TENDENCY OF PLAYERS IS TRIAL AND ERROR: CASE STUDY OF COGNITIVE CLASSIFICATION IN THE COGNITIVE SKILL GAMES

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Abstract

To assess the cognitive level of player ability is difficult; many instruments are potentially biased, unreliable, and invalid test. Whereas, in serious game is important to know the cognitive level. If the cognitive level can be measured well, the mastery learning can be achieved. Mastery learning is the core of the learning process in serious game. To classify the cognitive level of players, researchers propose a Cognitive Skill Game (CSG). CSG improves this cognitive concept to monitor how players interact with the game. This game employs Learning Vector Quantization (LVQ) for optimizing the cognitive skill input classification of the player. Training data in LVQ use data observation from the teacher. Populations of cognitive skill classification in this research are pupils when playing the game. Mostly players cognitive skill game have cognitive skill category are Trial and Error. Some of them have Expert category, and a few included in the group carefully. Thus, the general level of skill of the player is still low.

Keywords: *trial and error, cognitive classification, learning vector quantization, cognitive skill game,cognitive level*

Abstrak

Untuk menilai tingkat kognitif dari kemampuan pemain sangatlah sulit; banyak instrumen yang berpotensi bias, tidak dapat diandalkan, dan merupakan tes yang tidak valid. Padahal, dalam *serious game* penting untuk mengetahui tingkat kognitif. Jika tingkat kognitif dapat diukur dengan baik, penguasaan pembelajaran dapat dicapai. Penguasaan belajar adalah inti dari proses belajar dalam *serious game*. Untuk mengklasifikasikan tingkat kognitif pemain, kami mengusulkan Cognitive Skill Game (CSG). CSG meningkatkan konsep kognitif untuk memantau bagaimana pemain berinteraksi dengan permainan. Permainan ini menggunakan Learning Vector Quantization (LVQ) untuk mengoptimalkan *input* klasifikasi keterampilan kognitif pemain. Data trining dalam observasi LVQ menggunakan data dari guru. Populasi klasifikasi keterampilan kognitif dalam penelitian ini adalah siswa saat memainkan permainan. Sebagian besar pemain CSG berkategori keterampilan kognitif adalah coba-coba. Beberapa dari mereka memiliki kategori Ahli, dan sedikit yang termasuk dalam kelompok hati-hati. Dengan demikian, secara umum kemampuan pemain masih rendah.

Kata Kunci: *coba-coba, klasifikasi kognitif, learning vector quantization, permainan ketrampilan kognitif, tingkat kognitif*

1. Introduction

From previous research, researchers know that serious game support the education process. Marsh et al [1] and Clark [2] stated that serious game is learning through games which contain pedagogical aspects and is part of e-learning tools/media [3-5]. Clark [2], Arnseth [6], and Smith [7] further states that learning method using game is better then the conventional one since animations of learning material in game activates students' long term memories.

On the other hand, game learning has an inverse relationship with learning test in many instances. Clark [8] gives details, pedagogy in

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games is often based on unguided discovery such as; minimal guidance and only high skill works, overwhelming discovery evidence without any assistance for beginners or novices learners [9-10], discovery technique design and some game cause memory overwork and decrease the learning process [11].

Overload will not occur if the level of cognitive skill players is controlled. Inal, & Cagiltay [12] explains the research of Csikszentmihalyi, 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 cannot occur. Heavier duty resulted in the faster frustration; the challenges are too easy, getting bored quickly.

Proper classification of cognitive skills can be used to control the level of difficulty of the game. Providing an appropriate level of difficulty to the level of cognitive skill in a game scenario will balance the emotions of players. Researcher cannot provide an appropriate difficulty level of task if the cognitive skill of players is unknown.

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 [13]. In other words, researcher can say that 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 learning are often unreliable and invalid. Learning cannot be measured by self report, because there is an opportunity to manipulate data. In this research researcher propose the Cognitive Skill Game (CSG) to eliminate the data manipulation of learning tests in serious games. CSG is a model of indirect measurement of cognitive levels. CSG is a players' cognitive characteristics measurement by observing the players' cognitive behavior. The value of cognitive behavior can be taken from the indicators that appear when a game takes place.

