수학과목에서 77개의 핵심 기능이 있고, 이러한 기능들은 정서적이고, 인식적이고 그리고 정신운동적인 요소를 포함하고 있다. 비다누샤는 모든 요소를 요약하게 되고 그들 모두를 23개의 임무로 변형하게 된다.

이 논문의 목표는 Balanced Design 접근 방법을 사용함으로써 게임 학습 자료의 기능과 관계들을 설계하는 것이다. 이러한 접근은 연속적으로 3가지 모델이 존재하는데, 먼저 Content Model은 게임의 목표를 개요화하며, Task Model은 임무들을 매핑하며, 마지막으로 Evidence Model은 학생 평가를 개요화하게 된다.

이 연구는 효과적인 결과와 목표를 위한 유용성 요소에 관하여 생산된 게임의 가치를 논의할 것이다. 게임의 평가는 Software 품질 제품에 관한 국제 표준 ISO/IEC 9126-1 FDIS 에 기반하여 수행될 것이다.



# **Development of Game-Based Vidyanusa Mathematics Learning Systems Using Balanced Design**

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## **Abstract**

The development of Game Based Learning is a way of effective learning that help students and engages them in experience, understanding the material by playing games, and solve problems. The "fun" factor here is obtained when playing the games which becomes a trigger for the use of games in learning. However, there is a question of (linger) doubts whether the players actually learn while they play such games.

Vidyanusa (Vidya: Knowledge, Nusa: Island) is an Online Mathematics Education Game being developed by Crayonpedia Education Ecosystem in Indonesia. The learning goal of Vidyanusa is to engage junior high school students in learning mathematics. The content contained in Vidyanusa includes the subject matter of mathematics at levels 7, 8, and 9 in accordance with the curriculum of provided by states of Indonesia. In total, there are 77 core competences in the subjects of mathematics for junior level classes 7, 8 and 9. This competency includes aspects of affective, cognitive, and psychomotor. Vidyanusa summarizes all aspects and transforming them into 23 missions.

The purpose of this study is to design the Vidyanusa game material Functions and Relations by using Balanced Design Approach. This approach has three models in succession; the Content Model outlines the purpose of the game, the Task Model maps out the mission, and the Evidence Model outlines student measurement.

This study will then discusses the quality of games produced in term of Usability factor for effective results and objective. The measurement of the game was carried out based on International Standard ISO/IEC 9126-1 FDIS about Software Quality Product.

# **Chapter 1**

## **Introduction**

### **1.1. Background**

An Agency Organization Economic Cooperation and Development (OECD) conducts a survey through a Programme of International Student Assessment (PISA) on the educational system and the ability of the students in the school. This survey is conducted every three years and involved 65 countries representing 80% of the global economy of the world. Test participants are students aged 15-16 years. Based on the survey results, in 2012 Indonesia ranked 64 out of 65 countries. In a survey earlier in 2009, Indonesia is ranked 59. This survey is conducted to measure student learning outcomes in Mathematics, Reading, and Science [9], [10].

In a survey conducted by PISA, a Mathematics lesson aims to measure understanding of identification as well as the use of the mathematical foundations needed by someone in daily life [9 and 10]. In Indonesia, the basic objects that are studied in Mathematics are abstract covering facts, concepts, operating rules, and principles. At the moment, students in Math lesson act passively by just paying attention to the teacher who writes formulas

on the board. This lead students dislike Math lesson because it is considered difficult. As a solution for creating a fun learning, Game Based Learning approach can be proposed as one of the alternatives.

2012 Rank (n=65)	Country/Economy	Mathematics		Reading		Science	
		2009	2012	2009	2012	2009	2012
1	Shanghai-China	600	613	556	570	575	580
2	Singapore	562	573	526	542	542	551
3	Hong Kong-China	555	561	533	545	549	555
4	Chinese Taipei	543	560	495	523	520	523
5	Korea	546	554	539	536	538	538
7	Japan	529	536	520	538	539	547
17	Viet Nam	n.a.	511	n.a.	508	n.a.	528
50	Thailand	419	427	421	441	425	444
52	Malaysia	n.a.	421	n.a.	441	n.a.	420
<b>64</b>	<b>Indonesia</b>	<b>371</b>	<b>375</b>	<b>402</b>	<b>396</b>	<b>383</b>	<b>382</b>
65	Peru	365	368	370	384	369	373

Source: OECD, PISA (The Programme for International Student Assessment) database.

Figure 1.1 Position of Indonesia based on the survey results by PISA in 2012

Game Based Learning (GBL) is a method of learning that use digital games as a medium to reach the learning objectives. According to the March Prensky, the emergence of the GBL began in the last decade of the 20th century, along with the global technological developments [1]. The developments of GBL are influenced by a large number of

benefits that can be obtained by applying this method. One of the benefits be that this method is presents an excellent opportunity to engage students in activities which can enhance learning and produce a range of educational benefits [2].

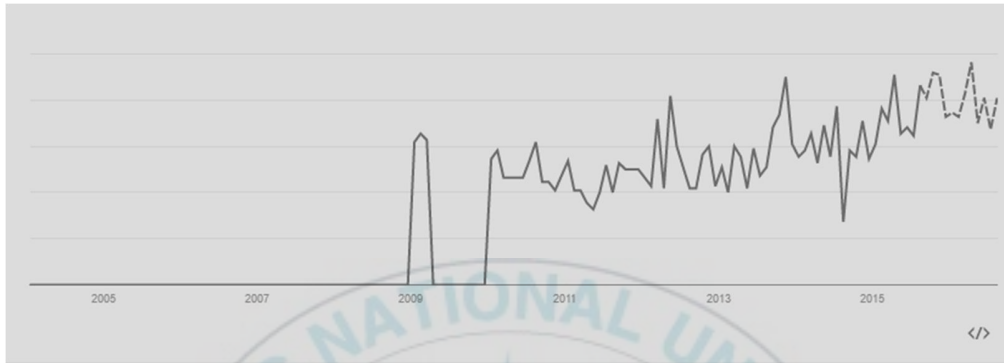


Figure 1.2 Google Trends chart showing Internet user interest in the topic of Game Based Learning [7]

In GBL, students actively do experiences, understanding the game, and solve problems in it [3]. Normally, students will feel delightful and satisfaction when they solve mysteries in the game. The "fun" obtained during playing games become a trigger for the use of games in learning. However, there are often doubts whether the players really learn while they are playing game? This becomes important when teachers conduct the assessment. The assessment is a side that is very important and inseparable from learning. Learning can be defined by two related questions that drive never-end cycle of improvement: what to teach and how to ensure a student know it [3].

For the purpose of learning, students' understanding towards the meaning of the game is very important. One of the solutions is by making a game design learning. This design should be able to answer questions about what knowledge to achieve, what tasks the student will do in the game, and how to measurements is performed [3]. Harmonization of the answers of 3 questions will produce a balanced game design and is expected to make learning not only fun but also more meaningful.

## **1.2. Problem Statement**

Issues to be addressed in this study are:

- a. How to analyze Mathematics subject material Functions and Relations into the game using Balanced Design approach?
- b. How to design user interface Vidyanusa game material Functions and Relations?
- c. Is the result of the game has a value of high quality in term of usability that can be supported learning Mathematics?



### **1.3. Thesis Objective**

The main purpose of this thesis is to design and develop a Mathematics Education Game using the Balanced Design. This study aims to:

- a. Analysis Mathematics subjects material Functions and Relations using Balanced Design approach,
- b. Design user interface of Vidyanusa game material Functions and Relations, and
- c. Measure Software Product Quality of Vidyanusa game material Functions and Relations.

### **1.4. Scope**

To make the scope of the problem is not too extensive, there is some limitations in this thesis include:

- a. The material in Vidyanusa game based on the Curriculum of 2013 for Junior High School.
- b. The material tested in this study is the Functions and Relations in Mathematics.
- c. Software product quality measurement only measure an aspect of usability.
- d. Adobe Flash with action script 3 is an application used to create Vidyanusa games.

## 1.5. Thesis Outline

The thesis has been divided into five chapters which are:

**Chapter 1** First chapter discussing about the facts and figures of Mathematics subjects in Indonesia and solutions that can be done to make learning mathematics more fun.

**Chapter 2** Related works discuss about previous work that related work to this system. The related work that contain the Lure of the Labyrinth game and Radix Endeavor game. At the end of this chapter, there are a metrics comparison the system with related works.

**Chapter 3** Literature Review explains the theoretical support and methods. It includes explanations about Balanced Design, Game Education, Mathematics Subject in Junior High School, and Software Quality Product.

**Chapter 4** System requirement and design Vidyanusa game generally, and specific about mission 21 and mission 22.

**Chapter 5** Implementation and experiment result chapter contains the result from implementation the system in actual environment.

Finally, **Chapter 6** Discussion and future works talk about the possible future works and suggestion for future works contain in this chapter.

## **Chapter 2**

### **Related Works**

There are several studies and works which related to the thesis. The following are the related works some educational games that using same method with Vidyanusa.

