Cognitive level Classification of Senior High School Students in Trigonometry Comparison Using LVQ-Method-Based Trigonometry Game

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Abstract

Students' cognitive level classification which is used for monitoring students' learning progress is very much needed in education. The application of students' cognitive classification method through educational games has not been widely explored. Schools generally use students' mean score calculation to determine students' cognitive level which needs recalculation when new students come. One alternative is to apply Learning Vector Quantization (LVQ) method and the use of computer games to create educational-game-based learning media which include pedagogic elements. The developed product is expected to be able to measure students' cognitive level in comprehending a mathematical concept trigonometry comparison based on students' input after playing the educational game. The method used is LVQ which is used for classifying students' cognitive level into two levels: upper class (KA) and lower class (KB). The classification is based on 5 parameters: the number of correct answers (JB), the number of wrong answers (JS), the number of delayed answers (TJ), the number of steps (JL) and time taken (W). The testing of the LVQ method is conducted at SMAN (Public Senior High School) 1 Genteng, Kabupaten Banyuwangi on year 10 students. The testing results are inputted as data for the developed system which produce classification output of two classes: 35% upper class and 53% lower class.

Keywords: *Learning, trigonometry comparison, LVQ method, cognitive level classification*

1. INTRODUCTION

Students' cognitive level classification (Carroll, 1982) is very much needed in education. One form of such a classification is students' belonging to the upper class or lower class. This can be used for monitoring students' learning progress. The application of students' cognitive classification has not been widely explored. Schools generally use students' mean score calculation to determine students' cognitive level which needs recalculation when new students come. Besides that, an educator finds difficulties determining students' cognitive level classification directly after the learning is complete.

Trigonometry comparison is one of the sub topics in trigonometry which is presented by some teachers through the lecture method or the conventional fashion in which students' merely sit, listen and take notes. This condition causes the knowledge conferred by the teacher to be not fully understood by the students. In addition to that, the teaching and learning tends to be teacher-centered in which teacher is the source of knowledge. The knowledge is conferred directly without any verification process as to where it derives. This causes students to merely take in and memorize the lesson which leads to boredom. Creative and innovative learning media can potentially overcome such a condition. One of such alternative media is computer-based educational games that can be utilized in the learning process.

Electronic games (e-games) can be alternative learning media. E-games are games which are developed to run on electronic appliances. The building components or elements of e-games are a combination of computer science, art and design. (Zyda, 2006). Special elements which generally signify games and also usually prevail in e-games are rules, strategic situation, and player payoff (Camerer, Ho, & Chong, 2001).

E-games offer direct learning taking the form of learning-by-doing pattern. Learning is a consequence which a player has to deal in order to pass the challenges in an e-game. The learning pattern is obtained from the failure factor encountered by the player which encourages him/her not to repeat the same mistake in the following stage (Syufagi et al, 2011). E-games offer very big potentials in building students' motivation in the learning process. Generating learning motivation in the conventional method to be as high as it is in e-games requires that a teacher should be resourceful and skillful in managing the learning process as well as keeping the students motivated and happy all the time. In addition to generating motivation, e-games offer better aspects than that of conventional learning methods, since animations of learning material in game activates students' long term memories (Clark, 2006; Arnseth, 2006; Smith, 2006).

E-games can be designed as autonomous pedagogy systems or systems which conduct education autonomously, such computer-based instruction or programmed learning, whereby most of the time the students can be independently learn a subject. All pedagogic components such as teaching material, teachers, educational environments (classrooms, laboratories, surroundings etc), teaching method, teaching media, evaluation tools and educational psychology can be provided in the autonomous system (Syufagi et al, 2012). This concept is important in the application of the computer game design so that the game is not only entertaining but also packed with pedagogic elements.