CSG is Pedagogic Player Character (PPC) based on artificial intelligent agent. CSG can forecast the cognitive character of players. Learning Vector Quantization (LVQ) method is used in CSG. LVQ is used to classify players' the cognitive level. The teachers' data are neuron vector to use in learning or supervising data in LVQ method. Three multi objective classifications in CSG are; trial and error, carefully, and expert cognitive skill. In this research, students are respondent players demonstrates.

Empirical studies have shown that, although video and computer games are usually highly engaging and have suggested the potential educational tools, they often do not trigger the constructive reasoning necessary for learning. Conati & Klawe [14] proposed SIAs (Socially Intelligent Agents) architecture to support Game-Based Collaborative Learning. They have presented a preliminary architecture based on Bayesian networks and influence diagrams. However, they have not explained the methods used to detect level of cognitive players' ability.

In several ongoing studies, researchers have suggested the cognitive architecture and cognitive model [15-16]. CBR (Case-Based-Reasoning), as conceptualized in rule-based classification and similarity-based classification, is the technical counterpart of psychological exemplar-based reasoning [15]. Conde & Thalmann [16] propose the concept of a Learning Unit Architecture that function as a control unit of the AVA's brain (Autonomous Virtual Agents). Both [15-16] are Non Player Character (NPC) agent, the cognitive skill of which are applied into behavioral animation and machine learning agent. CSG improves this cognitive concept to monitoring how players interact with the game.

In addition to the development of cognitive research in the game [1-11][13-16], there are also some researchers use LVQ method for data classification in game [17-20]. CSG based on two phenomena (cognitive game and LVQ in game) are developed.

CSG is a game that measures the level of players' cognitive process-based. This gives more emphasis on the achievement level of ability, for example; calculating the number of correct and incorrect items, and the competence by considering the weight of error, truth, and cancellation. 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 cognitive skills in the process.

The result of the cognitive skill classification is used to leveling cognitive of task in game engine. The method of cognitive leveling in game engine is using the algorithm which will adapt the cognitive skill 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. CSG supported achievement balance

between an individual's skills and difficulties of tasks. CSG can prevent boredom and frustration.

2. Methodology

Design system of CSG is illustrated in a model of Cognitive Skill Game with Petri net and modeling functions use the LVQ method.

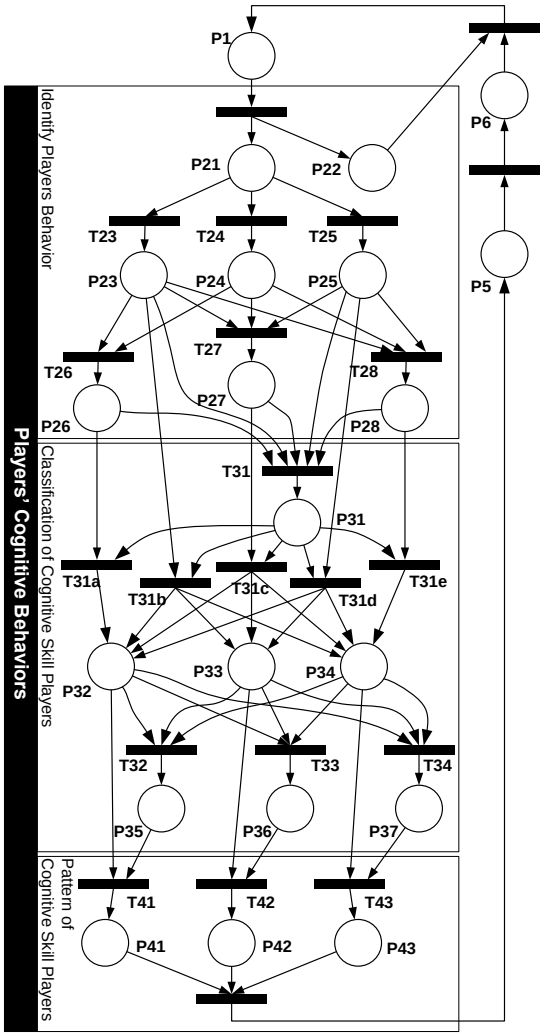

Figure 1. Detail of cognitive skill game model [21].