#### **2.1. The Lure of the Labyrinth**

The Lure of the Labyrinth is a game developed by The Education Arcade at the Massachusetts Institute of Technology. The target audience of this game is middle school students, and its primary goal is the enhancement of pre-algebra math learning, with a secondary goal of improving literacy. It is a long-form puzzle adventure game played over many sessions, with a persistent narrative that evolves over time. In order to complete the game players must navigate complex mathematical spaces, and solve puzzles that embody the big ideas of mathematics.

Playing on teams, students also have incentives to share their ideas about puzzle solving through an in-game message board, thereby bringing into the game space the kind of literacy activities usually reserved for game FAQs and interest groups. Teachers are

encouraged to let students play the game in advance of encountering the same material in school, so that when the topic is introduced in the classroom students can demonstrate their hard-earned expertise, rather than meet each new subject as neophytes [20]. The figures below illustrate the game:



Figure 2.1 Narrative Lure of the Labyrinth Game

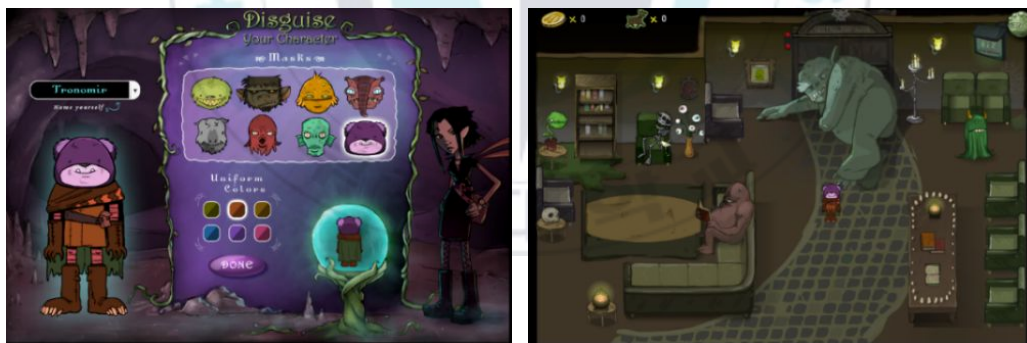


Figure 2.2 Game Environment



Figure 2.3 Game Mission

The mission of this game is to save a pet who was abducted to another place. An atmosphere full of mystery and darkness can be found when playing this game. That impression was further felt with the selection of characters in the form of various forms of monsters and a thrilling sound.

## 2.2. Radix Endeavor

The Radix Endeavor is a Massively Multiplayer Online Game (MMOG) being developed by The Education Arcade at the Massachusetts Institute of Technology, designed to improve learning and interest in STEM in high school students. The content specifically focuses on statistics, algebra, geometry, ecology, evolution, genetics, and human body systems. Players take on the role of mathematicians and scientists and embark on quests

that encourage them to explore and interact with the virtual world through math and science. Players become embedded in a narrative in the world, where they encounter a villain who does not believe in the practices of science. Players have to reason about science issues applicable to game characters' daily lives, refute the unscientific claims of the villain, and make choices based on what they consider to be valid evidence. The figures below describe the game:

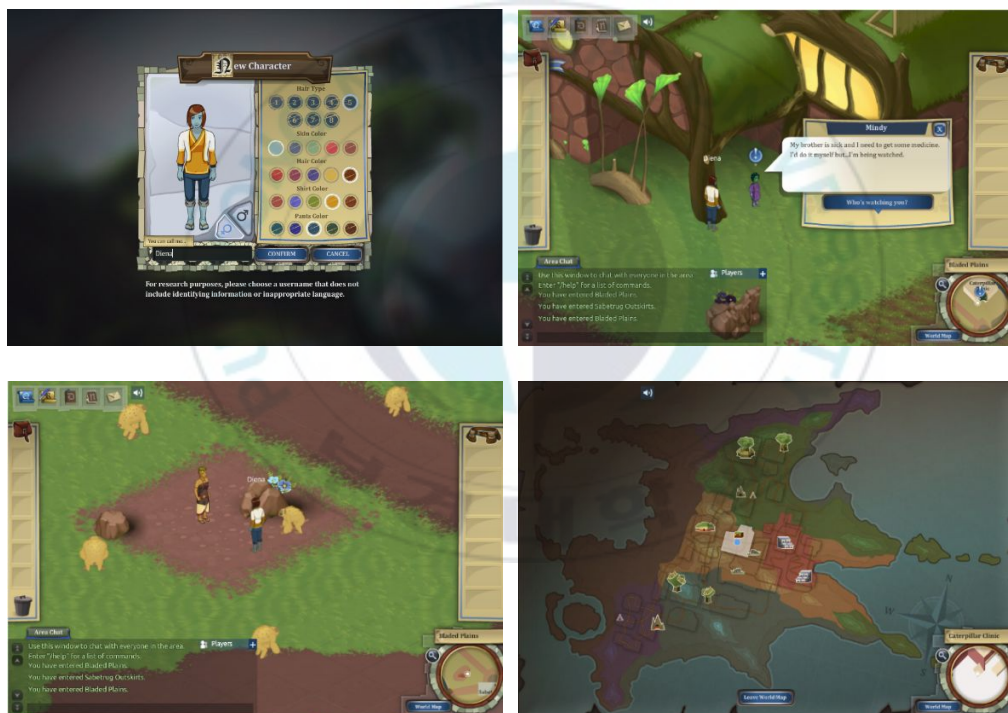


Figure 2.4 Radix Endeavor Game



Currently, there are seven quest lines in Biology and six in Math. Each quest line contains a series of quests around a specific content area (for example, human body systems, geometry, etc.). The quests start out easier and get progressively harder, building off what is learned in the previous quest. The goal is to have a culminating quest activity at the end of each quest line where students will apply what they have learned to a problem or new situation [21].

### 2.3. Comparison

This is a brief comparison between the proposed system and previous system on education game. The comparison result between our system and the related work display in Table 2.1.

Table 2.1 Comparison the system with related works

Game	Target Audience	Material	Game Characteristic	Type of Game
The Lure of the Labyrinth	Middle School student	Pre-algebra math learning and Literacy	Mystery with thrilling sound and monsters as Non Player Character.	Puzzle adventure game
Radix Endeavor	High School students	Statistics, Algebra, Geometry, Ecology,	Adventure in a village.	Massively Multiplayer

Game	Target Audience	Material	Game Characteristic	Type of Game
		Evolution, Genetics, and Human Body Systems		Online Game (MMOG)
Proposed thesis	Junior High School student	Mathematics and Sciences	Cheerful, delight, daily activities in different jobs.	Puzzle adventure game





## **Chapter 3**

### **Literature Reviews**

#### **3.1. Balanced Design**

Balanced Design is an approach to design educational games. The idea was created by a team from the MIT Scheller Teacher Education Program and Education Arcade staff in 2014. The purpose of this approach was made not to impose a new game development method, but rather to present a learning design approach to be integrated with current best practices in game design [3].

Balanced Design was adapted from the fundamental structure of Evidence-Centered Design Model, an approach to constructing educational assessments in terms of evidentiary arguments. In Evidence Centered Design, there are six steps to review whether or not the students has achieved the standard, namely: define the domain, define claims to be made, define assessment targets, define evidence required, develop task model, and develop items or performance task [16]. Balanced Design is a simpler approach that focuses on instructional design approach to integrate best practices in game

design. This approach emphasizes on proportionality between the content of games with game design [3].

In Balanced Design elements of playful engagement and fun as it is on Game Based Learning remains the primary concern in designing games. The advantages of this approach are a concern for the purpose of topic subjects that made the game. This aims to create a better and more effective game for students. Using a Balance Design creates an educational game where the learning goals, game mechanics, and assessment about the students play and performance are aligned. To achieve the alignment, there are three models that must be met, namely Content Model, Task Model, and Evidence Model. For each model, there are several key questions as a reference for the achievement of the objectives to be achieved. All three methods have a relationship and function, respectively as illustrated in the following figure 2.1 [3].

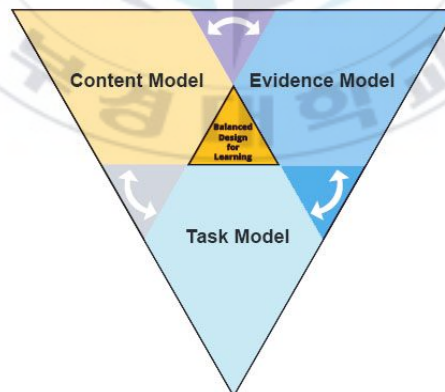


Figure 3.1 Element of Balanced Design

**a. Content Model**

Content models used to describe any knowledge, skills and abilities to be achieved by students. In each subject there is a syllabus about what material will be taught. The teacher should make a lesson plan based on this syllabus. Lesson plan outlines the core competencies, an indicator of a student's success, and the elaboration of learning activities. A content model can be likened as a lesson plan in a shorter version.

**b. Task Model**

The task model aims to describe the main tasks in the game and how the situation in the game is made to get the kind of evidence required. This model explains the Mission of what the player will do as well as description step by step to do the players. It also explained about the game features, tasks, and experience the students will engage in.

**c. Evidence Model**

Evidence model related to measurement. At this stage of discussion about how the measurements to be performed and the behavior and performance of what it will be used. The evidence model defines the rules for how to interpret a learner's performance on each task and how the content model should be updated given this

interpretation (for example, does the learner grasp the construct or do they need additional support?) [3].

