A MULTI-USER EDUCATIONAL ONLINE GAME WITH WEB BASED MATHEMATIC LEARNING BY USING ACTIVITY THEORY ANALYSIS

Chi-Yuh Shen, Gwo-Dong Chen, Kuo-Liang Ou
Department of Computer Science and Information Engineering National Central University
No.300, Jhongda Rd., Jhongli City, Taoyuan County 32001, Taiwan(R.O.C.)

Department of Applied Mathematics
National Hisn-Chu University of Education
No. 521, Nan-Da Road, Hsin-Chu City, Taiwan, (R.O.C)

Keywords: Activity theory, intrinsic motivation, educational online game, machine learning, web based mathematic learning.

Abstract: In this paper, we use activity theory to analyze the process and out come of mathematic learning by using MEOG (Multi-User Educational Online Game) based on the previous research (Gwo-Dong Chen, Gee-Yu Shen, 1997) described a multi-user educational online games which can motivate and guide students to learn and practice courses on the web. In order to reduce the obstacle of MSEOG applying in instructional activity in classroom, first, we adopt the factors of motivation as outcome and decided the tools and rule by found the cue in the questionnaires and server log. Second, we consider events of instruction and learning phrases (Gagne) and using Machine Learning Technique to get the potential rule (activity theory). From these, we want to develop a methodology to get stability of guiding online game applying in instruction of classroom.

1 INTRODUCTION

To play the game is the important part of our mental and social development (Alan Amory, Kevin Naicker, Jackie Vincent and Claudia Adams, 1998). There are so many young men and younger adults volunteer to spend much time to play online game.(Alexamder E. Voiskounsky, Olga V. Mitina, Anastasiya A.Avetiso, 2004). Recently, an online game called "world of war craft" is popular in Taiwan. It is a obvious evidence. Using game to support in learning is not new research e.g. increasing motivation (Westrom, Mary 1992, Gwo-Dong Chen, Gee-Yu Shen, 1997,Maria M. Klawe 1999),enhancing achievement in mathematics learning(Maria M. Klawe 1999), effect the cognitive function (Rieber 1996) and training Skill to play adventure games includes : logics, memory, visualization, and problem solving (Quinn, 1994, 1997 Amory et al, 1999b).

In the study of Tom S. Chan (1999) mentions "Deci and Ryan(1985) noted that making all school work intrinsically motivating is impossible".

Few research in game applied in school activity.From BECTA surveying , Kirriemuir, JK, McFarlane, A(2003) point out the main obstacle of apply computer and video game in school is learning in time, but teacher not allow student spend time in the control of complex learning.

From E-GEMS project, Maria M. Klawe (1999) got the result of gaming supporting learning are effective increasing motivation and achievement. But, in Muti-user network game, there is "significant and persistent difficulties in bringing the games to the level of stability needed to conduct field studies of the games as a whole" (cited by Maria M. Klawe 1999).

In previous study (Gwo-Dong Chen, Gee-Yu Shen, 1997), student volunteer to spend more time to play MSEOG, besides, there are some factors of motivation decided by T-test, but not study in achievement and low rate in relearning the CAI.

Shen C., Chen G. and Ou K. (2006).
A MULTI-USER EDUCATIONAL ONLINE GAME WITH WEB BASED MATHEMATIC LEARNING BY USING ACTIVITY THEORY ANALYSIS.
In *Proceedings of WEBIST 2006 - Second International Conference on Web Information Systems and Technologies - Society, e-Business and e-Government / e-Learning*, pages 312-319
DOI: 10.5220/0001252103120319

A few study in using activity theory applied in gaming related work. Activity theory provide a method to analyzing learning processes and outcomes (Lucia Rohrer-Murphy)

Kurt Squire 2002 argued the Game-Playing as Social Practice and activity theory was proposed under the issue-"how can one theoretical framework for socio-cultural contexts" by psychologists. Victor Kaptelinin Michael Cole 2002 adopted activity theory in the research work about educational computer game playing.Pippon Barr 2005 think activity theory may prove a useful analytic approach to the computer playing, and use activity theory to develop a conceptual framework which describes the role of value in computer game.