Model of cognitive skill game with Petri net. From [21], detail of CSG model with Petri net is shown in figure 1, the interpretations detail of places on CSG model is shown in table I, and table II is show detail of transition. The three main part of CSG are; i) Identify players behavior, ii) Classification of cognitive skill players, and iii) Pattern of cognitive skill players. More details can be viewed at [21].

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. [22], 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.

TABLE I
DETAIL OF PLACE ON COGNITIVE SKILL GAME MODEL

Place	Interpretation
P1	Problems arise in the game
P21	Players resolve the problem
P22	Players avoid / leave the problem
P23	Number of wrong / lost (m)
P24	Number of true / win (b)
P25	Number of the players is Uncertainty / to Decline (escape) (c)
P26	Fixes the value of Try to Answer / to Finish (tr)
P27	Fixes the value of Pick Question / Playing the Game (q)
P28	Fixes the value of Self Efficacy / Ability (e)
P31	Fixes the value of maximal (max)
P32	LVQ method to classify the Players Cognitive Skill of Trial & Error (te) into; Low Trial & Error (te_1), Semi Trial & Error (te_2) or High Trial & Error (te_3)
P33	LVQ method to classify the Players Cognitive Skill of Carefully (cf) into; Low Carefully (cf_1), Semi Carefully (cf_2) or High Carefully (cf_3)
P34	LVQ Method to classify the Players Cognitive Skill of Expert (ep) into; Low Expert (ep_1), Semi Expert (ep_2) or High Expert (ep_3)
P35	Value is one or zero
P36	Value is one or zero
P37	Value is one or zero
P41	Value is Trial & Error (te) or zero
P42	Value is Carefully (cf) or zero
P43	Value is Expert (ep) or zero
P5	Cognitive Leveling algorithm
P6	Responds to the players level of cognitive skill as the reference to selection of problem in game

Figure 2 is a LVQ method contained in place of petri net. LVQ used to classify data of input vector in CSG into three clusters. The input vector of LVQ is the weight of variables in CSG, namely; weight of trying to answer, picking up questions, competency, errors, and cancellation. The outcome of LVQ is three clusters of cognitive skill data type, namely; trial and error (te), careful (cf) and expert (ep) cognitive skill with three levels of clusters each. Those levels are high, middle and low cognitive skill [21]. The value of trial and error in CGS is te_j, and $C_{j,te}$ is the classification of trial and error level. cf_j is value of careful variable in CSG, $C_{j,cf}$ is the classification of careful level. ep_j is the value of expert in CGS, and $C_{j,ep}$ is the classification of expert level.

Some researchers use the optimum method based on LVQ [23-24]. L is classification of CS optimum conditions. L is defined at three

probability optimum conditions, namely; i) trial and error, ii) careful, and iii) expert. *CS* is the classification of CSG outcome that can be defined at nine probability optimum conditions, namely; i) high trial and error, ii) semi trial and error, iii) low trial and error, iv) high careful, v) semi careful, vi) low careful, vii) high expert, viii) semi expert, and ix) low expert.

Figure 3 is Action Flow of CSG. The first CSG will be identify players. Furthermore, players will be classified based on the character of cognitive skills tests in each state. Data obtained from the evidence of the players in each state that is the out come of classification process of cognitive skills by using the LVQ method.