### **3.2. Digital Game Based Learning**

Game Based Learning or education game is a game created to teach the user a specific learning, concept development and understanding and guide them in exercising their abilities, and to motivate them to play it [6].

Following the opinion of the experts regarding the Education Game [5]:

1. According to Karl Royle, an academician: "Educational games are games designed with specific curriculum objectives in mind, often games that have been used in education have been developed to support the practice of factual information."
2. Marc Prensky, a speaker and author: "Educational game one designed for learning, is a subset of both play and fun. It is a melding of educational content, learning principles, and computer games."
3. Bill MacKenty, a practitioner of technology and academics: "An educational game (computer): as known as: edutainment, is a deliberately structured and scaffolder learning activity, usually constructed with colorful, fun puzzles interspersed with learning activities."

### **3.3. Function of Game Education**

According to Eko [18], functions of educational game can be grouped into 3 parts, namely:

#### **a. Motivation**

Good games can provide a good motivation for the players. Motivation can be influenced from 2 things, external and internal. Externally, for example the whole students play one game. Each student can see the results of other students of the game. Students more successfully solve a game in advance can trigger another student motivation to solve the game. Internally, the motivation of students will ride along with their success playing the game.

#### **b. Data Collecting**

Each activity carried out the players in the game will be better when recorded. The data recorded is then collected into a database. Later, this data can be used for a particular purpose.

#### **c. Measurement**

Another important measurement is included in the function of the game. With the activity data of players, the measurement of the extent of the success rate of the player

can be measured. The score obtained in-game players can become a benchmark value of players in the same issue to troubleshoot on the real world.

### **3.4. Elements of Game**

In a game, there are many elements that are incorporated into one. At least every game has two important elements in it, namely: the game objective and game mechanics. The following are important elements in the game [18]:

#### **a. Game Objective**

The game objective is the goal of the game. For example, the objective of the game is to accumulate points, attack the enemy, heading to a place, and so on. On educational games, the goal of making games is usually to teach certain material to the students.

#### **b. Game Mechanics**

The mechanism of the game is the game rules which consist of interaction, change, effect or any that might occur in the game. The gameplay mechanics are set what happens when players interact with different components of the game, with the other players, the game conditions change (points, strategies that can be taken, challenges, and more), and how the player can achieve the objective of a game.

### **c. Narrative (Story)**

Narrative (story) in the game can be a story line, a collection of information or interrelated events, or just a limited description of a thing. One of the functions of the narrative is to motivate or facilitate the players in order to adopt the game objective being personal objective. When this occurs, then the player can easily engage in full in the game.

Refers to Erik Wolpaw [19], games tell two stories:

- The story about the story: the narrative story that's the sum total of a game's cut scenes and dialogue, and
- The gameplay story: the story described by the actions the player takes in the game world.

### **d. Technology**

The last element is the technology either visual, audio, music or other effects. With this technology, more players will enjoy a variety of gameplay mechanism, drawn up by the makers of the game.

### **3.5. Role of Play**

On educational games, an understanding of how a play can effectively incorporate learning environment is urgently important. As one solution, in his book "Moving forward learning game" Scot Osterweil explain there are five freedoms in play that can be applied in educational games, namely:

1. Freedom to fail,
2. Freedom to experiment,
3. Freedom to fashion identities,
4. Freedom to effort, and
5. Freedom of interpretation.

The following are the explanations:

#### **1. Freedom to fail**

Failure is the thing that skeptically many people. Whereas it is possible that this failure teach about something. The freedom to files giving unlimited freedom to players to keep trying gamely although not succeeded. The player is free to learn from failure and move ever closer to mastery of their world [12].

#### **2. Freedom to experiment**

Pertaining to the freedom to fail, at this point the players have the freedom to complete the game in his own way. There is no specific rule that assigns the player



competes with a definite pattern. However, the experiment will not mean anything if the player does not have the ability to fail regularly and learn from failures made.

### **3. Freedom to fashion identities**

Players have the freedom to be anyone in the game. Each player can choose a character, clothing, and his own name.

### **4. Freedom to effort**

When playing, each player certainly has different effort. There are players who never give up, also there are players who are easily discouraged. The principle of freedom of effort gives players freedom to play games with each of the effort. The effort of each player will be recorded in the database.

### **5. Freedom of interpretation**

The experience obtained by each player in a game is usually different. After the play, each player has the freedom to interpret the respective purpose and goal of the game being played. This will make the game have a diverse point of view.

### **3.6. Curriculum 2013**

According to the philosophy, education is a long process and continuing to transform learners being human which corresponds to the purpose of his creation, that is of benefit to himself, for others, for the universe, with all its content and its civilization.

Curriculum 2013 (K-13) is a curriculum that is implemented by the Ministry of Education and Culture of the Republic of Indonesia to replace Curriculum Education Unit which has been in force for 6 years. This curriculum has three aspects of assessment, namely: Cognitive, Affective, and Psychomotor [23]. Some aspects contained in the curriculum of the 2013 are as follows:

#### **1. Cognitive Domain**

In 1956, Benjamin Bloom wrote "Taxonomy of Educational Objectives: Cognitive Domain", and since then the description of the six-level description of the thought process been widely adapted and used in different contexts. List of cognitive processes, compiled and sorted from the most simple, given back the knowledge that has been owned, to the most elaborate, that decided the value and benefits of an idea.

Cognitive domain was the realm of discussion related to understanding and knowledge. Assessment of cognitive aspects indicator intended to measure the achievement of learning outcomes in terms of intellect, the ability to dig and process information or knowledge. Cognitive assessment consists of six stages, called Bloom's Taxonomy, where this theory has previously been revised by Anderson, L. W and Krathwohl in her book “A taxonomy for learning, teaching and assessing: A revision of Bloom's Taxonomy of educational objectives” [26]. Six stages and is explained in detail in the following figures and tables.

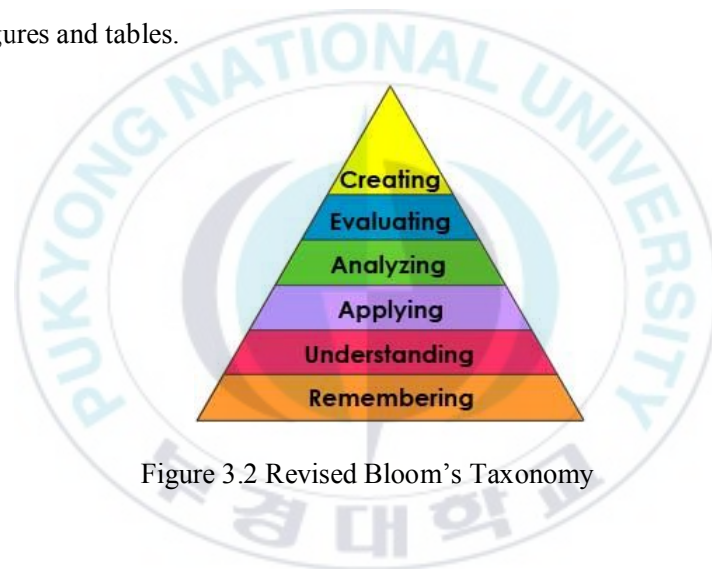


Figure 3.2 Revised Bloom's Taxonomy

Table 3.1 Explanation of the Revised Bloom's Taxonomy

Level	Definition	Keyword
Remembering	Redial or recall data or information	Definitions, duplication, register, memory, redial, repeat, reproduction.

Level	Definition	Keyword
Understanding	Explaining ideas or concepts	Classification, decryption, discuss, explain, identify, recognize, report, selection, concluded.
Applying	Use the information in new ways.	Choose, demonstrate, illustrate, interpret, operate, schedule, finishing, execution, implementation.
Analyzing	Divide the material into different sections, determine how the parts can be interconnected.	Comparing, differentiation, differentiates, experiment, ask, test, adjust, attributes, analyze.
Evaluating	Making a decision based on the criteria and standards.	Assessment, arguments, decide, select, support, value, evaluate.
Creating	Creating a new product or a new angle, rearrange the elements into a new pattern or structure.	Assemble, plan, build, create, design, develop, and formulations.

## 2. Affective Domain

Affective learning is demonstrated by behaviors indicating attitudes of awareness, interest, attention, concern, and responsibility, ability to listen and respond in interactions with others, and ability to demonstrate those attitudinal characteristics or values which are appropriate to the test situation and the field of study. Similar with cognitive objectives, affective objectives can also be divided into a hierarchy (according to Krathwohl). This

area is concerned with feelings or emotions. Again, the taxonomy is arranged from simpler feelings to those that are more complex [27].