For this reason, this study based on the advantage of combination online game and instruction, issue of educational online game, using activity theory, consideration events of instruction and learning phrase (gagne) to develop the next generation of educational online game applied in instructional activity of classroom.

2 DEFINITION

Online game: players can interact in the same time.

Educational online game: combining CAI and online game to achieve the goal of instruction.

Loosely mode educational online game: lower learning support or intervene, player has the higher degree of control in the game e.g. previous study (Gwo-Dong Chen, Gee-Yu Shen, 1997). It let student spend more time in learning. So, this model could partial apply in classroom and continue learning in out of school.

Tightly mode educational online game: higher learning support or intervene, player has the lower degree of control in the game e.g. this study. This model designed to apply in instruction of classroom.

Mix mode educational online game: higher learning support or intervene, player has the lower degree of control in the game e.g. this study. This model designed to apply in instruction of classroom under tightly mode and adaptive tuning the mode in out of school.

3 RELATED THEORY AND RESEARCH

3.1 Intrinsic Motivation

The primary reason of embedding learning materials into a multi-user computer game is to promote the learning motivation of the students. Lepper and Malone (1981) investigated what makes a computer game fun. Malone,T.W.&Lepper, M.R.(1987) found that motivation factors can be divided into two groups: intrinsic motivation and extrinsic motivation. The motivation factors of a single user game are mostly related to intrinsic motivation. The intrinsic motivation factors include:

Challenge: a game always provides missions to be accomplished or virtual enemies to fight with. It provides a challenge to the players;

Curiosity: a game always has a fantasy story with graphic animation and sound. The missions provided are like puzzles. A player is always trying to find how to solve and what is in the fantasy scene;

Engagement: a game provides a simulated environment. The players feel like they are the role in the game for they always get response quickly after they take actions. This keeps the players focusing on the game. And, the players feel like they are involved in the missions and environment;

Autonomy: a game provides a simulated

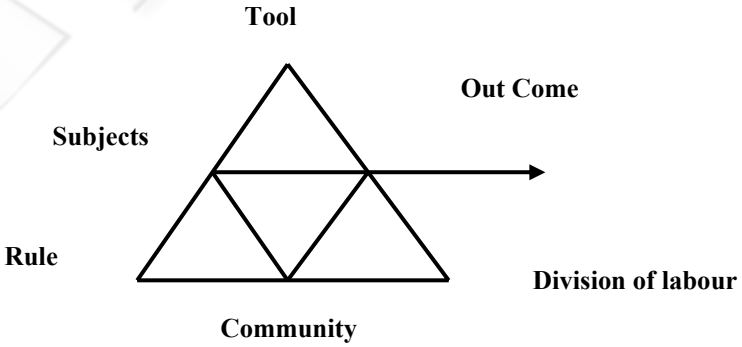

Figure 1: Yrjö Engeström's activity system model.

environment. Also, it provides actions the players can take and control in order to achieve what they expected. They do not have these capabilities in the real world;

And Fantasy: a game can provide graphic animation, music and sound, and actions with response. These make a fantasy feel like real.

When Lepper and Malone (1981) studied computer games, most computer games are only single user games. Therefore, the factors considered in what make computer games fun are related to intrinsic motivation. However, in a multi-user game, extrinsic motivation factors should be included. The extrinsic includes

Competition: players in a multi-user game can see the scores, level of other players. Besides, they can compete or fight with other players;

Collaboration: a multi-user game can arrange missions that are to be accomplished by group of players. It can also provide an environment for players to make friends;

And recognition: if a player got high score or promote to higher level, other players can know from the game. Thus, a multi-user game provides chances for players to be recognized by other people.