TABLE II
DETAIL OF TRANSITION ON COGNITIVE SKILL GAME MODEL

Transition	Interpretation
T23	The result of wrong / lost
T24	The result of true / win
T25	The result of the players is Uncertainty (cancel) / to Decline (escape)
T26	Average of lost (*m*), and win (*b*) value
T27	Average of lost (*m*), cancel (*c*) and win (*b*) value
T28	Sum of 30% lost (*m*), 20% cancel (*c*) and 50% win (*b*) value
T31	Obtain the highest value of the *m*, *b*, *c*, *q* or *tr*
T31a	Divide the *tr* value by the *max*
T31b	Divide the *m* value by the *max*
T31c	Divide the *q* value by the *max*
T31d	Divide the *c* value by the *max*
T31e	Divide the *e* value by the *max*
T32	Set (one value) if then value of High Trial & Error (te_3) in LVQ method is higher of value of High Expert (ep_3) or value of High Carefully (cf_3), else reset (zero value)
T33	Set (one value) if then value of High Carefully (cf_3) in LVQ method is higher of value of High Trial & Error (te_3) or value of High Expert (ep_3), else reset (zero value)
T34	Set (one value) if then value of High Expert (ep_3) in LVQ method is higher of value of High Trial & Error (te_3) or value of High Carefully (cf_3), else reset
T41	To multiply
T42	To multiply
T43	To multiply

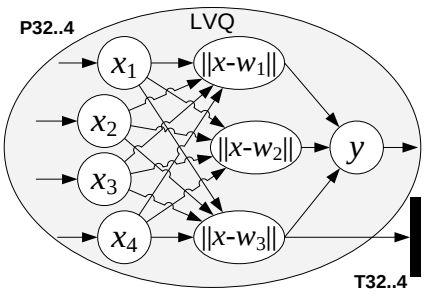

Figure 2. LVQ method in P32, P33 and P34 of Cognitive Skill Game Model [21].

In previous studies [21] conducted testing on only one state, in the present study was developed for seven states. All states in CSG provides only one level of cognitive difficulty. Each player will be identified as many as seven times include the seven state existing. Scenario game at CSG is shown in figure 4. Players must complete the tasks within each state. After completing the task of the player will return to later transition into another state. Game is complete if the player has completed the task of all existing state.

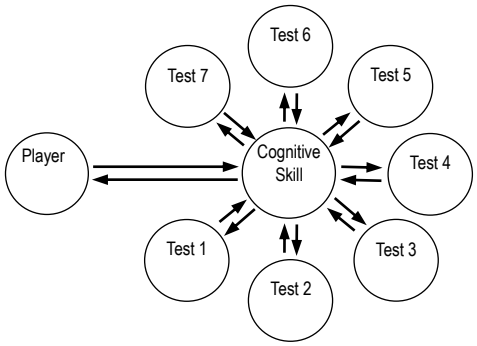

Figure 3. Action flow of cognitive skill game model.

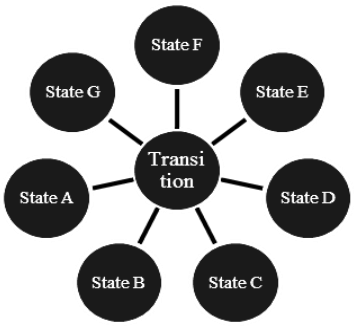

Figure 4. Scenario of cognitive skill game model.

3. Results and Analysis

Researcher conducted a survey to twenty teachers to obtain three characteristic of cognitive skill. The aims of choosing teachers as the respondents is to get the ideal cognitive skill characteristics based on the assumption that teachers are the best cognitive skill evaluator. It is also the consideration 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 cognitive skill 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 cognitive skills. Variable reference from teachers includes; pick questions (*q*), try to

answer (*tr*), self efficacy (*e*), mistake (*m*), and cancels (*c*).

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

Populations of cognitive skill 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 16 to 19 years old. Respondents are used to test the CSG system. CSG base on LVQ will classify the students cognitive.

Value of *b*, *m*, and *c* is taken when students play the game. The variable of *b*, *m*, and *c* are players' characteristic of cognitive behavior. These variables are the input of CSG.

