A Motivation Behavior Classification based on Multi Objective Optimization using Learning Vector Quantization for Serious Games

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ABSTRACT
The player's motivation a significant role in the success of the learning process and of the game for educational purpose. However, not an easy to determine the level of player's motivation while playing the serious game. To assess the motivation level of player interest, this paper proposes a Motivation Behavior Game (MBG). MBG improves this motivation concept to monitor how players interact with the game. This game employs Learning Vector Quantization (LVQ) for optimizing the motivation behavior input classification of the player. MBG is using teacher's data to obtain the neuron vector of motivation behavior pattern supervise. Three clusters multi objective target will be classified as; active choice, persistence, and mental effort motivation behavior. In the game play experiments employ 33 respondent players demonstrates that 12.12% of players have high and 6.06% have semi mental effort, 3.03% have high and 3.03% semi persistence, and 66.67% have high and 9.09% low active choice motivation behavior. MBG may provide information to game engine when a player needs help or when wanting a formidable challenge. The game engine will provide the appropriate tasks according to players' ability. MBG will help balance the emotions of players, so players do not get bored and frustrated. The high interest players will finish the game if their emotions are stable. The players' interests strongly support the procedural learning in a serious game.

General Terms
Mechine learning, neural network, serious games.

Keywords
Motivation behavior classification, multi objective, learning vector quantization, serious game.

1. INTRODUCTION
A growing number of reformers are looking to computer and video games to improve motivation in educational settings [1]. The game has enormous potential to motivate someone [2], seemingly originating from the electronic game learning are allows students to immerse themselves in real simulated [3] [4].

It is almost universally accepted that there is a positive correlation between motivation and learning [5]. PC-based games are currently being used for training, but the instructional and motivational features of such technology are not well understood [6].

Serious games, like every other tool of education, must be able to show that the necessary learning has occurred. Specifically, games that teach also need to be games that test. Fortunately, serious games can build on both the long history of traditional assessment methods and the interactive nature of video games to provide testing and proof of teaching [7]. In other words, the serious games should be reliable as a teaching aid as well as an assessment device.

In contrast, Clark [8] in Evaluating the Learning and Motivation Effects of Serious Games explains that the tests of motivation are most often unreliable and invalid. Self-reported enjoyment does not aid learning, because there is an opportunity to manipulate data.

This research propose the Motivation Behavior Game (MBG) to eliminate the data manipulation of motivation tests in serious games. MBG is a model of indirect measurement of motivation levels. MBG is a players' motivation characteristics measurement by observing the players' motivation behavior. The value of motivation behavior can be taken from the indicators that appear when a game takes place.

The amount of motivation can be measured in many ways that vary [2] [9] [10]. However, few studies examining methods of measuring motivation especially on serious games [8]. Clark and Choi [11] recommend the measurement of at least three different types of motivational outcomes; 1) Active choice, 2) Persistence, 3) Mental effort

On the other hand, game learning has an inverse relationship with learning test in many instances. Clark [8] gives details, pedagogy in games is often based on unguided discovery such as; minimal guidance and only high skill works, overwhelming discovery evidence without any assistance for beginners/novices learners [12] [13], discovery technique design and some game cause memory overwork and decrease the learning process [11].

Overload will not occur if the level of motivation players is controlled. Inal, & Cagiltay [14] explain the research of Csikszentmihalyi who emphasized the balance between an individual's skills and difficulties of tasks. He theorizes that the occurrence of flow experiences depends on this balance, and that if the balance does not exist between the individual's skills and the task, flow experiences will not occur. It is because heavier duty will cause faster frustration while too easy challenge will cause faster boredom.

Proper classification of motivation behavior can be used to control the level of challenge of the game. Providing an appropriate level of difficulty to the level of motivation in a game scenario will balance the emotions of players. The scenario of games cannot provide an appropriate challenge level of task if the motivation behaviors of players are

unknown. MBG is used to cluster motivation behavior process when the player is playing the serious game.

Typical assessments are likely to disrupt flow experience in immersive games. Thus there is a need for embedded assessments that would be less obtrusive and hence less disruptive to flow experience [15]. This project presents two original contributions that make this approach generic in serious game. The first contribution is proposes a method for embedding assessments in immersive games to reveal the behavior of player's motivation. The second contribution is a complementary the serious game with embedded sensitivity of teachers to classification the motivation behavior.

In an ongoing global research will construct the pedagogic engine for all game which is called game pedagogic (shown in Figure 3.). The purpose of this research is to give a new alternative to know the players' motivation behavior. MBG is a part of pedagogic game, which is a model of motivation measurement on a serious game. MBG can support the decisions of pedagogic game engine to give a reward or warnings to the player when the serious game is being played. The game engine will provide the appropriate tasks according to players' ability.