3.2 Activity Theory

Activity theory originates from Vygotsky's idea that explicit description of activity (Leont'ev 1978). His student, Leont've, develops hierarchical levels style from Vygotsky's and Yrjö Engeström extended Vygotsky's to the activity theory (figure 1). Lucia Rohrer-Murphy (1999) thinks that activity theory provides a unique lens for analyzing learning processes and outcome and activity theory is an important precursor to good instructional design.(figure 1)

3.3 Learning Stage (Gagne's 1970)

The purpose of instruction is to assist learning process (Robert M. Gagne, Leslie J.Briggs, and Walter W. Wager 1988). The learning processes are included in cognitive learning theory (Anderson, 1985; Estes, 1975; Klatzky 1980). They are Attention, Expectancy, Retrieval of Relevant Information to Working Memory, Selective Perception, Encoding: Entry of Information into Long-Term Storage ,Responding ,Feedback ,and Cueing Retrieval.

3.4 Events of Instruction (Gagne's 1970)

They deduce the event's of instruction from learning processes. They are Gaining attention, Activating motivation: Informing the learner of the objective ,Stimulating recall of prerequisite learning, Presenting stimulus material, Providing learning guidance, Eliciting the performance, Providing feedback ,Assessing the learner's performance, Promoting retention and transfer.

3.5 Machine Learning Technique-Decision tree

Decision tree: Decision Tree (Jiawei Han, Micheline Kamber, 2001; Tom M. Mitchell, 1997) is a tree structure similar to flow char structure. The internal node represent the testing on attribute with condition an branch represent the result of testing. The leaf nodes represent the last result of classification.

A typical example of Decision Tree (figure 2) is that decision tree judge a customer whether buy the car or not. The rectangle is equal to the node and the ellipse is equal to the leaves. To judge one man whether could buy the car or not, we have to get some attributes of the man and use the attributes tested by decision tree. The test is begun from the root of the tree and test along to leaf. The leaf represent the result of predict. For example: some attributes of a man description below:

Table 1: Decision tree could easy transfer to these rules of classifying (age=30, city=no, background=master).

If salary<=20 AND city=no	THEN buys_car=no
If salary<=20 AND city=yes	THEN buys_car=yes
If salary =20…30	THEN buys_car=no
If salary =>30 AND background=master	THEN buys_car=no
If salary =>30 AND background=bachelor	THEN buys_car=yes

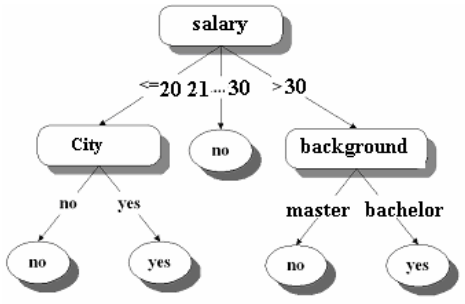

Figure 2: Example of Decision tree.

Now, There are some decision support systems of commercial use Decision tree to predict the market of stock ,evaluate the risk of economic,.. and so on.

3.6 A MUD Game

Many ideas of our multi-user game come from Multi-User Dungeon MUD games. A MUD game is a text base game. In a MUD game, there are (1) levels of players and (2) communication tool such as talk and chat room. Each level in MUD has different privileges. Thus, it forms a players community. Because it is a text base game, it provides users imagination possibilities. However, it is not suitable for elementary school students. We adopt its ideas to form a community of practice.

3.7 Study of Westrom and Shaban

Westrom and Shaban (1992) investigated the effect difference between a game and an instructional game. They showed an instructional game is not so fun as a pure game. In this paper, we investigate the degree of effect for motivation factors proposed by Lepper and Malone. We compare the difference between a pure tutorial course and an instructinal game.