Screen shoot transition place at CSG is shown in figure 5. Players must be go in this place to choice the state. Players who had entered into a certain space (state) cannot do it again. The player is directed to take the new state.

Screen shoot one of state place at CSG is shown in figure 6. Of the transition location, players will be entered into one of the existing state space (one of seven states). Players must complete the tasks in each state. Players can not leave the room before completing the task at least 75% of all available tasks. This done for players to mastery learning.

Result, value of cognitive skills. 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 cognitive skill classification. Table V is the result of LVQ training (from data teachers) includes; weight of pick questions (*q*), weight of try to answers (*tr*), weight of self efficacy (*e*), weight of mistake (*m*), and weight of cancels (*c*). The value of table III is a reference weight value of cognitive skills in the CSG. The Table value is showing the character of cognitive skill reference which is in accordance with the players' character.

Cognitive skills classification. From chapter 2, it can be stated that, this research is a method implementation in game to know the three cognitive skill behaviors from 33 players (students), and three cognitive skill levels in each cognitive skill. Trial and error cognitive skill indicates low competency in playing a game. Carefully cognitive skill indicates good ability and expert cognitive skill shows players high ability in game.

Of the 33 players will get the 231 players data. each player completes 7 state (state A, ..., state G), in each state would be classified cognitive skill players (C_1, C_2 and C_3). Based on the C_1, C_2 and C_3 will be determined type of cognitive skill based on the optimum value. Table IV shows results of experiments in State A (examples one of state) and table V in all State. Table V shows the number of players who are classified in the C_1, C_2 and C_3, which can be determined the type of cognitive skill players (*L*).

Figure 5. Screen shoot of transition place.

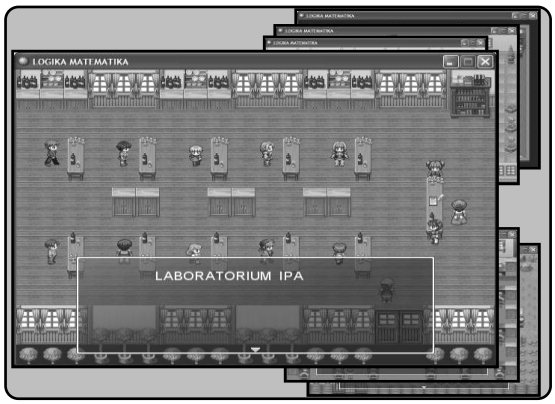

Figure 6. Screen shoot of state place.

The characteristic of cognitive skill are divided into three groups, namely; high cognitive skill, middle cognitive skill, and low cognitive skill. High cognitive skill is the highest cognitive performance of the players during the process of completing a game mission. The characteristic of high cognitive skills are experts, includes; never make mistakes, have a high competence (high self efficacy), always confident with high level of efficiency to answer, and finish the tasks thoroughly.

Middle cognitive skill is a cognitive performance that is good enough at the time of completing the mission of the game. Cognitive skills have good characteristics as careful, includes; few errors, low confident, low level of efficiency to answer, and finish the tasks thoroughly.

TABLE III
WEIGHT OF COGNITIVE SKILL REFERENCE

Pick questions (*q*)	Tray to answers (*tr*)	Self efficacy (*e*)	Mistake (*m*)	Cancels (*c*)	Class (*C*)	Cognitive skill type (*L*)
0.119625	0.124634	-	0.124744	0.310473	low	
0.821745	0.801989	-	0.822156	0.851593	semi	Trial and Error
0.840679	0.790841	-	0.822156	0.109681	high	
0.870272	-	-	0.87992	0.299464	low	
0.870449	-	-	0.88013	0.859627	semi	Carefully
0.8001	-	-	0.129553	0.860264	high	
0.859762	-	0.124506	0.879788	0.6648206	low	
0.110407	-	0.889593	0.119265	0.8791854	semi	Expert
0.131112	-	0.868888	0.120705	0.1207046	high	