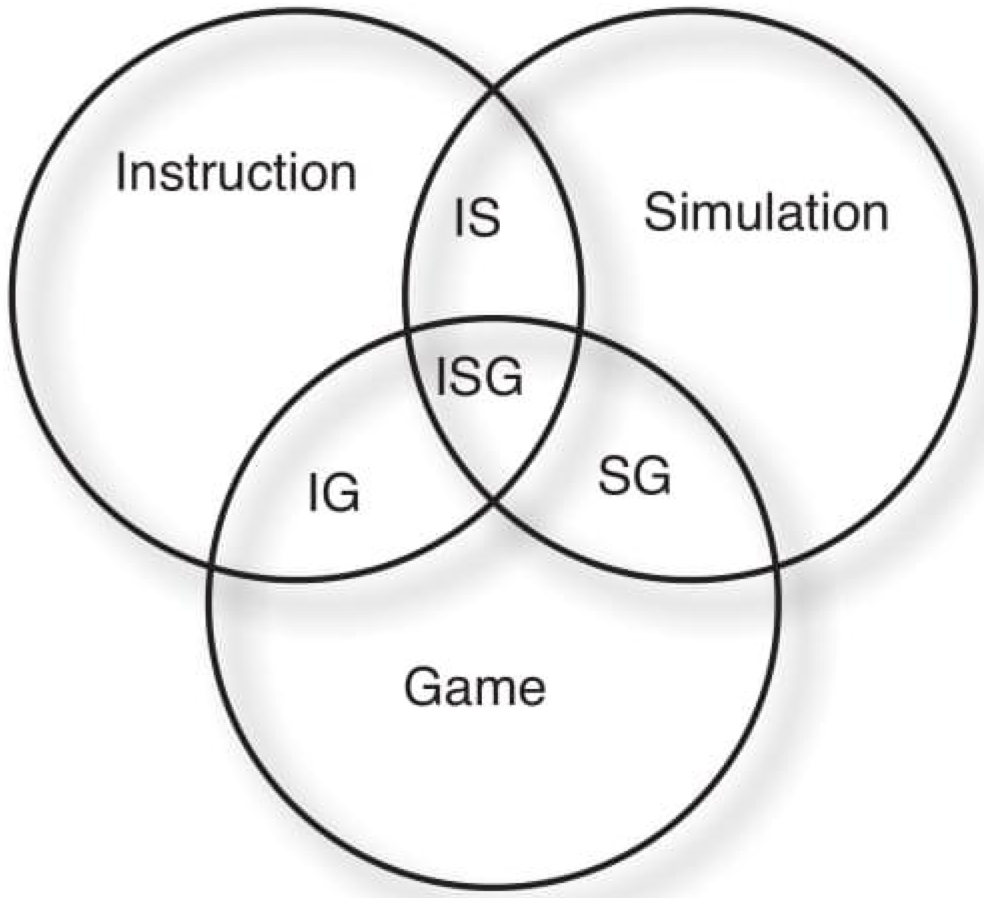
In this research, the author develops a method which can give an illustration of students' cognitive level qualification in comprehending a lesson through an educational game. The method to be developed is Learning Vector Quantization (LVQ). LVQ is supervised Artificial Neural Network (ANN) using competitive learning method developed by Kohonen, et al (1995) and used in guided training from layers in ANN.

The educational game which is developed is a game which includes pedagogic elements especially in the lesson of trigonometry comparison. The educational game to be developed is designed with RPG Maker XP.

2. THEORETICAL BACKGROUND

2.1. Games as Learning Media

Based on their characteristics, games can be used as instructional media (Smalldino, 2004). Games offer objectives, challenges and competition. Games may intersect with the simulation and instructional concepts which create an instructional simulation media, instructional games, simulation games and instructional simulation games (Picture 1)



Picture 1: Relationship between Instruction, Simulation and Game Concepts (Smalldino, 2004)