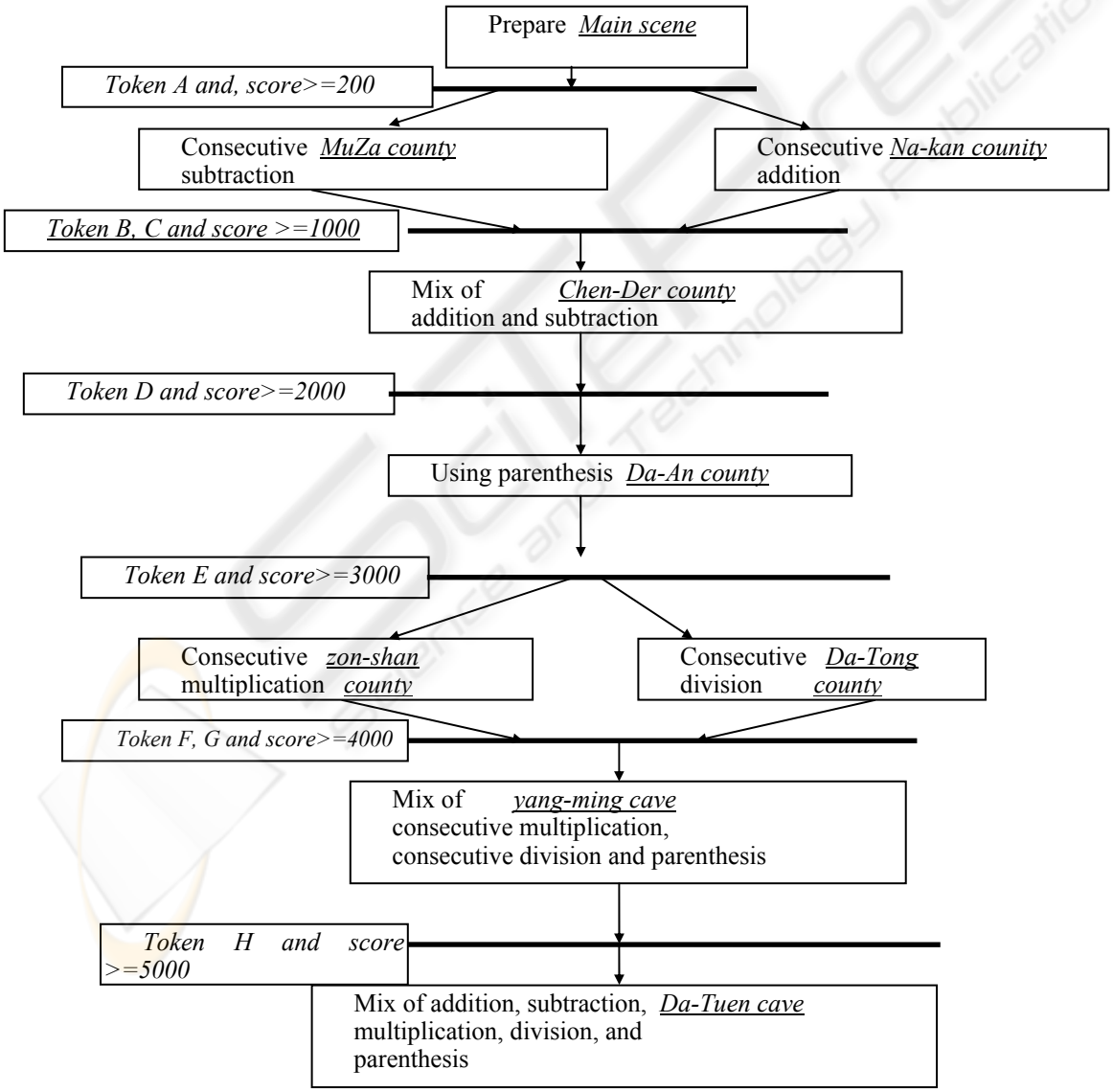

Figure 3: Arranging the game script according to the learning hierarchy.