Figure 3.3 Affective Domain

Table 3.2 Explanation of the Affective Domain

Level	Definition	Keyword
Receiving	Student's willingness to attend to particular phenomena of stimuli (classroom activities, textbook, music, etc.).	asks, chooses, describes, follows, gives, holds, identifies, locates, names, points to, selects, sits erect, replies, uses
Responding	Active participation on the part of the students.	answers, assists, complies, conforms, discusses, greets, helps, labels, performs, practices, presents, reads, recites, reports, selects, tells, writes
Valuing	Concerned with the worth or value a student attaches to a particular object, phenomenon, or behavior.	completes, describes, differentiates, explains, follows, forms, initiates, invites, joins, justifies, proposes, reads, reports, selects, shares, studies,

Level	Definition	Keyword
		works
Organization	Concerned with bringing together different values, resolving conflicts between them, and beginning the building of an internally consistent value system.	adheres, alters, arranges, combines, compares, completes, defends, explains, generalizes, identifies, integrates, modifies, orders, organizes, prepares, relates, synthesizes
Characterization by value or by value set	Learning outcomes at this level cover a broad range of activities, but the major emphasis is on the fact that the behavior is typical or characteristic of the student.	acts, discriminates, displays, influences, listens, modifies, performs, practices, proposes, qualifies, questions, revises, serves, solves, uses, verifies

### 3. Psychomotor Domain

The psychomotor domain deals with manual or physical skills. It is the "doing" domain.

The table below outlines the five levels in this domain and verbs that can be used to write learning objectives [28].

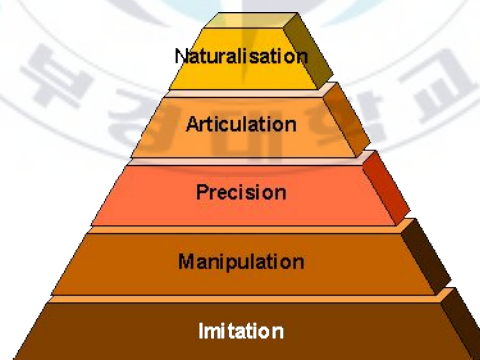


Figure 3.4 Psychomotor Domain

Table 3.3 Explanation of the Psychomotor Domain

Level	Definition	Keyword
Imitation	Observing and copying another's action/skill.	Adhere, Copy, Follow, Repeat, Replicate
Manipulation	Reproducing action/skill through instruction	Build, Execute, Implement, Perform, Recreate
Precision	Accurately executing action/skill on own	Calibrate, Complete, Control, Demonstrate, Perfect, Show
Articulation	Integrating multiple actions/skills and performing consistently	Adapt, Combine, Construct, Coordinate, Develop, Formulate, Integrate, Master, Modify
Naturalization	Naturally and automatically performing actions/skills at high level	Design, Invent, Manage, Project, Specify

In K-13, there are a learning principles drawn up in order to attain the expected quality.

The following are the explanation:

1. Learners are facilitated to find out and learn from a wide range of learning resources,
2. Learning process using a scientific approach,
3. Competency-based learning,
4. Integrated learning,
5. Learning that emphasizes on the divergent answers that have multi-dimensional truths,
6. Applicable skills-based learning,
7. Improved balance, continuity, and the link between the hard skills and soft skills,
8. Learning with a culture and empowerment of students as lifelong learners, and

9. Learning that applying the values by giving example (*ing ngarso sung tulodo*), build a willingness (*ing madyo mangun karso*), and develop the creativity of learners in the learning process (*tut wuri handayani*) [24].

### 3.7. Mathematics Subject

Mathematics originates from Greece language, *mathein* or *mathenien* which means studies. Mathematics words alleged to be closely related to the Sanskrit word, “*medha*” or “*widya*” meaning cleverness, caught or intelligence [17].

Mathematics is a subject that is studied from elementary to college level. In general mathematical characteristics are: a study of abstract objects have, referring to the deal, patterned thought deductive, consistent in his system, the symbol of the empty of meaning, observing the universe talks [4].

The purpose of this subject’s Mathematics for Junior High School students was declared so that students are able to:

1. Understand the math concepts, explains the relation between concepts and apply concepts or algorithms, for flexible, accurate, efficient, and precise in problem solving.



2. Use the reasoning on the nature, patterns and doing mathematical manipulations in making generalizations, compile evidence, or explain the idea and mathematical statements.
3. To solve problems that include the ability to understand the problem, designing a mathematical model, complete model and interpret the solution obtained.
4. Communicating the idea of symbols, tables, diagrams, or other media to clarify the circumstances or issues.
5. Have an attitude to appreciate the usefulness of mathematics in life, for example, have curiosity, attention, and interest in learning mathematics, as well as a tenacious attitude and confidence in problem solving.

### **3.8. Software Product Quality**

According to the rules McCall, a way of measuring the quality attributes hierarchically structured, where the top level (high-level attribute) is called factoring (factor), and the lower level (low level attribute) is called the criterion (criteria) (Table 3.4). Factor indicates attributes product quality from the perspective of the user. While the criteria are product quality parameters from the perspective of its own software. Factor and these criteria have a causal relationship (cause-effect) [29]. The formula is:

$$Fa = (w_1c_1 + w_2c_2 + \dots + w_nc_n) \quad (1)$$

while,

$Fa$  : total value of factor a,

$w$  : weight of the criteria,

$c$  : value of the criteria.

From equation (1), there are several stages in the calculation as following:

1. Stage 1: determine the criteria used,
2. Stage 2: specify the weight ( $w$ ) of each of the criteria (usually,  $0 \leq w \leq 1$ ),
3. Stage 3: specify the scale of the value of each criteria (i.e.  $0 \leq w \leq 1$ ),
4. Stage 4: give value to each criteria, and
5. Step 5: calculate the total value of  $Fa$  [29].

Based on ISO/IEC FDIS 9126-1 Standard, software quality attributes categorized into six characteristics, namely: functionality, reliability, usability, efficiency, maintainability and portability [30]. Each characteristic divided into sub characteristics. The sub characteristics can be measured by internal or external metrics. Figure 3.4 below illustrated the details.

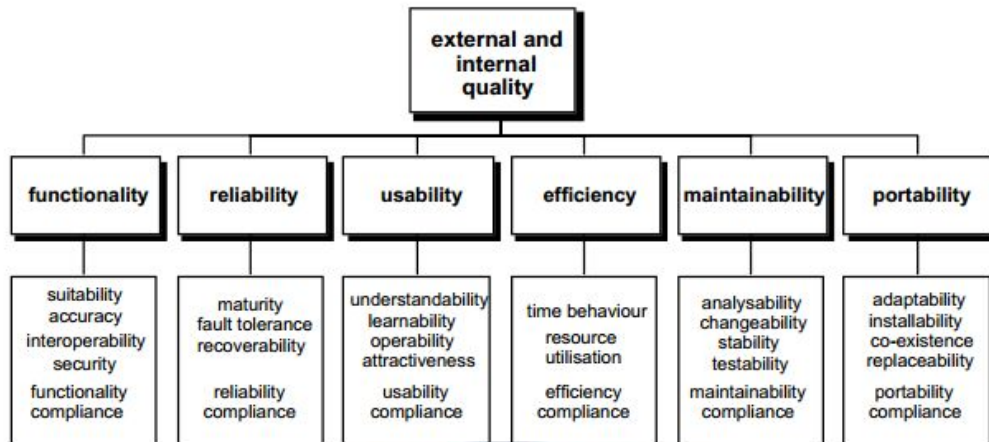


Figure 3.5 Quality model for external and internal quality

Definitions are given for each quality characteristic and the sub characteristics of the software which influences the quality characteristic. For each characteristic and sub characteristic, the capability of the software is determined by a set of internal attributes which can be measured.

## Chapter 4

### System Requirements and Design

#### 4.1. System Architecture

Vidyanusa consist of two main applications game and dashboard which is web-based. The system can be accessed via online by students, teachers, parents and developer. Each user can access the different features of the system depends on access rights.

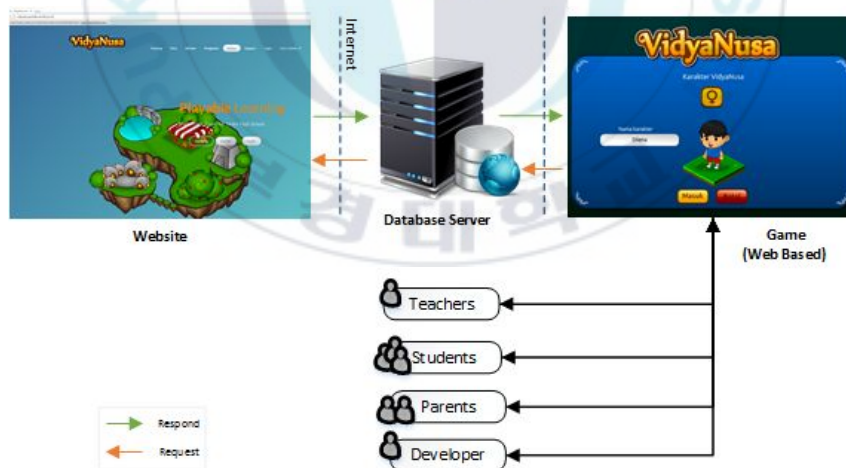


Figure 4.1 Overall Vidyanusa System

System architecture consists of three major parts, namely:

### **1. Front end**

Front end contains the world of Vidyanusa games that can be played by students. In each game there is a mission (quest) to do. These missions are the learning material presented in the form of a game.

### **2. Databases**

Databases designing by appropriate tables and mutual needs have a relationship to each other.

### **3. Back end**

Back end is associated with the recording process data obtained from the student's activities when playing a game. This information will be process and display the data through a dashboard that can be accessed by teachers. Data visualization is made in the form of graphs and reports on students learning outcomes after playing games in a certain period.