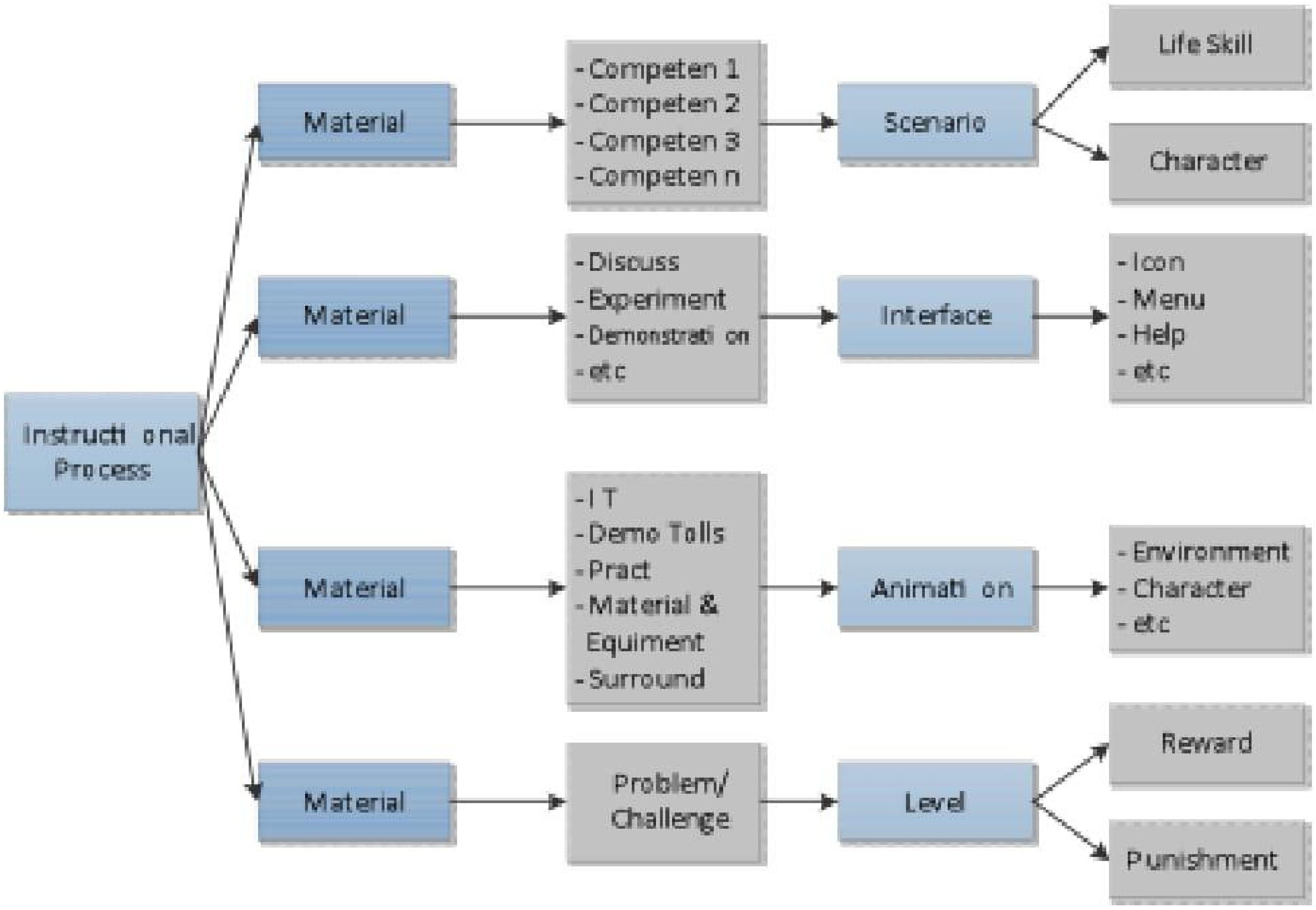
2.2. Elements of Pedagogic Games

Elements of pedagogic games are game domain, learning domain and pedagogic domain (Syufagi et al, 2012). Game domain covers rule, strategic situation and player payoff (Camerer, Ho & Chong, 2001). Curriculum domain covers learning material, learning method and life skills. Learning domain covers cognitive, affective and psychomotor aspects. Pedagogic domain covers all learning processes.

The elements of computer games are a combination of computer science, art, and design (story), in addition to rules, strategic situation, and player playoff (Camerer, Ho, & Chong, 2001). Rules are conditions which players have to meet. Rules are the results of conflicts created in the games. Player payoff is a consequence which players must accept as the result of the players' success or failure.

2.3. Instructional Process Mapping

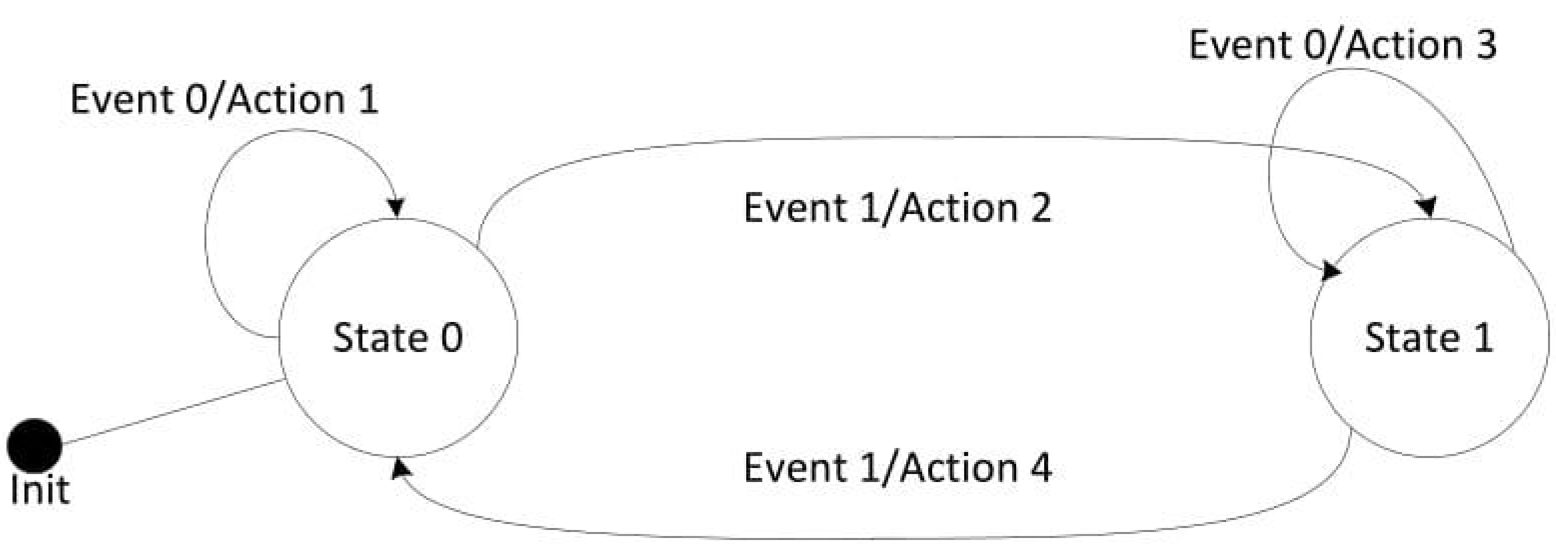
The first step to designing an educational game is to map the instructional process into scene, interface, animation and level. It is so done as to enable the game to accommodate and follow the learning process like the conventional method does (Syufagi et al, 2012). The following is the instructional process hierarchy (Picture 2).