TABLE IV
RESULTS OF EXPERIMENTS IN STATE A

ID respondent	Expert class (C_1)	Carefully class (C_2)	Trial and error class (C_3)	Cognitive skill type (L)
12	high	high	low	carefully
10	high	high	low	carefully
20	low	high	semi	carefully
2	high	high	low	carefully
4	semi	high	low	carefully
17	semi	high	semi	carefully
33	low	high	semi	carefully
9	high	high	low	expert
7	high	low	low	expert
5	high	high	low	expert
11	high	high	low	expert
3	high	high	low	expert
1	high	high	low	expert
23	high	low	high	trial and error
15	low	low	high	trial and error
19	low	low	high	trial and error
16	high	low	high	trial and error
18	low	low	high	trial and error
8	high	low	high	trial and error
6	high	low	high	trial and error
14	low	low	high	trial and error
25	low	low	high	trial and error
13	low	low	high	trial and error
30	low	low	high	trial and error
28	low	low	high	trial and error
22	low	low	high	trial and error
24	low	low	high	trial and error
21	low	low	high	trial and error
26	low	low	high	trial and error
27	low	low	high	trial and error
29	low	low	high	trial and error
31	low	low	high	trial and error
32	low	low	high	trial and error

TABLE V
RESULTS OF EXPERIMENTS IN ALL STATE

State	Expert class (C_1)			Carefully class (C_2)			Trial and error class (C_3)			Cognitive skill type (L)		
	High	Semi	Low	High	Semi	Low	High	Semi	Low	Expert	Carefully	Trial & error
A	13	2	18	12	0	21	20	3	10	6	7	20
B	29	1	3	3	0	30	23	1	9	14	1	18
C	25	0	8	3	1	29	28	3	2	9	2	22
D	29	1	3	2	1	30	28	2	3	2	2	29
E	25	1	7	2	1	30	26	1	6	1	5	27
F	31	1	1	5	0	28	14	1	18	26	1	6
G	25	1	7	5	1	27	27	3	3	3	3	27
all										61	21	149

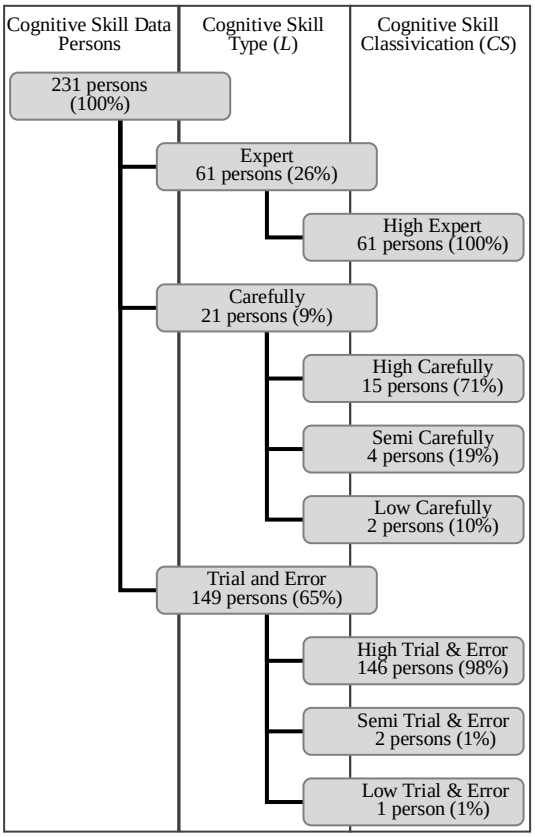

Figure 7. Classification of cognitive skill.

Low cognitive skill is the lowest performance of the players' cognitive during serious games. The characteristic of this skill are trial & error, includes; tend to make many mistakes (high error factor), always try to respond or try to answer, low confident, low efficiency in answering questions and solve the problem thoroughly.

Classification of cognitive skill is depicted in figure 7. From the results of 231 experimental data of players, type of Cognitive Skill players are divided into 26% (61 players data) are the Expert, 9% (21 players data) is Carefully, and 65% (149 players data) is a Trial and Error Cognitive Skill.