MBG is Pedagogic Player Character (PPC) based on artificial intelligent agent. MBG can forecast the motivation character of players. Learning Vector Quantization (LVQ) method is used in MBG. LVQ is used to classify players' the motivation level. The teachers' data are neuron vector to use in learning or supervising data in LVQ method. Three multi objective classifications in MBG are; active choice, persistence, and mental effort motivation behavior. In this research, students are respondent players demonstrates.

2. RELATED WORK

It is almost universally accepted that there is a positive correlation between motivation and learning. Instructional designers must pay more attention to motivational constructs when designing instruction and games. Bernard & Cannon [16] investigates the use of an emoticon based instrument, supporting the investigation with a study involving undergraduate students. At the end of each class period, the students were asked to indicate their level of motivation before and after the decision making process, but before disclosure of results. Students used a 5 item, emoticon anchored scale ranging from Highly Unmotivated to Highly Motivated. In this studies have already noted the possibility of measurement bias resulting from administering questions relating to both motivation at the beginning of the class period and the end of the class period at the end of the period. Another possibility is that use of emoticons was too simplistic for the purpose.

Educational virtual games and simulations (EVGS) are also noted as agents that may enhance user motivation and satisfaction and subsequently engage learners in innovative and timely ways. Higher levels of success in EVGS' are measured by the intrinsic motivational factors created by the activity [17]. Konetes [17] is analyze the applications of learning simulations and games through the lens of the intrinsic and extrinsic motivational factors associated with different academic EVGS use. Learning to better control and apply these motivational concepts could enhance the value of educational simulations and magnify their impact and effectiveness.

Derbali & Frasson [18] investigated players' motivation during a serious game. The assessment of motivation was made using questionnaire (after Keller's ARCS model) and electroencephalography (EEG).Thirty three volunteer subjects took part in the test. Each subject was placed in front of two computers: one for playing and one for answering the questionnaires. The results have shown that the EEG waves patternsare correlated with the increase of motivation during certain parts of a serious games play.

The motivation research in the game [16], [17], [18] is an extrinsic motivational. Thus, the motivation measurement process is still done separately of the game.

Many study use LVQ method for classivicaton data in game. Figure 1 is design motivation measurement in game pedagogic by Syufagi et.al. [19]. This research focus on single objectife motivation, it is classivication level of mental effort only.

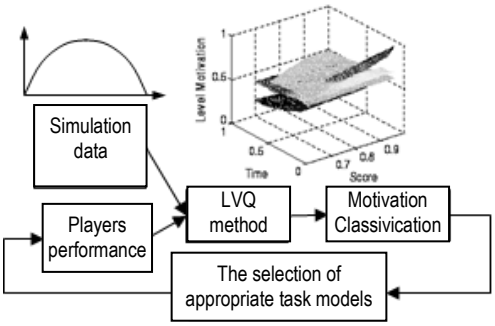

Fig 1: Design motivation measurement in game pedagogic [19]

Harini [21] is studies Comprehensive Learning Achievement Affectivity using the LVQ method in serious game. LVQ architecture is shown in Figure 2.

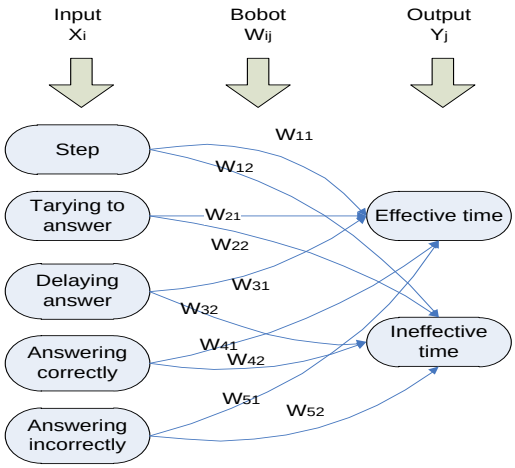

Fig 2: LVQ architecture of Comprehensive Learning Achievement Affectivity [21]

3. MOTIVATION BEHAVIOR GAME

In addition to the development of motivation research in the game [16], [17], [18], there are also some researchers use LVQ method for data classification in game [19], [20], [21], [22]. MBG based on two phenomena (motivation game and LVQ in game) are developed.

The MBG position in pedagogic game engine is shown in Figure 3 by the block with dark color. Two important parts of the game pedagogic engine are; i) artificial intelligent pedagogic and ii) autonomous pedagogic. The artificial intelligent pedagogic is used to observe the behavior of the

players. There are four behaviors observed, including; i) players' motivation, i) players' cognitive, iii) players' time response, and iv) mistake goal of players. Autonomous pedagogic will provide a response to the behavior patterns of the players by providing feedback in the form of task and guidance automatically.