## 4.2. Functional Requirements

The functional requirements describe the possible effect of the system or what the system must accomplish. Based on the studies in the literature review, we determine the functionalities that are needed for the application are as follows:

- Able to change learning from the teacher center into a student center,
- Able to make learning a more enjoyable and enhance student learning motivation,
- Able to be used by thousands of people (massive), and
- Able to create learning more effective and efficient.

The capabilities should be presented to four types of users involved within the system, which are depicted by actors in figure below.

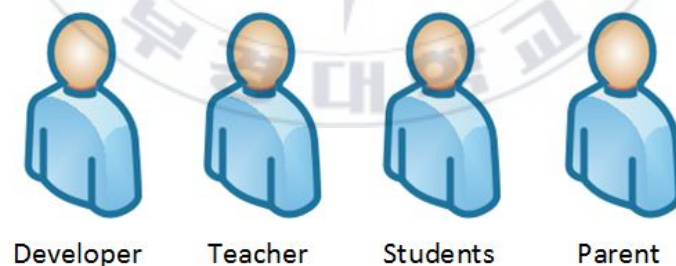


Figure 4.2 Use case diagram actors

In more detail, functional requirements of Vidyanusa presented in a Function Block Diagram. A Function Block Diagram (FBD) is an image that explains the function of variable input and output in of a system. A set of elementary block denotes a function. Input and output variables linking to blocks by connection lines. The figure 4.1 below shows the FBD of Vidyanusa system.



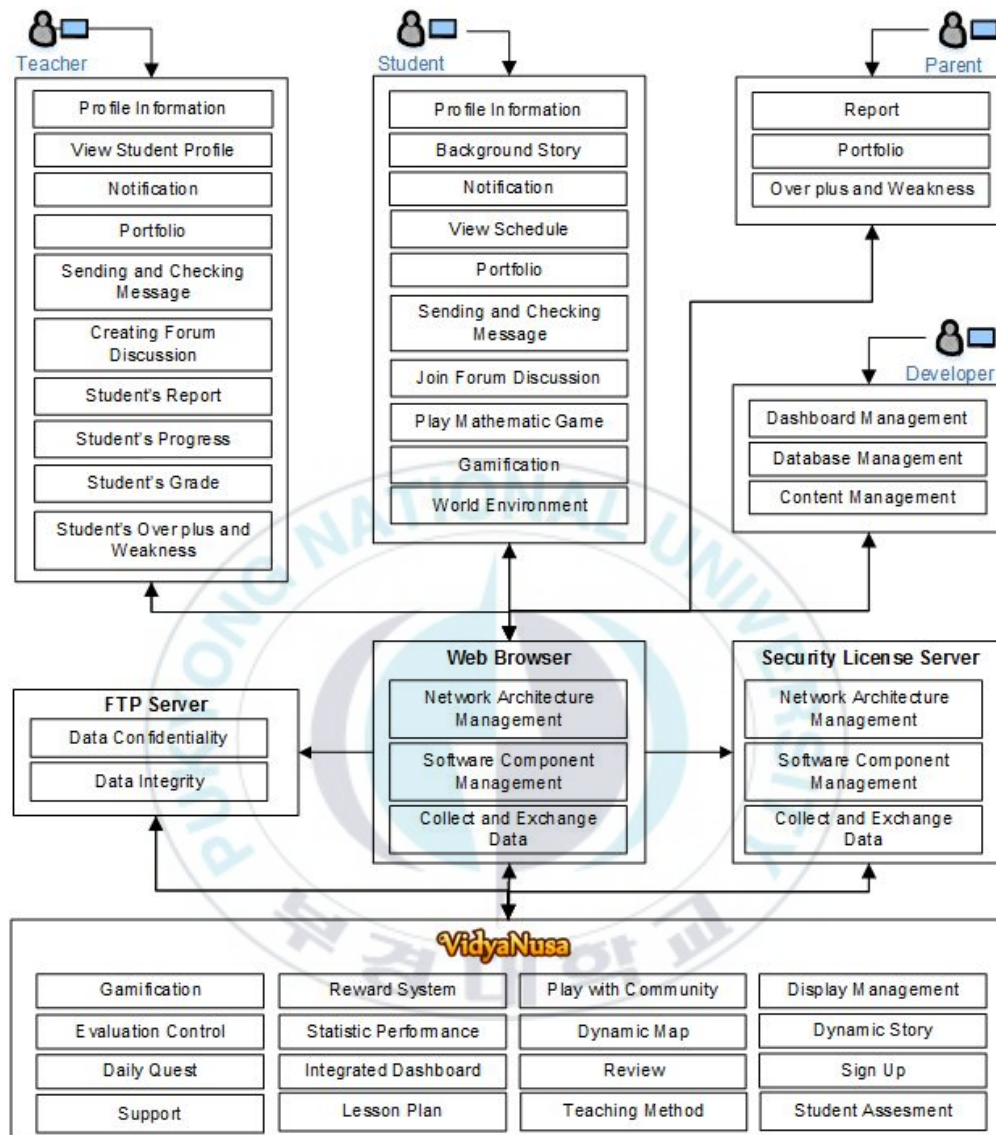


Figure 4.3 Function Block Diagram of Vidyanusa System



Students and teachers are required to create an account to access Vidyanusa. After obtaining the access rights from the developers, teachers can log in and create a group for students in their class. Teachers can also register their student's parents to see their child's achievement of results on the games played. Therefore, parents have the knowledge about how the achievement of their child as well as the advantages and disadvantages on mathematical subjects. It is made so that the pace is good cooperation between teachers with parents. Students can play the Vidyanusa game at school with the guidance of teachers, and can continue the game at home under parent supervision.

The practice in the classroom, teachers plays a role to direct students on a particular mission in accordance with the subject matter to be achieved. Each student plays on his computer and tries to solve the mission individually. After the game ends, the teacher asked the students to share their experiences about what lessons gained from those games and their solutions. Then the teacher describes the subject matter of mathematics which deals with the game played.

## **4.3. System Environment**

### **4.3.1. Narrative**

Vidyanusa is an Online Education Game being developed by the Crayonpedia Education Ecosystem in Indonesia. The game is set in a random area of the island. The game begins after the enemy forces attack. Vidyanusa are in need of assistance so the headman called for help from all over the country. Player's role is to help villagers set back to Vidyanusa into normal condition.

The learning goal of Vidyanusa is to engage junior high school students in learning mathematics. The content contained in Vidyanusa is the subject matter of mathematics level 7-9 in accordance with the curriculum of 2013 states of Indonesia. Based on the syllabus, Vidyanusa collect all the material and turn into 23 missions of the game.

### **4.3.2. Asset**

Asset games are designed in accordance with the category of the users of junior high school students using fictional characters that have a wide range of unique characters. Narrative stories are fantasy and adventure. Players can choose male or female avatar

when first going into the environment. In addition, there is an NPC as a character, not a player, but is involved in the story that serves to give instructions to the player's mission. Designs on Vidyanusa game characters shown in the figure 4.4 below.

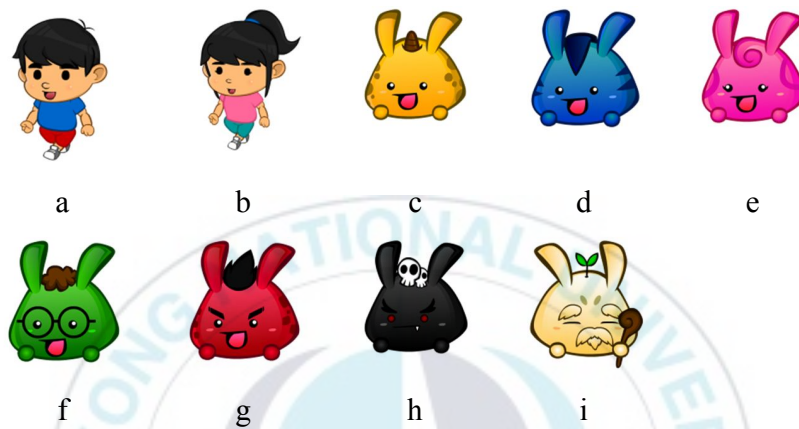


Figure 4.4 Character designs game

Table 4.1 Character Design Specification

Label	Character Name	Characteristic
a	Male avatar	Helper, adventurous, curious, friendly.
b	Female avatar	Helper, adventurous, curious, friendly.
c	Chula	Optimistic, spirit, cheerful, critical.
d	Byu	Calm, focused, diplomatic, friendly.
e	Aruna	Gentle, sensitive, compassionate.
f	Aptana	Casually, calm, analytical.
g	Abya	Energetic, passionate, emotional.

Label	Character Name	Characteristic
h	Kepala Suku	Wise, thoughtful, analytical, cautious.
i	Asura Pataka	Stubborn, mysterious, assertive.

#### 4.3.3. Area and Missions

Vidyanusa game has 5 areas as the location of the mission to be done by the player. The locations are a farm, factory, market, home and dam. Each place has a different mission in accordance with the subject of mathematics goals to be achieved.

Overall, there are 23 missions and scattered in five different areas. On the farm area, there are 7 missions. The factory and have 5 missions. Two missions in the home area and 4 missions in the market and dam area. If the entire mission has been completed, the player can select any mission to be played. Players get a reward if successful doing missions. Figure 4.5 below illustrate the area and missions in storyline of the game.