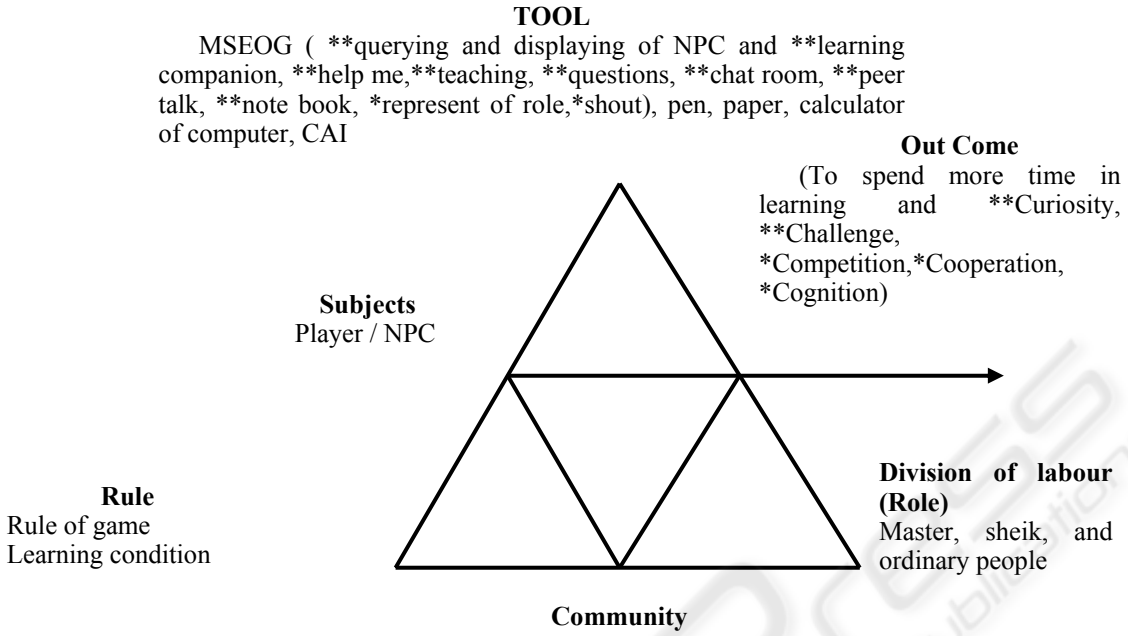

Figure 4: MSEOG based activity theory.

3.8 WebQuest

Web Quest (CoDa96) is a web based instructional game. The students ramble about in the game to find related information to pass a scene. When facing with problems, the students can invoke a web browser to find the answer. The students can design their own game. Experiment shows that the students more like to design a game than to play the game. They did not try to build a community of practice in the game.

4 GAME SCRIPT AND LEARNING MATERIALS

4.1 Selection of the Style of the Game

The first thing of developing a instructional game is to design a game script and put learning materials into the game. Since a learning material always has a learning hierarchy (Gagn68), the game script should follows the learning hierarchy. Therefore, we decide to implement our game as a role playing for the following reasons.

First, role playing games are the most popular games in Taiwan and this style of games allows player to explore and think. A player is required to figure out the structure of the game and learn the strategies to overcome the problems in order to accomplish the missions given in the game script and to get score.

Second, a role playing game always has a hierarchical script structure. Thus, it is easy to design the game script according to the learning hierarchy. When the learners try to accomplish the script's mission, they will learn and practice the learning material according to the learning hierarchy.

Third, a multi-user role playing game can forms an environment to serve as a community of practice. We can design different roles in the game. Each role has different privileges. A role can invoke an action only if it has the privilege to take the action. Thus, the game scenery forms a community of practice if every role is using the learning topics to solve problems in order tp accomplish missions. However, there should be missions assigned for roles to cooperate or collaborate.