Picture 2: Instructional Process Hierarchy Scheme

2.4. Finite State Machine (FSM)

Finite State Machine (FSM) is a control system design methodology which illustrates the behavior or the working principles of a system by the means of: state, event, and action (Setiawan, 2006). At one point of a significant period of time, a system is in an active state. The system can move to another state when receiving a certain input or event from outside tools or components inside the system

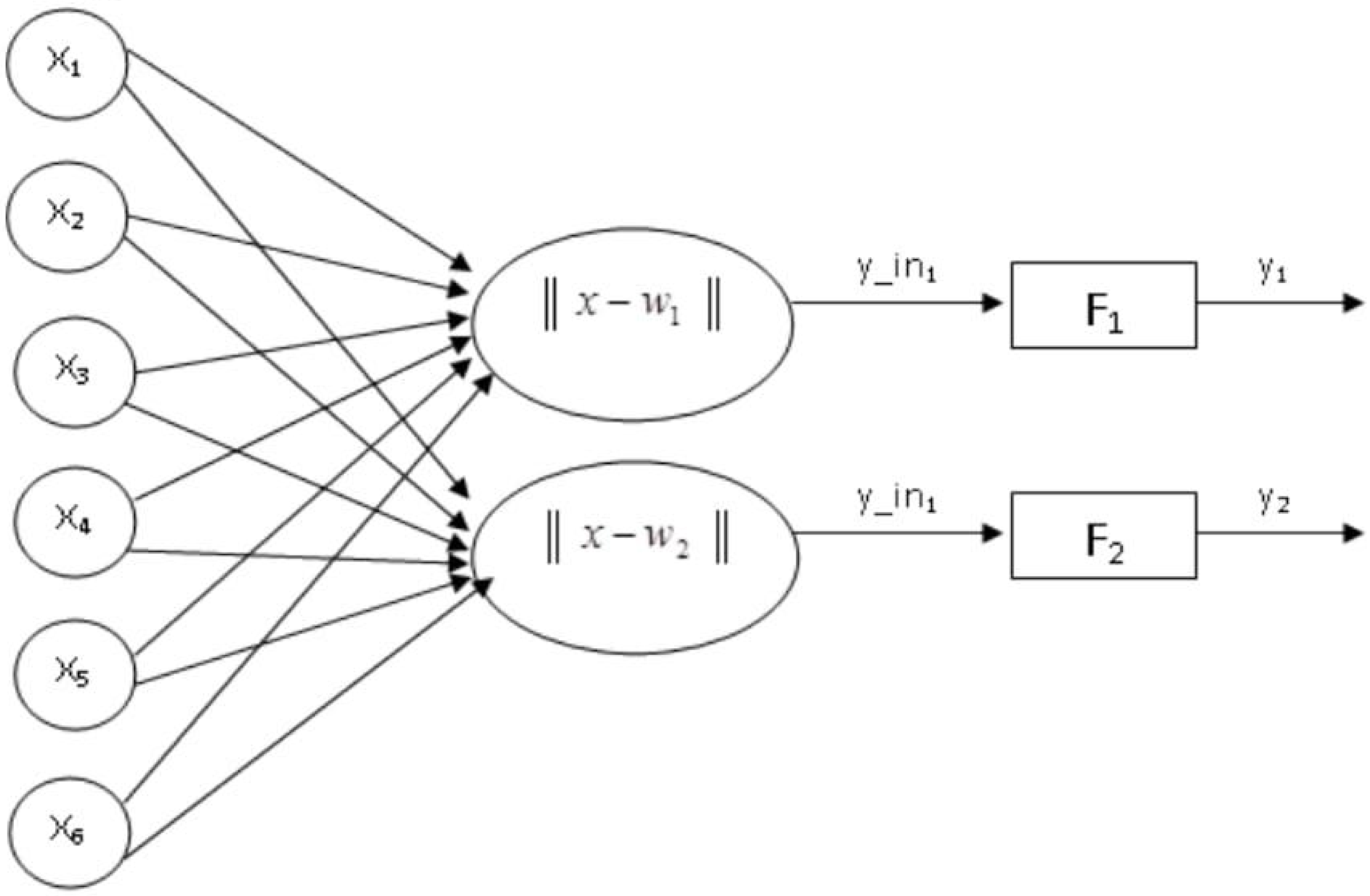


Picture 3: Example of Simple State Diagram (Setiawan, 2006)

2.5. LVQ Method

LVQ is a supervised network. An LVQ network has two layers. The first layer is the competitive layer and the second layer is the linear layer. The competitive layer learns to classify input vectors. The linear layer turns the competitive layer classes into the defined classification target. The classes learned by the competitive layer are called subclasses and linear layer classes are called target classes.