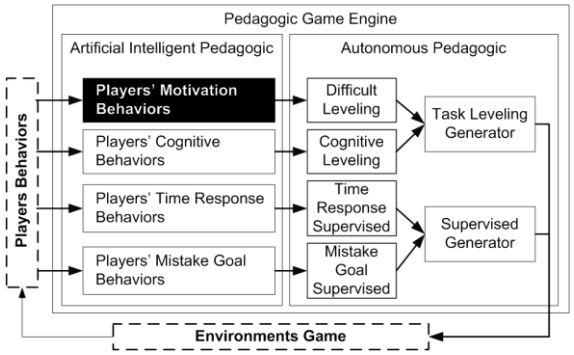

Fig 3: Pedagogic game engine structure

MBG is a game that measures the level of players' motivation process-based. This gives more emphasis on the achievement level of interest, for example; counting how much frequency of players to search info or try to finish the job, and the persistence by considering how long the players using time was done the job. The weakness of the measurement-based results is not considering players' characteristics of the action in completing the mission in the game. Players' game characteristics are in the forms of motivation behavior in the process.

The result of the motivation behavior classification is used to classify the challenge level of task in game engine. The method of challenge leveling in game engine is using the algorithm which will adapt the motivation behavior classification. The accuracy of classification results will determine the accuracy of the game engine to provide the appropriate level of difficulty of the task in the task level generator. MBG supported achievement balance between an individual's motivation and difficulties of tasks. MBG can prevent boredom and frustration.

Referring to Clark and Choi [11] on excellent discussion about "motivational indexes", they recommend the measurement of at least three different types of motivational outcomes; a) active choice, b) persistence, and c) mental effort. Based on these recommendations, MBG is divided into three parts too. Those parts have a tendency of multi-objective due to the parameters that appears from each contrasted indicator.

4. DESIGN SYSTEM AND METHOD

Design system of MBG is illustrated in a classifier structure and modeling functions use the LVQ method.

4.1 Classifier Structure

MBG represented in a classifier structure is shown in Figure.4 and Table 1. Three elements of MBG structure are; i) Identify Players Behavior, ii) Classification of Motivation Behavior Players and iii) Pattern of Motivation Behavior Players.

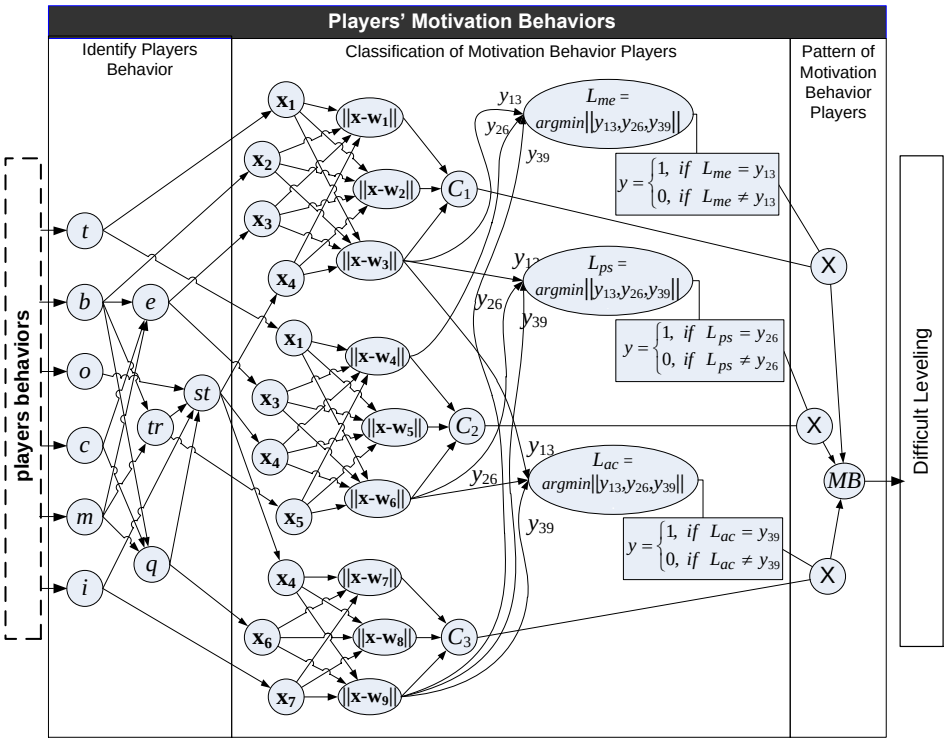

Fig 4: Classifier Motivation Behavior structure

Table 1 Notation of classifier Motivation Behavior structure.