All Players with the type of Cognitive Skill Expert has High Expert classification. Cognitive Skill Carefully type classified to 71% (15 players' data) is High Carefully, 19% (4 players' data) is Semi Carefully, and 10% (2 players' data) is Low Carefully. While the Trial and Error Cognitive Skill type classified to 98% (146 players' data) is the High Trial and Error, 1% (2 players' data) is Semi Trial and Error, and 1% (1 player data) is Low Trial and Error.

On Cognitive Skill Classification (*CS*) is more dominant at high levels of classification. Thus the optimum level of classification is higher. So the type Cognitive Skill (*L*) of players will be more definitely lead to one type of cognitive skill that exists (Expert, Carefully, or Trial and Error).

4. Conclusion

In CSG modeling research, researcher gets the model of CSG with Petri net and function of cognitive skill behavior identification. LVQ method is used to classify player's characteristic in playing games. In CSG classification research, game can identify player's cognitive skill behavior. Players can be classified in three cognitive skill clusters namely; i) expert, ii) careful and iii) trial and error, by result are 63% high trial and error (146 from 231 persons), 26% high expert (61 from 231 persons), 7% high carefully (15 from 231 persons), 2% semi carefully (4 from 231 persons), 1% low carefully (2 from 231 persons), 1% semi trial and error (2 from 231 persons), 0.4% low trial and error (1 from 231 persons). Thus, there are many players who have cognitive level is trial and error. One reason is the application of this research has not been setting the appropriate level of difficulty. In a further research, CSG can provide feed back to determine the level or used as a guide in game. Individual behavior can influence the scenario changes in game. CSG can be fun and personality challenges in serious game.

To wrap up, it can be concluded that the CSG is embed sensitivity of teachers in the game, cause CSG data training is taken from the teachers. Dominant characteristic of the all the players is trial and error. More than half (63%) players have a high trial and error characters. It can be concluded that, the player is still a low level of cognitive skill.

References

[1] T. Marsh, W.L. Wong, E. Carriazo, L. Nocera, K. Yang, A. Varma, H. Yoon, Y.-L. Huang, C. Kyriakakis, & C. Shahabi, User Experiences and Lessons Learned from Developing and Implementing an Immersive Game for the Science Classroom, Information laboratory (InfoLAB), University of Southern California, http://infolab.usc.edu/DocsDemos/hci05.pdf, 2009, retrieved November 15, 2011.

[2] D. Clark, Game and e-learning, Sunderland: CaspianLearning, http://www.caspianlearning.co.uk, 2009, retrieved November 15, 2011.

[3] H. Ndahi, "The Use of Innovative Methods to Deliver Technology Education Laboratory Courses via Distance Learning: A Strategy to

Increase Enrollment," *Journal of Technology Education*, vol. 17, pp. 33-42, 2006.

[4] A. Hayashi, C.C. Chen, & H. Terase, "Aligning IT Skills Training With Online Asynchronous Learning Multimedia Technologies," *Information Systems Education Journal (ISEDJ)*, vol. 3, pp. 3-10, 2009.

[5] N.P. Ololube, "Appraising the relationship between ICT usage and integration and the standard of teacher education programs in a developing economy," *International Journal of Education and Development using Information and Communication Technology (IJEDICT)*, vol. 2, pp. 70-85, 2006

[6] H.C. Arnseth, "Learning to Play or Playing to Learn - A Critical Account of the Models of Communication Informing Educational Research on Computer Gameplay," *The international journal of computer game research*, vol. 6, 2009.

[7] J.H. Smith, "The Games Economists Play - Implications of Economic Game Theory for the Study of Computer Games," *The international journal of computer game research*, vol. 6, pp. 1-15, 2006.

[8] R.E. Clark, Evaluating the Learning and Motivation Effects of Serious Games, Rosier school of Education Center for Creative Technologies, USC, http://projects.ict.usc.edu/itgs/talks/Clark_Serious Games Evaluation.ppt, 2010, retrieved December 10, 2011.