2.6. LVQ Network Architecture



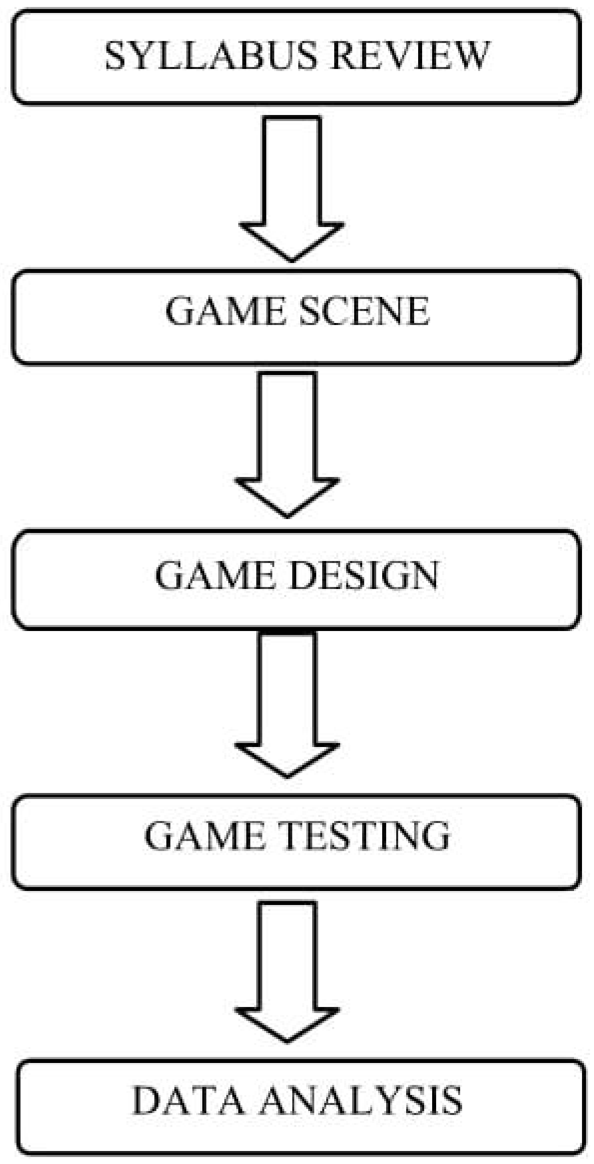
Picture 4: LVQ Network Architecture

The learning process taking place in each neuron is to find the space between input vector to the corresponding weights w_1 and w_2; w_1 is the weight vector which connects each neuron in the input layers to the first neuron in the output layers; w_2 is the weight vector which connects each neuron in the input layers to the second neuron in the output layers.

The activation function F_1 maps y_in_1 ke $y_1 = 1$ if $\| x - w_1 \| < \| x - w_2 \|$ and $y_1 = 0$ if $\| x - w_1 \| > \| x - w_2 \|$. The same applies when the activation function F_2 maps y_in_2 ke $y_2 = 1$ if $\| x - w_2 \| < \| x - w_1 \|$ and $y_2 = 0$ if $\| x - w_2 \| > \| x - w_1 \|$.