Notation	Description
t	Input from Players (Using time to finish the job)
b	Input from Players (Number of Correct Answers / Number of Victory in the Game)
o	Input from Players (Overlook in tests or to Avoid in games)
c	Input from Players (Number of Uncertainty (cancel) / to Decline (escape))
m	Input from Players (Number of Wrong / Lost)
i	Input from Players (How many to search info)
e	Value of Players Ability / Self Efficacy
tr	Value of Players Try to Answer / Try to Finish
q	Value of Players Pick Question / Playing the Game
st	Value of Players (Step report)
$\mathbf{x_1}$	Input vector of Using time (t)
$\mathbf{x_2}$	Input vector of Correct / Victory (b)
$\mathbf{x_3}$	Input vector of Self Efficacy / Ability (e)
$\mathbf{x_4}$	Input vector Step report (st)
$\mathbf{x_5}$	Input vector Try to Answer / to Finish (tr)
$\mathbf{x_6}$	Input vector Pick Question / Playing the Game (q)
$\mathbf{x_7}$	Input vector Search info (i)
$\|\mathbf{x}-\mathbf{w_n}\|$	Distance between the input vector ($\mathbf{x}$) and weight vector ($\mathbf{w_n}$) in competitive layer (hidden layer)
$\mathbf{x}$	input vector
$\mathbf{w_n}$	weight vector for the nth output unit
$\mathbf{w_1}$	Weight vector of Low Mental Effort ($\mathbf{w}_{j,me}$ for j =1)
$\mathbf{w_2}$	Weight vector of Semi Mental Effort ($\mathbf{w}_{j,me}$ for j =2)
$\mathbf{w_3}$	Weight vector of High Mental Effort ($\mathbf{w}_{j,me}$ for j =3)
$\mathbf{w_4}$	Weight vector of Low Persistence ($\mathbf{w}_{j,ps}$ for j =1)
$\mathbf{w_5}$	Weight vector of Semi Persistence ($\mathbf{w}_{j,ps}$ for j =2)
$\mathbf{w_6}$	Weight vector of High Persistence ($\mathbf{w}_{j,ps}$ for j =3)
$\mathbf{w_7}$	Weight vector of Low Active Choice ($\mathbf{w}_{j,ac}$ for j =1)
$\mathbf{w_8}$	Weight vector of Semi Active Choice ($\mathbf{w}_{j,ac}$ for j = 2)
$\mathbf{w_9}$	Weight vector of High Active Choice ($\mathbf{w}_{j,ac}$ for j = 3)
C_1	Class of Mental Effort Level Classification ($C_{j,me}$)
C_2	Class of Persistence Level Classification ($C_{j,ps}$)
C_3	Class of Active Choice Level Classification ($C_{j,ac}$)
y_{13}	Output of High Mental Effort (me_3)
y_{26}	Output of High Persistence (ps_3)
y_{39}	Output of High Active Choice (ac_3)
L	Motivation Behavior Type
MB	Classification of MBG

For example A is Cognitive Steps containing all skill contest with tests forms or all competitions items in the game. The number of skill contest (test) / competition (game) is $A = \{t,b,o,c,m,i\}$. t, b, o, c, m, and i are players' parameter in playing the game. t is the number of how much using time to finish the job, b is the number of correct answers in the tests or the number of victory in the game, o is the number of overlook in tests or to avoid in games, m is the number of mistakes in the tests or the number of lost in the game, c is the number of hesitation (canceled) in the tests or step back (escape) from competition in the game, and i is the number of how many to search info during the tests or to get help for the period of the game.

$tr=\{b,m\}$ is the condition when players try to answer a number of tests or try to finish all competition of MBG modeling which is also the indication of players' correct item/ victory and mistakes/ lost.

$$tr = \frac{b+m}{2} \quad (1)$$

$e=\{b,m,c\}$ is self-efficacy or ability and also $q=\{b,m,c\}$ is the number of picking up questions from all of tests or playing all competition in the game, that is the content of players' characters in mistakes, correct items, and doubts in game.

$$e = 0.5b + 0.3m + 0.2c \quad (2)$$

$$q = \frac{b+m+c}{3} \quad (3)$$

st is step report of player at some stage in the game. $q \in st$, $tr \in st$, $st=\{\{b,m,c\},\{b,m\},o,i\}$ is step of player playing the game which contains picking up question, trying to answer, search info, and overlook in tests.

$$st = \frac{o+i+q+tr}{4} \quad (4)$$

Three domains MBG are; i) mental effort domain, ii) persistence domain and iii) active choice domain. $e \in me$, $st \in me$, $me=\{\{b,m,c\},\{\{b,m,c\},\{b,m\},o,i\},t,b\}$ is mental effort domain which contains self efficacy, step, time, and correct items. $e \in ps$, $st \in ps$, $tr \in ps$, $ps=\{\{b,m,c\},\{\{b,m,c\},\{b,m\},o,i\},\{b,m\},t\}$ is persistence domain which contains self efficacy, step, try to answer, and time. Whereas, $q \in ac$, $st \in ac$, $ac=\{\{b,m,c\},\{\{b,m,c\},\{b,m\},o,i\},i\}$ is active choice domain which contains picking up question, step, and search info. To classify this domain is using LVQ method.