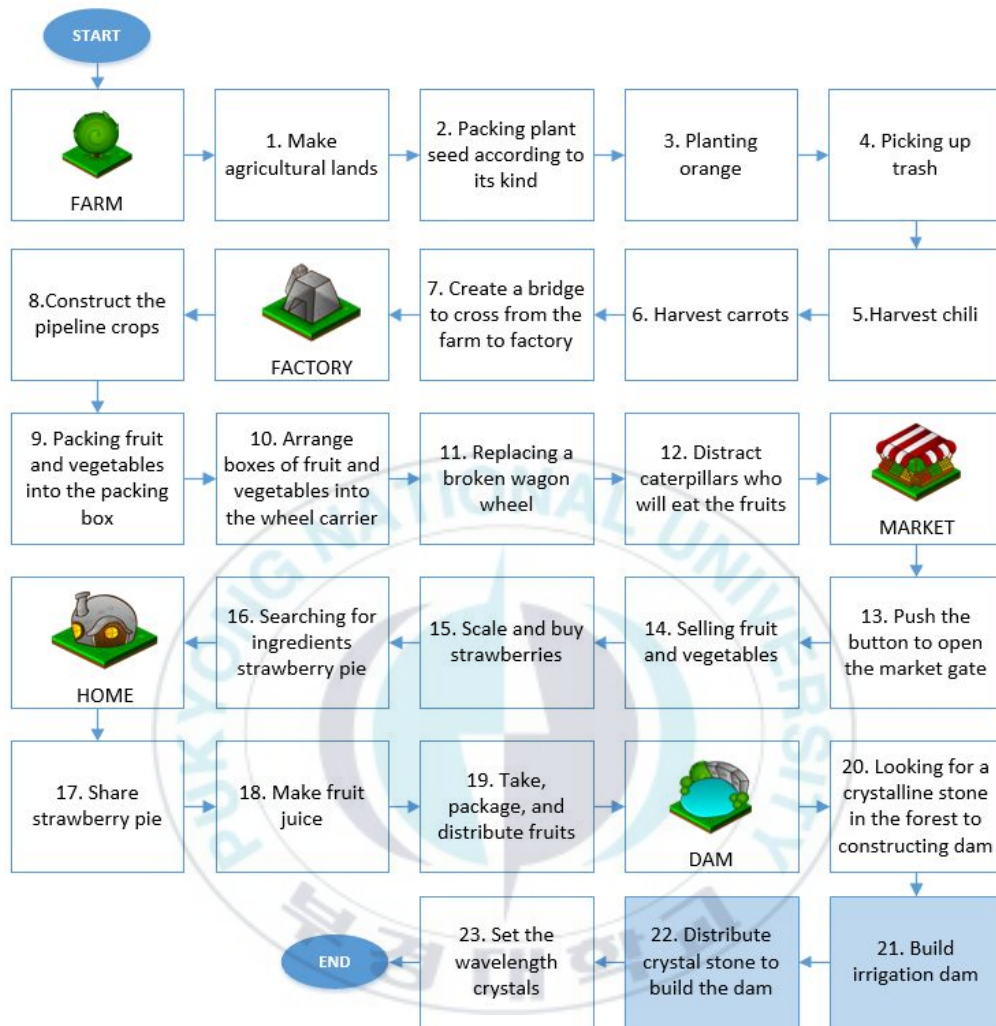


Figure 4.5. Storyline of Vidyanusa game

Two missions will be explained in this thesis are mission 21 and mission 22. These missions located in the dam area. The goals of this game are build irrigation dam and

distribute crystal stone to build the dam. The material in these games is Functions and Relations.

#### **4.3.4. Game Flowchart**

A flowchart is a formalized graphic representation of a logic sequence, work or manufacturing process, organization chart, or similar formalized structure. The purpose of a flow chart is to provide people with a common language or reference point when dealing with a project or process [22].

In Vidyanusa game, the first activity to be done in a user login. Once logged in, the player will be faced with a background story that tells the beginning why the player can enter the world of Vidyanusa. Before starting the game, players will be faced with a direction that contains a hint towards the mission. The conversation between the player and the character in the game is made so that the game is more interactive. Furthermore, players can play the game directly. In general, the game flowchart on Vidyanusa depicted on figure 4.6 below.

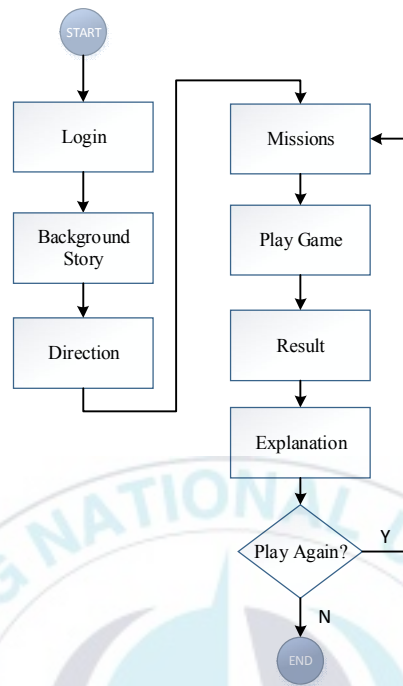


Figure 4.6 Game Flowchart

## 4.4. System Analysis

### 4.4.1. Analysis of Mathematics Subject Using Balance Design

Totally, there are 77 core competencies in the Subjects of mathematics junior level classes 7, 8 and 9. This competency includes aspects of affective, cognitive, and

psychomotor. Vidyanusa summarizes the aspects of cognition and transforming them into 23 missions. These thesis will explain two mission, namely mission 21 and mission 22. Table 4.2 below is design of Vidyanusa System based on Balance Design on that missions.

Table 4.2 Design Vidyanusa System Mission 21 and 22

No	Class	Content Model	Task Model	Evidence Model
1	8	2.3 Demonstrate honesty and responsible behavior as a form of implementation of honesty in reporting the observation data	All missions.	Students are able to: 1. Working on the Mission of the game so that it meets the specified minimum frequency experiments, 2. Reporting the results of activities that have been carried out in the form of photos, videos and reports.
2	8	3.5 Serves a function in various forms of relationship, the couple ordered by formula, functions, tables, charts, and diagrams.	Mission 21	Students are able to: 1. Resolve the real problems using relations, 2. Stating the relationship two objects by drag and drop.
3			Mission 22	Students are able to solve real problems using the functions.



#### **4.4.2. Assessment Analysis**

There are three domains of assessment of student learning outcomes, namely cognitive, affective and psychomotor. The third domain has a provision each assessment. The following are the explanation.

##### **A. Assessment of Affective Domains**

Affective learning is demonstrated by behaviors indicating attitudes of awareness, interest, attention, concern, and responsibility, ability to listen and respond in interactions with others, and ability to demonstrate those attitudinal characteristics or values which are appropriate to the test situation and the field of study. Based on the Curriculum of 2013 state of Indonesia, affective assessment related to attitude like spiritual, and social attitude. Social attitude divide into five category, namely: responsibility, discipline and consistent, confident and initiative, honesty and self-reliance, and mutual cooperation and compassion. Every aspect has their own calculation. The following tables are the explanation.

Table 4.3 Assessment of Spiritual Attitude

No	Rubric assessment per week	Achievements of student competency
1	<p>Number of video events pray in one meeting;</p> <ul style="list-style-type: none"> <li>• 1 video prayer = 100 points + badge/reward</li> <li>• 1 video prayer = 50 points</li> <li>• 0 videos prayer = 0 points</li> </ul>	<p>Number of praying points in 1 meeting:</p> <ul style="list-style-type: none"> <li>▪ 100 points + badge / reward: students showed prayerful in initiating and terminating activities.</li> <li>▪ 50 points: students showed less prayerful in initiating and terminating activities.</li> <li>▪ 0 points: students show never prayed in initiating and terminating activities.</li> </ul>
2	<p>Number of photos of religious activities in 1 day:</p> <ul style="list-style-type: none"> <li>• 5 photos prayer = 100 points + badge</li> <li>• 4 photos prayer = 80 points</li> <li>• 3 photos prayer = 60 points</li> <li>• 2 photos prayer = 40 points</li> <li>• 1 photo prayer = 20 points</li> <li>• 0 photo prayer = 0 point</li> </ul>	<p>Number of photos of religious activities in 1 day:</p> <ul style="list-style-type: none"> <li>▪ 100 points + badge / reward: students always diligent practice their religion as a form of obedience, faith and devotion to God in daily life.</li> <li>▪ 80 points: students pretty diligent practice their religion as a form of obedience, faith and devotion to God in daily life.</li> <li>▪ 60 points: students less diligent practice their religion as a form of obedience, faith and devotion to God in daily life.</li> <li>▪ 40 points: students rarely practice their religion as a form of obedience, faith and devotion to God in daily life.</li> <li>▪ 20 points: students almost never carry a form of prayer as a form of obedience, faith and devotion to God in daily life.</li> <li>▪ 0 points: students have never practiced their religion as a form of obedience, faith and devotion to God in daily life.</li> </ul>
3	<p>The amount of information and stories about religion in social media in 1 day:</p>	<p>Number of hashtags information and stories about religion in social media:</p>