3. RESEARCH METHODOLOGY

3.1. Research Steps



Picture 3: Research Flowchart

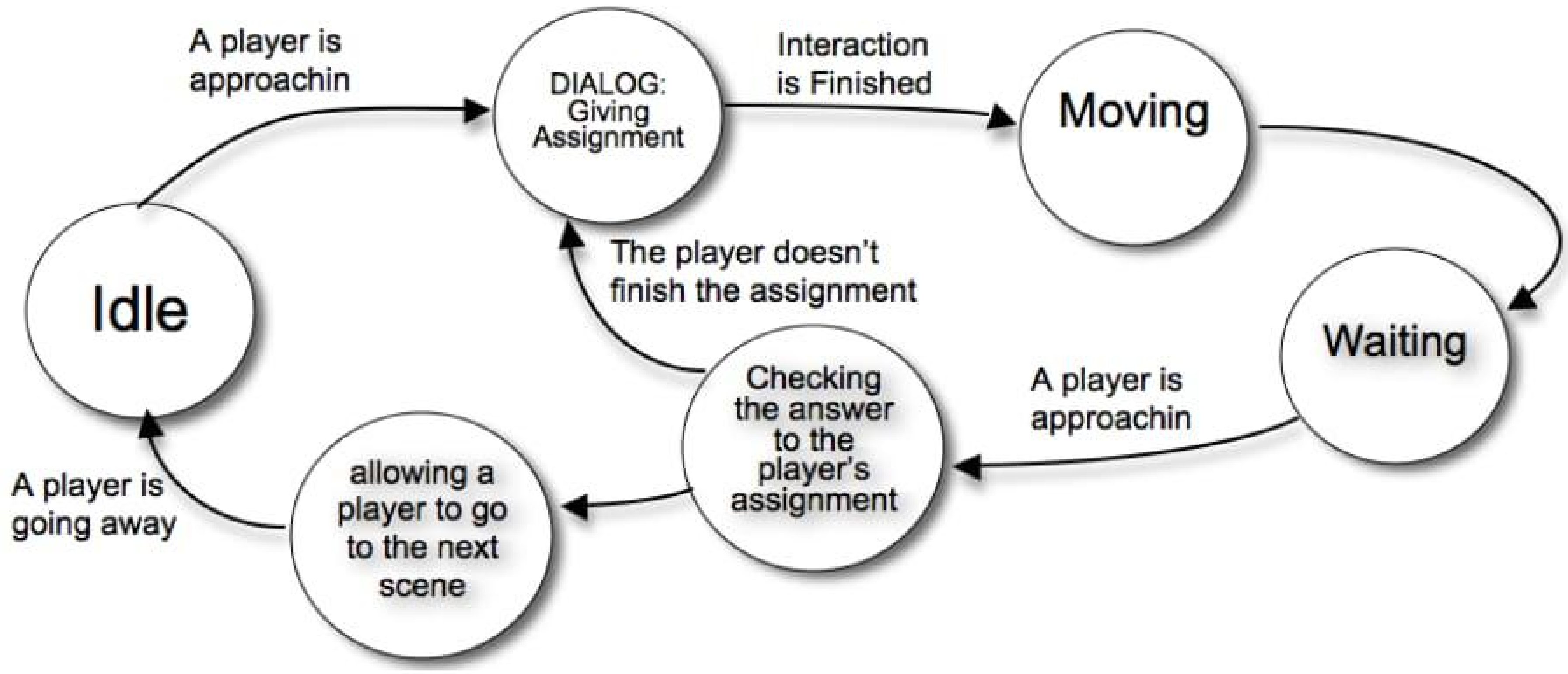
3.2. Indicator Mapping in Game Scene

The following is the trigonometry comparison achievement indicator mapping in visuals and game scene.

Tabel 1 Example of indicator mapping in game scene

No	Achievement Indicator	Visual and Game Scene
1.	Defining congruence (Depdiknas, 2006)	**Visual** : The use of 2 stacks of flowers in the garden **Scene** : The player observes the flower stacking in the garden to get 2 flat surfaces which match the stacking so they can make a conclusion about the relationship based on its size and geometric shape. The result is used for opening the door of the cave using a matching key.

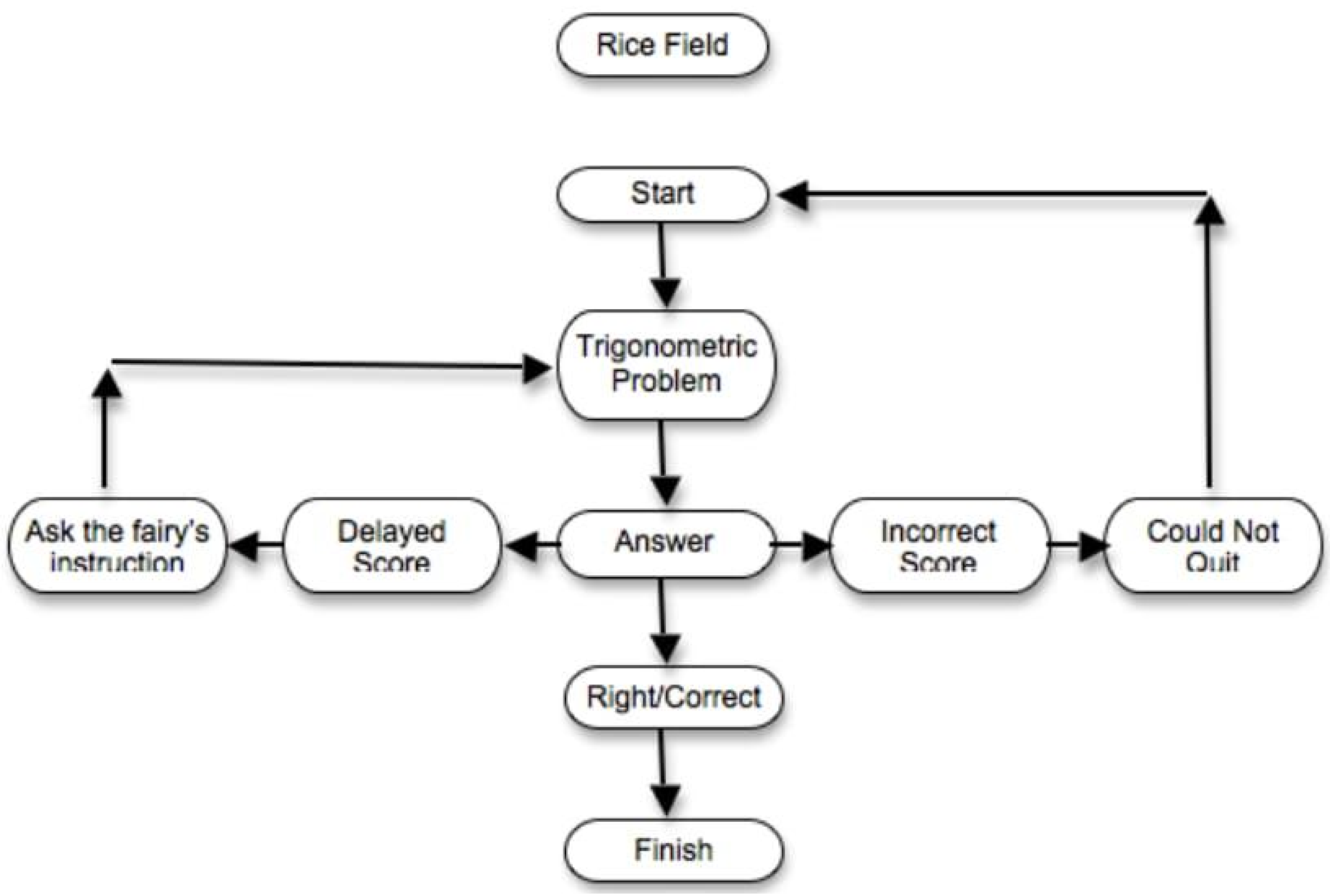
3.3. The Design of FSM for Non-Player Character (NPC)