$L=(s,j)$ is MBG representative, s is the notation of three domain in MBG, and j is three level in every domain. L has nine probability out comes, those are ; i) low mental effort, ii) semi mental effort, iii) high mental effort, iv) low persistence, v) semi persistence, vi) high persistence, vii) low persistence, viii) semi persistence and ix) high persistence.

4.2 LVQ Method

Many methods can be used for classifying data. Learning Vector Quantization (LVQ) is the data classification method used in this research. LVQ is supervised Artificial Neural Network (ANN) using competitive learning method developed by Kohonen et al. [23], used in guided training from layers in ANN competition. Competitive layers will automatically learn to improve the classification of input vector performance periodically. When some input has very close distance vectors, those vectors will be grouped in the some class.

$$\mathrm{c} = \arg\min \left\| \mathbf{x} - \mathbf{w}_j \right\| \quad (5)$$

The algorithm of LVQ includes learning and recalling processes. In the learning process, in order to achieve accurate classification, Euclidean distance (D_i) was utilized as a basic rule of competition [12].

$$D_j = \left\| \mathbf{x} - \mathbf{w}_j \right\| = \sqrt{\sum_i (\mathbf{x}_i - \mathbf{w}_{ij})^2} \quad (6)$$

LVQ is used to classify data of input vector in MBG into three clusters. The input vector of LVQ is the weight of variables in MBG, namely; weight of trying to answer, picking up questions, competency, errors, and cancellation. The outcome of LVQ are three clusters of motivation behavior data type, namely; mental effort (me), persistence (ps) and active choice (ac) motivation behavior with three levels of clusters each. Those levels are high, middle and low level.

$\mathbf{x}_{1,me} \Leftrightarrow t$, $\mathbf{x}_{2,me} \Leftrightarrow b$, $\mathbf{x}_{3,me} \Leftrightarrow e$, $\mathbf{x}_{4,me} \Leftrightarrow st$

$$me_j = \sqrt{\sum_i (\mathbf{x}_{i,me} - \mathbf{w}_{ij,me})^2} \quad (7)$$

$$C_{j,me} = \arg\min \left\| \mathbf{x}_{me} - \mathbf{w}_{j,me} \right\| \quad (8)$$

me_j is the value of mental effort in MBG, and $C_{j,me}$ is the classification of mental effort level. Three classes of mental effort are $j = \{1,2,3\}$, in which; i) the value of j is equal to one at *j,me* for low condition of mental effort representation index, ii) semi mental effort index will be presented with j having value is two at *j,me*, and iii) three is value of j at *j,me* for index of high mental effort conditions. The variables *t, b, e* and *st* for mental effort have weight (**w**). The weight of *me* in j class is $\mathbf{w}_{j,me}$.

ps_j is value of persistence variable in MBG, $C_{j,ps}$ is the classification of persistence level. Three persistence classes are $j = \{1,2,3\}$ in which; i) j value which is one at *j,ps* is used as a representation index for low persistence, ii) j which is two at *j,ps* is index for semi persistence and iii) j which is three at *j,ps* is the index for high persistence. The weight of *ps* in j class is $\mathbf{w}_{j,ps}$.

$$\mathbf{x}_{1,ps} \Leftrightarrow t \,,\ \mathbf{x}_{3,ps} \Leftrightarrow e \,,\ \mathbf{x}_{4,ps} \Leftrightarrow st \,,\ \mathbf{x}_{5,ps} \Leftrightarrow tr$$

$$ps_j = \sqrt{\sum_i (\mathbf{x}_{i,ps} - \mathbf{w}_{ij,ps})^2} \quad (9)$$

$$C_{j,ps} = \arg\min \left\| \mathbf{x}_{ps} - \mathbf{w}_{j,ps} \right\| \quad (10)$$

ac_j is value active choice variable in MBG in which $C_{j,ac}$ is the classification of active choice level. Three active choice classes are $j = \{1,2,3\}$ where; i) j which is one at *j,ac* variable is the index for low active choice, ii) j which is two at *j,ac* is the index for semi active choice, and iii) j which is three at *j,ac* is index for high active choice. The weight of *ac* in j class is $w_{j,ac}$.

$$\mathbf{x}_{4,ac} \Leftrightarrow st \,,\ \mathbf{x}_{6,ac} \Leftrightarrow q \,,\ \mathbf{x}_{7,ac} \Leftrightarrow i$$

$$ac_j = \sqrt{\sum_i (\mathbf{x}_{i,ac} - \mathbf{w}_{ij,ac})^2} \quad (11)$$

$$C_{j,ac} = \arg\min \left\| \mathbf{x}_{ac} - \mathbf{w}_{j,ac} \right\| \quad (12)$$