No	Rubric assessment per week	Achievements of student competency
	<ul style="list-style-type: none"> <li>• 2 hashtags story or religious information = 100 points</li> <li>• 1 hashtags story or religious information = 50 points</li> <li>• 0 hashtags story or religious information = 0 points</li> </ul>	<ul style="list-style-type: none"> <li>▪ 100 points: very competent students in sharing religious knowledge in theory with other peers.</li> <li>▪ 50 points: students sufficiently competent in sharing religious knowledge in theory with other peers.</li> <li>▪ 0 points: students incompetent in religious sciences theoretically share with other peers.</li> </ul>

Table 4.4 Assessment of Social Attitude

Aspect	Rubric assessment per week	Achievements of student competency
Responsibility	Number of photos theme psychomotor activity during the first meeting:	<ul style="list-style-type: none"> <li>• 520 points: students very consistent instill responsible behavior, discipline, confidence, honesty, cooperation and independent in the process of teaching and learning activities.</li> <li>• <math>\geq 400</math> points: students have consistently instill responsible behavior, discipline, confidence, honesty, cooperation and independent in the process of teaching and learning activities.</li> <li>• <math>\geq 300</math> points: students quite able to instill</li> </ul>
	<ul style="list-style-type: none"> <li>• &gt; 3 photos = 100 points + badge/reward.</li> <li>• 3 photos = 100 points.</li> <li>• 2 photos = 60 points.</li> <li>• 1 photo = 20 points.</li> <li>• 0 photos = 0 points.</li> </ul>	
	Number of journal/report during the first meeting of psychomotor aspects:	
	<ul style="list-style-type: none"> <li>• 3 journals = 100 points + badge/reward.</li> <li>• 2 journals = 60 points.</li> <li>• 1 journal = 20 points.</li> <li>• 0 journals = 0 points.</li> </ul>	
Discipline and Consistent	Time to submit photos theme psychomotor activity during the first meetings:	
	<ul style="list-style-type: none"> <li>• Timely = 100 points.</li> <li>• Late 10 min = 70 points.</li> <li>• Late 20 min = 40 points.</li> <li>• Late 30 min = 10 points.</li> </ul>	

Aspect	Rubric assessment per week	Achievements of student competency
	<ul style="list-style-type: none"> <li>Late &gt; 30 minutes = 0 points.</li> </ul>	<p>responsible behavior, discipline, confidence, honesty, cooperation and independent in the process of teaching and learning activities.</p> <ul style="list-style-type: none"> <li>≥ 200 points: poor students, instill responsible behavior, discipline, confidence, honesty, cooperation and independent in the process of teaching and learning activities.</li> <li>&lt; 200 points: students have not seen instill responsible behavior, discipline, confidence, honesty, cooperation and independent in the process of teaching and learning activities.</li> </ul>
	Time to submit journal / report psychomotor aspect for 1 meetings:	
	<ul style="list-style-type: none"> <li>Timely = 100 points.</li> <li>Late 10 minutes = 70 points.</li> <li>Late 20 minutes = 40 points.</li> <li>Late 30 minutes = 10 points.</li> <li>Late &gt; 30 minutes = 0 points.</li> </ul>	
Confidence and initiative	Number of statements, questions, responses and comments during the first meeting of a discussion forum:	
	<ul style="list-style-type: none"> <li>10 statements = 10 points.</li> <li>9 statements = 9 points</li> <li>8 statements = 8 points</li> <li>7 statements = 7 points</li> <li>6 statements = 6 points</li> <li>5 statements = 5 points</li> <li>1 statement = 1 point</li> </ul>	
Honesty and Self-Reliance	Number of like portfolio / tasks in a discussion forum during the one meetings:	
	<ul style="list-style-type: none"> <li>&gt; 15 like = 100 points.</li> <li>14 like = 90 points</li> <li>13 like = 80 points</li> <li>12 like = 70 points</li> <li>11 like = 60 points</li> <li>10 like = 50 points</li> <li>&lt;10 like = 0 points</li> </ul>	
Mutual cooperation and compassion	Number of statements, questions, responses and comments during the one meeting of a discussion forum:	
	<ul style="list-style-type: none"> <li>10 statements = 10 points.</li> <li>9 statements = 9 points</li> <li>8 statements = 8 points</li> <li>7 statements = 7 points</li> </ul>	

Aspect	Rubric assessment per week	Achievements of student competency
	<ul style="list-style-type: none"> <li>• 6 statements = 6 points</li> <li>• 5 statements = 5 points</li> <li>• one statement = 1 point</li> </ul>	
	Teamwork: <ul style="list-style-type: none"> <li>• 100% completeness teamwork mission in construction projects = 100 points per member</li> <li>• 75% completeness teamwork mission in construction projects = 75 points per member</li> <li>• 50% completeness teamwork mission in construction projects = 50 points per member</li> <li>• 25% completeness teamwork mission in construction projects = 25 points per member</li> <li>• 0% teamwork mission completeness in construction projects = 0 points per member</li> </ul>	

## B. Assessment of Cognitive Domains

In Cognitive domain, assessment of the student's understanding viewed from two aspects, namely Score and Play Point. To get the results of the assessment, there are assumptions that must be applied, which is: every game has indicators of achievement by different amounts, each indicator is assumed to be one scene, and every scene has a value of 100 points if players wins the game. The following is how to calculate the value of student understanding.

## 1. Score

The score is obtained from the value of the average score of the students play each one scene at one time class meeting. Score formula:

$$(Scene_1 + Scene_2 + \dots + Scene_n) \times 100, \quad (2)$$

## 2. Play Point

The Play Point is the number of times to play the game during the first meetings:

- 3 times = 100 points,
- 2 times = 50 points,
- 1 time = 10 points,
- 0 times = 0 points.

From the two calculation above, we can get Total Point for Cognitive domain with formula (3):

$$TP = \frac{S + PP}{i}, \quad (3)$$

where,

TP : Total Point

PP : Play Point

S : Score

i : the sum of indicators.

### **Description of achievement of student competency:**

- 76-100: Students are very capable to resolve the real problems using relations, stating the relationship between two objects, and resolve the real problems using functions method.
- 51-75: Students are able to understand all the indicators of achievement.
- 26-50: Students are quite able to understand 50% indicators of achievement.
- 0-25: Students are not able to understand the indicators of achievement.

### **C. Assessment of Psychomotor Domains**

The psychomotor domain deals with manual or physical skills. It is the "doing" domain.

Assessment for psychomotor domain divide into three groups as table below:

Table 4.5 Assessment of Psychomotor Domains

No	Rubric Assessment per week	Achievement of student competency
1	<p>The number of photos theme psychomotor activity during the first meeting:</p> <ul style="list-style-type: none"><li>• &gt; 3 photo = 100 points + badge / reward.</li><li>• 3 photos = 100 points.</li><li>• 2 photos = 60 points.</li><li>• 1 photo = 20 points.</li><li>• 0 photos = 0 points.</li></ul>	<ul style="list-style-type: none"><li>• 300 points: students are highly skilled in using the concept in accordance with the indicators of achievement.</li><li>• <math>\geq 200</math> points: students are skilled in using the concept in accordance with the indicators of achievement.</li></ul>

No	Rubric Assessment per week	Achievement of student competency
2	The number of journal / report during the first meeting of psychomotor aspects:	<ul style="list-style-type: none"> <li>• <math>\geq 150</math> points: students sufficiently skilled in using the concept in accordance with the indicators of achievement.</li> <li>• <math>\geq 100</math> points: students are less skilled in using the concept in accordance with the indicators of achievement.</li> <li>• <math>&lt; 100</math> points: students have not skilled in using the concept in accordance with the indicators of achievement.</li> </ul>
	<ul style="list-style-type: none"> <li>• 3 photos = 100 points + badge / reward.</li> <li>• 2 photos = 60 points.</li> <li>• 1 photo = 20 points.</li> <li>• 0 photos = 0 points.</li> </ul>	
3	The number of like portfolio / tasks in a discussion forum during the first meeting:	
	<ul style="list-style-type: none"> <li>• <math>&gt; 15</math> like = 100 points.</li> <li>• 14 like = 90 points</li> <li>• 13 like = 80 points</li> <li>• 12 like = 70 points</li> <li>• 11 like = 60 points</li> <li>• 10 like = 50 points</li> <li>• <math>&lt; 10</math> like = 0 points</li> </ul>	



## Chapter 5

### System Implementation and Experiment Result

#### 5.1. Background Story

Background Story displayed in a Flash animation with text in Indonesia language. The text in this section tells about the beginning of why players can enter the Vidyanusa world. The figures below illustrate the implementation of background story.



Figure 5.1 Player enters the old library



Figure 5.2 Player meets a librarian



Figure 5.3 Player takes a book in a book  
that he read



Figure 5.4 The player goes into the world



Figure 5.5 Player has a mission to  
rescue Vidyanusa of darkness



Figure 5.6 Player enters the gates

## 5.2. Directions

Before the player starts working on missions, the player is given the challenge to help the inhabitants of Vidyanusa. Players have the option to accept or decline the challenge. Dialogue between players and Vidyanusa figures are made so that the game is more communicative. The following image is the implementation.