Picture 4 Fisherman FSM NPC model

3.4. Players' Flow of Action in the Game

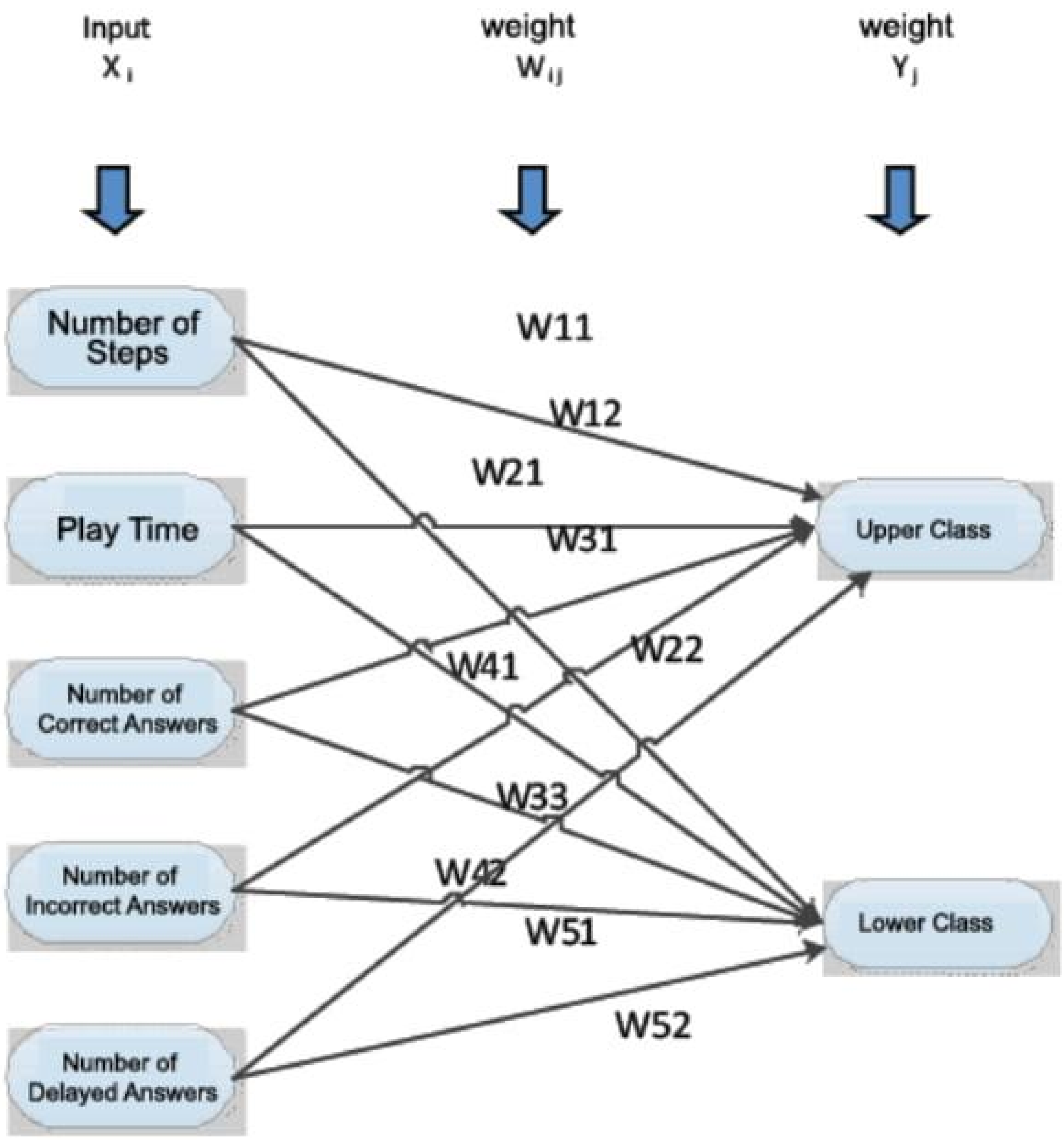
It is important to arrange the players' movement in the game so that the movement matches the game scene. That said, players' flow of action is required in the game scene. Picture 5 illustrates the players' flow of action in the trigonometric game.



Picture 5: Players' Flow of Actions in Taman Padi (The Rice Field) Scene

3.5. LVQ Method Architecture

Data obtained from the trial of the game are processed and analyzed with the LVQ method to classify the students' cognitive level after playing the game. The following is the LVQ network architecture.