Some researchers use the optimum method based on LVQ [24][25]. L is classification of *MB* optimum conditions. L is defined at three probability optimum conditions, namely; i) mental effort, ii) persistence, and iii) active choice. *MB* is the classification of MBG outcome that can be defined at nine probability optimum conditions, namely; i) high mental effort, ii) semi mental effort, iii) low mental effort, iv) high persistence, v) semi persistence, vi) low persistence, vii) high active choice, viii) semi active choice, and ix) low active choice.

$$L = \arg\min \left\| \{me_3, ps_3, ac_3\} \right\| \quad (13)$$

$$MB = \begin{cases} C_{j,me}, if\ L = me_3 \\ C_{j,ps}, if\ L = ps_3 \\ C_{j,ac}, if\ L = ac_3 \end{cases} \quad (14)$$

L is considered as mental effort if high mental effort (me_3) value is smaller than high persistence (ps_3) and smaller than high active choice (ac_3) too. Then *MB* is low mental effort if $C_{j,me}$ value is close to low mental effort value. *MB* is semi mental effort if $C_{j,me}$ value is close to semi mental effort value and then *MB* is high mental effort if $C_{j,me}$ value is close to high mental effort value.

The description of L is persistence is when the value of high persistence (ps_3) is smaller than high mental effort (me_3) and smaller than high active choice (ac_3) too. *MB* is low persistence if $C_{j,ps}$ value is close to low persistence value, *MB* is semi persistence if $C_{j,ps}$ value is close to semi persistence value, and *MB* is high persistence if $C_{j,ps}$ value is close to high persistence value.

L is active choice outcome probabilities which is obtained if the value of high active choice (ac_3) is smaller than high mental effort (me_3) and smaller than persistence (ps_3) too. Then *MB* is low active choice if $C_{j,ac}$ value is close to low active choice value, *MB* is semi active choice if $C_{j,ac}$ value is close to semi active choice value, and *MB* is high active choice if $C_{j,ac}$ value is close to high active choice value.

5. EXPERIMENT

This experiment was conducted a survey to twenty teachers to obtain three characteristic of motivation behavior. The aims of choosing teachers as the respondents is to get the ideal motivation behavior characteristics based on the assumption that teachers are the best motivation behavior evaluator. The other consideration is that teachers have the qualification as pedagogic assessors which is shown by their diplomas, certificates, and teaching experience. Therefore, teachers are reliable in determining the parameters of motivation behavior indicators.

The population is senior high school teachers that consist of two groups, twelve respondents are the math and science teachers, and eight respondents are the social teachers.

Teachers will give weight of the variable reference can influence the value of type (L) and class (C) of motivation behavior. Variable reference from teachers includes; using time (*t*), correct/victory (*b*), self-efficacy (*e*), step report (*st*), try to answers (*tr*), pick questions (*q*), and search info (*i*).

Parameters of motivation behavior characteristic value can be used as a motivation behavior reference. The reference of motivation behavior is the value of ideal motivation behavior. Values of the parameters in the motivation behavior reference data obtained from the classification of the teachers' survey data. Data of motivation behavior characteristic from teachers will be applied on learning rate of the LVQ motivation behavior pattern.

Populations of motivation behavior classification in this research are 33 pupils, including; 18 male and 15 female. The respondents are students in a senior high school. The ages of respondents are ranged from 16 to 19 years old. Respondents are used to test the MBG system. MBG base on LVQ will classify the student's motivation.

Value of *t, b, o, c,* m, and i are taken when students play the game. The variable of *t, b, o, c, m,* and *i* are players' characteristic of motivation behavior. These variables are the input of MBG.

6. RESULT

6.1 Value of Motivation Behavior

MBG is embedded in sensitivity of teachers in the game. It is because MBG data training is taken from the teachers. The data observation from the teacher is ideal data that can be used as training data in LVQ method. LVQ training outcome

is used as weight value reference of motivation behavior classification. Table 2 is the result of LVQ training (from data teachers) which includes; weight of using time (*t*), weight of correct/victory (*b*), weight of self-efficacy (*e*), weight of step report(*st*), weight of try to answers (*tr*), weight of pick questions (*q*), and weight of search info (*i*). The value of Table 2 is a reference weight value of motivation behavior in the MBG. The Table value is showing the character of motivation behavior reference which is in accordance with the players' character.