[9] R.E. Mayer, "Should There be a Three-strikes Rule Against Pure Discovery Learning," *American Psychologist*, vol. 59, pp.14-19, 2004

[10] P. Kirschner, J. Sweller, & R.E. Clark, "Why Minimally Guided Learning Does Not Work: An Analysis of the Failure of Discovery Learning, Problem-based Learning, Experiential Learning and Inquiry-based Learning," *Educational Psychologist*, vol. 41, pp. 75-86, 2006

[11] R.E. Clark & S. Choi, "Five design principles for experiments on the effects of animated pedagogical agents," *Journal of Educational Computing Research*, vol. 32, pp. 209-223, 2005.

[12] Y. Inal & K. Cagiltay, "Flow experiences of children in an interactive social game environment," *British Journal of Educational Technology*, vol. 38, pp. 455–464, 2007

[13] S. Chen & D. Michael, Proof of learning: Assessment in serious games. Gamasutra. http://www.cedma-europe.org/newsletter articles/misc/Proof of Learning - Assessment in Serious games (Oct%2005).pdf, 2010, retrieved December 11, 2011.

[14] C. Conati & M. Klawe, Socially Intelligent Agents In Educational Games, University of British Columbia, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.6.6209&rep=rep1&type=pdf, 2011, retrieved December 3, 2011.

[15] P. Bosch, K. Dalinghaus, B. Hammer, J-P. Reuter, B. Schrader, T. Steffens, & C. Umbach, *Cognitive Architecture: The Integration of Rules and Patterns*, Institute of Cognitive Science University of Osnabrück, Germany, 2003.

[16] T. Conde & D. Thalmann, *Autonomous Virtual Agents Learning a Cognitive Model and Evolving*, Springer-Verlag, London, 2005.

[17] H. Isnaini, "Classification Efficiency Problem Solving Integer Arithmetic Operation Junior High School Class 7 With Game Using LVQ Method," Ph.D Thesis of Electrical Engineering, Department of Electrical Engineering FTI, Institut Teknologi Sepuluh Nopember (ITS), Indonesia, 2009.

[18] S.M. Harini, "Classification Of Comprehensive Learning Achievement Effectivity In Senior High School Students Based On Mathematical Logic Game Using LVQ Method," Ph.D Thesis, Department of Electrical Engineering FTI, Institut Teknologi Sepuluh Nopember (ITS), Indonesia, 2009.

[19] M.A. Syufagi, M. Hariadi, & M.H. Purnomo, "Model of Mental Effort Assessment in Pedagogic Games Based On LVQ Method" *In Proceeding of SESINDO 2008 Conference*, pp. 556-564, 2008.

[20] A. Myriam & W. Harry, A Distributed Reinforcement Learning Approach to Pattern Inference in Go, CiteSeerx, http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.9.7035, 2011, retrieved November 10, 2011.

[21] M.A. Syufagi, M.H. Purnomo, & M. Hariadi, "Modeling Serious Game based on Cognitive Skill Classification using Learning Vector Quantization with Petri Net" *In Proceedings of the ICACSIS International Conference on Advanced Computer Science and Information Systems*, pp. 159-164, 2011.

[22] C.R. Chen, L.T. Tsai, & C.C. Yang, "A Neural Network Approach for Random Samples to Stratified Psychometrical Population" *In Proceedings of the WSEAS International Conference on Sociology, Psychology, Philosophy*, pp. 51-54, 2010.

[23] S.H. Heon & L.S. Whan, "LVQ Combined with Simulated Annealing for Optimal Design of Large-set Reference Models," *Neural Networks Elsevier Science Ltd*, vol. 9, pp. 329-336, 1996.
[24] K.K. Dae, H.L. Sang, K.B. Sop & M. Gyu, "Generalized LVQ for Optimal Reference Vectors using a Differentiable MIN Module" *In Proceedings of International Conference on Neural Information Processing*, pp. 1937-1942, 1994.