Figure 5.7 Direction

## 5.3. Missions

### 5.3.1. Mission 21

**Title** : Build the dam

**Material** : Relations

**Location** : Dam

**Narrative** : After collecting crystals in the Vidyanusa forest, player given the task to help the villagers build a dam which was destroyed after the attack Asura Pataka forces. The trick is to lay the bricks that are applicable to the form and amount of which has been determined. If the shape of the stone is not in accordance with the amount, the dam will collapse. If the shape of the stone in accordance with the amount, the dams were built.

**Interface** :



Figure 5.8 Opening Mission 21

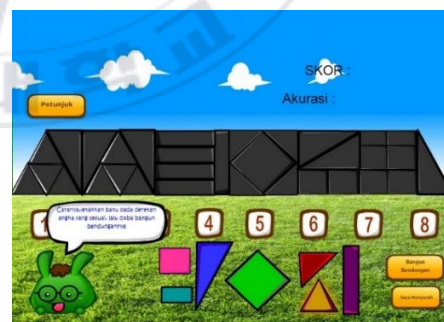


Figure 5.9 Instruction

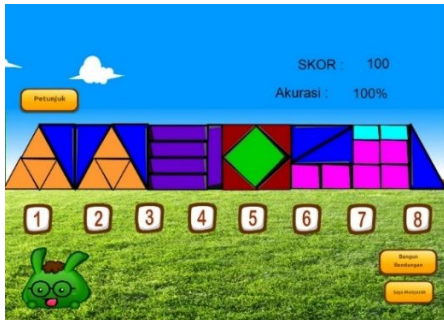


Figure 5.10 Winning Condition



Figure 5.11 Failure Condition

### 5.3.2. Mission 22

<b>Title</b>	: Distribute crystal stone to build the dam
<b>Material</b>	: Functions
<b>Location</b>	: Dam
<b>Narrative</b>	: The entire village mobilized to build a dam. However, each resident has a different capacity to transport stones leading to the dam. Each stone also have their respective weights. The player is asked to help Abya distribute crystal stone to villagers according to their capacities.
<b>Interface</b>	:



Figure 5.12 Opening Mission 22

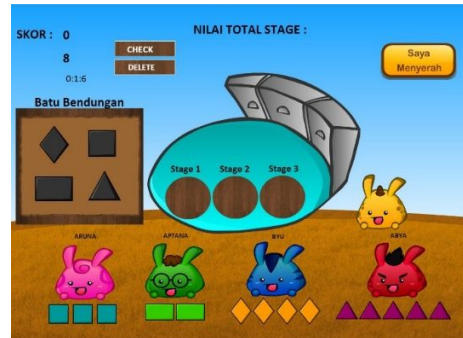


Figure 5.13 Instruction



Figure 5.14 Winning Condition



Figure 5.15 Failure Condition

## 5.4. Software Product Quality Measurement

In the assessment of the quality of products, the number of respondents used is 20 people came from Indonesian college students in Korea with different background study. The



selection of respondents is done by random sampling. It is intended that the assessment carried out completely objective.

Respondents asked to play the game Vidyanusa missions 21 and 22, then given a questionnaire in the form of questions about the usability of the product. To measure software product quality, there are several stages as following:

### **1. Stage 1: Determine the criteria used**

According to ISO/IEC FDIS 9126-1 Standard, usability factor is the capability of the software to be understood, learned, used, and attractive to user, when used under specified conditions. The criteria from usability factor are:

- Understandability: the capability of the software product to enable the user to understand whether the software is suitable, and how it can be particular tasks and conditions of use.
- Learnability: the capability of the software product to enable the user learn its application.
- Operability: the capacity of the software product to enable the user to operate and control it.
- Attractiveness: the capability of the software to be attractive to the user.
- Usability compliance: the capability of the software product to adhere to standards, conventions, style guides or regulations relating to usability.

**2. Stage 2: Specify the weight ( $w$ ) of each of the criteria (usually,  $0 \leq w \leq 1$ )**

We assume the weight of every criteria as table below:

Table 5.1 Weight of criteria

Criteria	Weight (0-1)
Understandability (U)	$w_1 = 0.2$
Learnability (L)	$w_2 = 0.3$
Operability (O)	$w_3 = 0.2$
Attractiveness (A)	$w_4 = 0.2$
Usability Compliance (UC)	$w_5 = 0.1$

**3. Stage 3: Specify the scale of the value of each criteria (i.e.  $0 \leq w \leq 1$ )**

**4. Stage 4: Give value to each criteria**

Stage 3 and Stage 4 explain in Table 5.2 below.

Table 5.2 Scale and value of each criteria

No	Criteria	Mission 21	Mission 22	Weight (0-1)	Total Value
1	Understandability (U)	7	9	$w_1 = 0.2$	2
2	Learnability (L)	8	8	$w_2 = 0.3$	3
3	Operability (O)	9	7	$w_3 = 0.2$	2
4	Attractiveness (A)	7	8	$w_4 = 0.2$	2
5	Usability Compliance (UC)	6	7	$w_5 = 0.1$	1
Max Value					10



Table 5.3 Metrics achievement of Total Value

No	Range value	Description
1	7 - 10	High quality
2	4 – 6.9	Medium quality
3	1 - 3.9	Low quality

### 5. Step 5: Calculate the total value of $Fa$

$$Fa = (w_1c_1 + w_2c_2 + \dots + w_nc_n) \quad (1)$$

while,

$Fa$  : total value of factor a,

$w$  : weight of the criteria,

$c$  : value of the criteria.

From the Table 5.2 we calculate  $Fa$  for every mission as follow:

#### Mission 21

$$\begin{aligned}
 Fa &= 0.2(7) + 0.3(8) + 0.2(9) + 0.2(7) + 0.1(6) \\
 &= 1.4 + 2.4 + 1.8 + 1.4 + 0.6 \\
 &= 7.6
 \end{aligned}$$

#### Mission 22

$$\begin{aligned}
 Fa &= 0.2(9) + 0.3(8) + 0.2(7) + 0.2(8) + 0.1(7) \\
 &= 1.8 + 2.4 + 1.4 + 1.6 + 0.7 \\
 &= 7.9
 \end{aligned}$$

From the above calculations, the total value of the results obtained in terms of usability mission 21 is mission 22 is 7.6 and 7.9. Referring to Table 5.3, the total value derived by the two missions is included in the category of high quality. This indicates, the mission of 21 and 22 have a high quality of in terms of usability.



## **Chapter 6**

### **Discussion and Future Works**

#### **5.1. Discussion**

Game Based Learning (GBL) is a method of learning that use digital games as a medium to reach the learning objectives. However, designing educational games in accordance with the purpose of learning is the first phase to do. It aims to create a fun and meaningful learning.

Balanced Design is an approach to design educational games. This approach was adapted from the fundamental structure of ECD Model, an approach to constructing educational assessments in terms of evidentiary arguments. The balanced design focuses on instructional design approach to integrate best practices in game design. This approach emphasizes on proportionality between the content of games with game design.

Vidyanusa is an Online Mathematics Education Game being developed by the Crayonpedia Education Ecosystem in Indonesia. The game is set in a random area of the island. There are 5 areas as the location of the mission to be done by the player. The locations, namely: farm, factory, market, home and dam. Each place has a different mission in accordance with the subject of mathematics goals to be achieved.

The learning goal of Vidyanusa is to engage junior high school students in learning mathematics. The content contained in Vidyanusa is the subject matter of mathematics level 7, 8, and 9 in accordance with the curriculum of the 2013 states of Indonesia. Totally, there are 77 core competencies in the Subjects of mathematics for junior level classes 7, 8 and 9. This competency includes aspects of affective, cognition, and psychomotor. Vidyanusa summarizes the aspects of cognitive and transforming them into 23 missions.

In this study, we apply the Balanced Design approach on mission 21 and mission 22 in Vidyanusa Game. The material on this mission is Functions and Relations. In Content Model phase, we describe any knowledge, skills and abilities to be achieved by students based on the curriculum of 2013 State of Indonesia. The next step we think about game structures and mechanism to engage Task Model. This model explains the step by step of the mission that player must tackle. The evidence model defines the rules for how to interpret a student's performance on each task and how the content model should be updated given this interpretation. We described the interpretation into the assessment. Assessment of student's understanding is shown by a score resulted from the game. We analyzed the assessment into three aspects, namely affective, cognitive, and psychomotor. Experiments were conducted to test the usability of the product, namely mission 21 and 22. Usability factor is the capability of the software to be understood, learned, used, and attractive to the user, when used under specified conditions. Respondents used is 20

people came from Indonesian college students in Korea with different background study. Based on the calculations, the results of every mission are respectively 7.6 and 7.9. The total value obtained by the mission indicates that 21 missions and 22 missions possess a high quality in terms of usability.

## **5.2. Future Works**

To be able to measure the implementation of Balanced Design approach more thoroughly, we are planning to do some research to the students of Junior High School in Indonesia. This study aims to measure evidence model of Balanced Design. The results obtained by the students after playing the game can be used as input for the assessment of cognitive aspects. While attitudes and student activity will be the input for affective and psychomotor aspects.

For future works we will also more focus on the design interface side. Vidyanusa game is expected to be more interesting and responsive, for example by adding a game with different difficulty levels.

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