Table 2. Weight of Motivation Behavior reference

using time (*t*)	correct/ victory (*b*)	self-efficacy (*e*)	step report (*st*)	tray to answers (*tr*)	pick questions (*q*)	search info (*i*)	class (*C*)	motivation behavior type (*L*)
0.860	0.159	0.150	0.369	-	-	-	low	Mental
0.141	0.869	0.820	0.900	-	-	-	semi	Effort
0.120	0.830	0.849	0.141	-	-	-	high	(*me*)
0.100	-	0.860	0.498	0.900	-	-	low	Persistence
0.810	-	0.100	0.900	0.129	-	-	semi	(*ps*)
0.900	-	0.130	0.100	0.100	-	-	high	
-	-	-	0.120	-	0.498	0.498	low	Active
-	-	-	0.820	-	0.100	0.139	semi	Choice
-	-	-	0.873	-	0.879	0.869	high	(*ac*)

In equation 7 and 8, the mental effort motivation behavior reference shows the weight of *t* in j class is $\mathbf{w}_{1j,me}$ = {0.860, 0.141, 0.120}, the weight of *b* in *j* class is $\mathbf{w}_{2j,me}$ = {0.159, 0.869, 0.830}, the weight of *e* in *j* class is $\mathbf{w}_{3j,me}$ = {0.150, 0.8205, 0.849}, and the weight of *st* in *j* class is $\mathbf{w}_{4j,me}$ = {0.369, 0.900, 0.141}.

In equation 9 and 10, the persistence motivation behavior reference shows the weight of *t* in *j* class is $\mathbf{w}_{1j,ps}$ = {0.1, 0.810, 0.9}, the weight of *e* in *j* class is $\mathbf{w}_{2j,ps}$ = {0.860, 0.1, 0.130}, the weight of *st* in *j* class is $\mathbf{w}_{3j,ps}$ = {0.498, 0.9, 0.1}, and the weight of *tr* in *j* class is $\mathbf{w}_{4j,ps}$ = {0.900, 0.129, 0.100}.

In equation 11 and 12, the active choice motivation behavior shows the weight of *st* in *j* class is $\mathbf{w}_{1j,ac}$ = {0.120, 0.820, 0.873}, the weight of *q* in *j* class is $\mathbf{w}_{2j,ac}$ = {0.498, 0.1, 0.879}, and the weight of *i* in *j* class is $\mathbf{w}_{3j,ac}$ = {0.498, 0.139, 0.869}.

6.2 Motivation Behavior Classification

From equation 6 until 14, it can be stated that, this research is a method implementation in game to know the three motivation behaviors from 33 players (students), and three motivation levels in each motivation behavior.

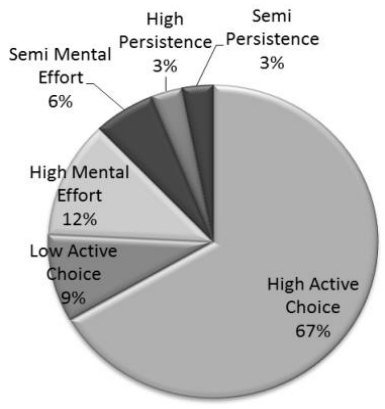

Fig 5: Classification of motivation behaviors.

Twelve percent players have high mental effort motivation behavior. Six percent players have semi mental effort motivation behavior. Tree percent players have high persistence motivation behavior and tree percent semi persistence too. Sixty seven percent high active choice motivation behaviors while nine percent players have low active choice motivation behavior (see Figure 5).

6.3 Motivation Behavior Game Multiple Objective

The results of experiment are shown in Table 3. MBG is identified from the motivation behavior of 33 respondents.

MBG is representing the three motivation behavior references; those are mental effort, persistence and active choice motivation behavior references. This is the MBG multi objective. Player's performance will be strong in one motivation behavior references and weak in the other. The first objective is mental effort (C_1), the second objective is persistence (C_2), and the third objective is active choice (C_3). Table 3 shows how the 33 respondents are multi-objective nature of each type of motivation behavior.

Table 3. Results of experiments

ID respon-dent	motivation behavior mental effort class (C_1) weight	per-sistence class (C_2) weight	active choice class (C_3) weight	motivation behavior type (*L*)	motivation behavior classification (*MB*)	% from all respon-dents
1	2	1	3	active choice	high active choice	
2	2	1	3	active choice	high active choice	
3	2	1	3	active choice	high active choice	
4	2	2	3	active choice	high active choice	
6	2	1	3	active choice	high active choice	
7	2	2	3	active choice	high active choice	
9	2	1	3	active choice	high active choice	
10	2	1	3	active choice	high active choice	
13	2	1	3	active choice	high active choice	
15	1	2	3	active choice	high active choice	
16	2	2	3	active choice	high active choice	
17	2	1	3	active choice	high active choice	67%
18	2	1	3	active choice	high active choice	
19	2	2	3	active choice	high active choice	
20	2	1	3	active choice	high active choice	
21	2	1	3	active choice	high active choice	
22	2	2	3	active choice	high active choice	
25	2	1	3	active choice	high active choice	
28	2	2	3	active choice	high active choice	
29	2	1	3	active choice	high active choice	
31	2	1	3	active choice	high active choice	
32	2	1	3	active choice	high active choice	
5	2	2	1	active choice	low active choice	
12	2	2	1	active choice	low active choice	9%
23	1	2	1	active choice	low active choice	
8	3	1	1	mental effort	high mental effort	
11	3	1	1	mental effort	high mental effort	12%
30	3	1	1	mental effort	high mental effort	
33	3	1	1	mental effort	high mental effort	
26	2	1	1	mental effort	semi mental effort	6%
27	2	1	1	mental effort	semi mental effort	
24	3	3	1	persistence	high persistence	3%
14	1	2	3	persistence	semi persistence	3%

Note: weight of class; 1 = low, 2 = semi, 3 = high motivation behavior

In this research, 33 respondents are playing the game to present MBG multiple objectives. 33 player's behavior shows multi-objective of mental effort, persistence and active choice motivation behavior. Table 3 shows the results of experiments in general. To facilitate observation is given performance value weighting of C_1, C_2 and C_3.