Picture 6: LVQ Network Architecture

The network components which are developed have five neurons in the input layers and 2 neurons in the output layers. The process taking place in each neuron is to find the space between an input vector x1, x2, x3, x4 x5 to the corresponding weight vectors w1 and w2 using Euclidean Distance equation:

$$D = \| x - w_j \| = \left(\sum_{i=1}^{n} | x_i - w_{ij} |^2\right)^{\frac{1}{2}} \quad .....(3.1)$$

This process is to find the shortest space with the 3.1 formula. The weight vector (w) which has the shortest space to the input vector is called the winner vector. The winner vector is updated by first checking if it is the same as the input vector category. If the winner vector is the same as the category in the input vector category, the input vector is updated with the equation:

$$W_j(new) = w_j(new) = w_j(old) + \alpha(x - w_j(old))$$

If the winner vector is not the same as the input vector category, the winner category is updated with the equation:

$$W_j(new) = w_j(new) = w_j(old) - \alpha(x - w_j(old))$$

Where x is input vector

α is learning rate, $0 < \alpha < 1$

To get a good network

The value of α is reduced

i is input index

j is class index

4. FINDINGS AND DISCUSSION

4.1. Trigonometric game Screen Shot

Picture 7. Screen Shot Synopsis

Picture 8. Mathematics Kingdom Screen Shot

4.2. Cognitive Level Analysis

Table 2 shows the results of the game testing on group two:

Table 2 Testing result

Test #	JB	JS	TJ	LG	WK
1	44	14	14	1040	34.40
2	49	25	10	1321	36.44
3	49	13	21	1171	38.05
4	45	9	12	1105	37.45
5	50	26	13	1388	40.08
6	50	14	15	1502	55.44
7	41	23	11	1260	41.25
8	44	15	16	1100	34.09
9	42	10	24	1192	47.18
10	42	3	15	852	31.20
11	50	13	13	1502	46.50
12	46	15	13	1329	54.30
13	42	18	19	1363	39.01
14	39	5	16	1016	37.35
15	46	25	14	1397	41.42
16	41	8	10	1036	57.35
17	50	12	21	1171	40.10

Note: JB (Correct Answer), JS (Wrong Answer), TJ (Delayed Answer), LG (the Number of Steps), WK (Time Taken).

Table 2 shows that the students or players who belong to the upper target are the students who have Correct Answers ≥ 75%, Wrong Answers salah ≤ 25%, the Number of Steps ≤ 1100, and Time Taken ≤ 50 minutes. This category is given the score of 1. Those who belong to the lower class are the students who have Correct Answers < 75%, Wrong Answers ≥ 25%, Delayed Answers ≥ 25%, the number of Steps ≥ 1100, Time Taken ≥ 50 minutes. This criterion is given the score of 0.

The learning outcome using LVQ method results in weights for each class:

Table 3 Weights of each class

KA	1,0000	11,45	-5,806	13,45	7,117
KB	1,0000	-10,51	5,8321	-12,51	-5,144

Note: KA = Upper Class; KB = Lower Class

The learning outcome using LVQ in Table 3 is tested to classify the students' cognitive level. The testing outcome is shown in Table 4:

Table 4 LVQ weight testing data

No	JB	JS	TJ	LG	WK	TGT	dKA	dKB	K L S
1	1	0	0	1	1	KA	18,905	19,099	KA
2	1	0	1	0	1	KA	19,898	18,114	KB
3	1	0	0	0	1	KB	19,578	18,405	KB
4	1	0	1	1	1	KA	19,235	18,818	KB
5	1	0	0	0	1	KB	19,579	18,406	KB
6	1	0	0	0	0	KB	19,914	18,096	KB
7	1	0	0	0	1	KB	19,579	18,406	KB
8	1	0	0	1	1	KA	18,905	19,099	KA
9	1	1	0	0	0	KB	19,356	18,695	KB
10	1	1	0	1	1	KA	18,317	19,668	KA
11	1	0	0	0	1	KB	19,579	18,406	KB
12	1	0	0	0	0	KB	19,914	18,096	KB
13	1	0	0	0	1	KB	19,579	18,406	KB
14	1	1	0	1	1	KA	18,317	19,668	KA
15	1	0	0	0	0	KB	19,914	18,097	KB
16	1	1	0	1	1	KA	18,317	19,668	KA
17	1	1	0	1	0	KA	18,675	19,378	KA

In Table 4, the yellow-colored and blue-colored columns are the minimum space of the weight vector to the input vector. The minimum space is used as the classification determiner. The red-colored columns are error because there is a difference between target and class. Each data item can be classified as follows: if the minimum space is in the upper class, the data are classified as target one. If the minimum space is in the lower class, the data are classified as target two.

Target column is the researcher's objective which consists of students who are grouped based on knowledge and experience previously obtained. The students who have the result criteria in the category or target column are those who belong in target one of the upper class which consists of six students (35%). Target two of the lower class consists of nine students (53%). The 17 data items show an error of 0.12 which means that two students do not belong to the designated class.

5. CONCLUSION AND FUTURE RESEARCH

In this research, the author analyzes a method which classifies students' cognitive level by implementing LVQ. Out of 17 students who are the subjects of the research 6 of them (35%) belong to the upper class, 9 (53%) belong to the lower class. The testing results in 12% error which means that two students do not belong to the designated class.

This research can be the foundation for future development to make more complex games to be utilized for learning the trigonometric subject or other subjects, to be utilized by students in the lower class to increase their capability so that they can get into the upper class. The complex game with more help can be utilized for independent learning activities by the students to decrease the teacher workloads.

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