6.4 Analysis of Motivation Behavior Characteristic

The characteristic of motivation behavior are divided into three objective groups, namely; mental effort, persistence, and active choice motivation behavior. Mental effort motivation behavior is the first objective motivation performance of the players during the process of completing a game mission, who are characterized as; always confident with high level of efficiency to using time, never make mistakes, have a high competence (high self-efficacy), and effective to finish the tasks thoroughly.

Persistence motivation behavior is the second objective motivation performance at the time of completing the mission of the game. Persistence have objective characteristics includes; tend to low self-efficacy, low efficiency to using time, few of try to answer, and finish the tasks thoroughly.

Active choice is the third objective performance of the players' motivation during serious games. The characteristic of active choice includes; tend often to search information, always respond to get the questions, low efficiency in solve the problem thoroughly.

7. DISCUSSION

7.1 Multiple Objective Characteristic

Based on the results of Motivation Behavior Classification (section 6.2 and 6.3), can be seen at the level of multi-objective character of each motivation behavior classification. Refer to the results of experiments in Table 3; value of motivation behavior multi-objective is presented in Table 4.

Table 4. Value of motivation behavior multi-objective

	motivation behavior objective		
motivation behavior classification of respondent	1st objective (**mental effort**) average of C_1 weights	2sd objective (**persistence**) average of C_2 weights	3rd objective (**active choice**) average of C_3 weights
high (12%) and semi (6%) mental effort	2.7	1	1
high (3%) and semi (3%) persistence	2	2.5	2
high (67%) and low (9%) active choice	1.92	1.4	2.76

Table 4 visualizes the multi-objective for each group of respondents with motivation behavior classification of mental effort, persistence, and active choice. Value of weight equals to three is having a strong character objective, and on the other hand a weight with one value is having a weak character objective.

In high and semi mental effort row from Table 4 displays multiple objectives of players with classification mental effort motivation behavior. These show that the players with mental effort motivation behavior character have highly multi objective with the persistence motivation behavior characters' and active choice motivation behavior characters' too. It means that, the multi objective character is strong for mental effort motivation behavior.

While almost the six percent players who have persistence motivation behavior are weak multi objective character. In Table 4 shows that the players with persistence motivation behavior character have low multi objective with the mental effort and active choice motivation behavior characters.

In row active choice of Table 4, the players who have active choice motivation behavior character is highly multi objective with the persistence motivation behavior character, but few with mental effort motivation behavior character. This means that active choice players also have the mental effort character.

8. CONCLUSION

In MBG modeling research, can be gotten the function of motivation behavior identification. LVQ method is used to classify player's characteristic in playing games. The MBG is embedding sensitivity of teachers in the game. It is because MBG data training in LVQ method is taken from the teachers.

In MBG classification research, game can identify player's motivation behavior. Players can be classified in three motivation behavior clusters namely; i) mental effort, ii) persistence and iii) active choice, by result are 12% is high mental effort, 6% is semi mental effort, 3% high persistence, 3% semi persistence, 67% high active choice, 9% low active choice.

In MBG multiple objective research, can be found the players with mental effort character are strong multiple objective. These players are weak in persistence and active choice character. The players have persistence character, relative have mental effort and active choice character too. These players are weak in multiple objective characters. Whereas, the players have active choice character tend to have mental effort character too, but weak in persistence character.

In education methodology (by utilizing games), mastery learning is the core of the learning process. Mastery learning can be achieved by always maintaining a high interest (included in serious game). Typical assessments are likely to disrupt the interest. MBG is embedding assessments of motivation behavior in serious game. Thus there would be less obtrusive and hence less disruptive to flow experience in a game.

For further research, MBG can provide feedback to determine the level or used as a guide in game. Individual behavior can influence the scenario changes in game. MBG can be fun and personality challenges in serious game.

To sum up it can be conclude that the MBG is embedded assessments of motivation behavior with the sensitivity of teachers in the serious game. MBG disposed have strong multi-objective character of motivation behavior classification. Thus there is a need the optimum method based on LVQ. Indirectly, MBG always observe fluctuations in the interest of the players. MBG informed an accurate level of motivation behavior, it strongly supports the completeness learning in serious game.

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