4.2 Arranging the Game Script According To the Learning Hierarchy

Gagne (Gagn68) proposed that a learning material can be decomposed into elements and learning should follow a procedure from simple to complex. Thus, learning material should organized as a learning hierarchy with a learning flow embedded in it. This structure can be perfectly fit into a role

playing game script. Figure-1 is a learning hierarchy for arithmetic skills. Each box represents a subskill. The arrow line represent the legal learning flow. The bar line represents a and join. A student should learn all the subskills connected to the bar line.(figure 3)

We can design a hierarchy of script scenery based on the learning hierarchy as shown in Figure-1. The text in *italic* form are of the game script. Each learning element or box is a scene or an act. In the scene, the background is a place in Taipei city with roles in it which give hints, asking question, and lecturing through page in world wide web. The player is trying to get scores and the token by studying courseware or practicing exercises.

Players should get enough score or token in order to get into another act or scene. The condition of passing is stored in the bar line in the above figure. The players are free to go to any scene if they hold enough tokens and scores. Since the game script is designed based on the learning hierarchy and flows, the players will learn and practice accordingly.

5 ACTIVITY THEORY ANALYSIS-ONLY CAI AND MSEOG WITH CAI IN INSTRUCTION OF CLASSROOM

We used the factor of motivation of learning and server log to serve as evidences to analyze activity of MSEOG in previous study. We found some questions of questionnaire related to the factors and decided some tools involved in the activity from the cue in the questions. We choose the most high score one of questions. They are listed below then tools and rules decided by the cue of question:

Curiosity: I want to know another player when I played the MSEOG. From this question, **querying and displaying of the NPC and learning companion** were the tools to do that.

Challenge: I continue to play next stage of game when I passed the condition of learning. From this question, question in the game is the tool. The challenge comes from two ways. One is the NPC and the other is learning companion. A player need help when answers the question. He could use "**help me**" function by clicking animation of learning companion. The challenge is to teach. In order to teach, we provide **discussion** and **synchronize action** function to reach "**let me do it show you**". Discussion function includes **peer talk**, **chat room**. A player could challenge another play via "**challenge you**" function with **notebook** to choice question when another higher degree role player use the "shout" function to show this position in the learning community designed by considering the Cognition of motivation (ML87).

Competition: I feel very happy when I passed the condition of learning. From this question, **condition of learning** is the rule.

Cooperation: I want to discuss with classmates after playing game and discuss seriously for answering question in the future to reach the condition of learning to go next stage of game. From this question, **language**, **paper** and **pen** are the tools.

Cognition: I feel exciting when I got the higher degree of role. From this question, the role representation and **"shout"** function are the tools.

To support the decision, we analyze the server log. We found the coincidence between curiosity to comparison for self and another and challenge to question answering by T-test significant degree and percent order.

In the server log, the communication by text supported the peer talk and chat room tool using and teach mode support the synchronize action.

The purpose of the previous study is focus on motivation supported by game, so the CAI presentation served as the same environment. But there is a problem generated from previous study about CAI presentation, e.g. how to identify the meaningful learning of frequency of CAI presenting.

Play Action	Count	Percent (%)
Communication by Text	558	14.114
Teach mode	61	1.546
Ask question to another	100	2.535
Choice style question answer	1037	26.242
Comparison for self & another	1401	35.451
CAI presentation	36	0.917
Virtual people hint	759	19.213

6 GUIDLINE OF APPLING EDUCATION ONLINE GAME IN CLASSROOM

By result, there are some guidelines to apply education online game in classroom in first stage by considering learner feeling.

1. “Learning condition” is the most important rule of game. It mediates the subjects in the community to use tool to let mathematic learning transform to outcome-Competition increasing.

2. “Querying and displaying of NPC and learning companion” are the most important tools to let subjects to transform mathematic learning to outcome-curiosity enhancing.

3. “Learning companion, help me, teaching, questions, chat room, peer talk, note book” are the same as important tools to let subjects to transform mathematic learning to outcome- Challenge.

4. “Represent of role, shout”- are the second important tools to let subjects to transform mathematic learning to outcome- Challenge enhancing.

5.”shout” is the same as the second important tool to let subjects to transform mathematic learning to outcome- Cognition enhancing.

6. Above 5 points based on students’ feeling about intra-game situation, we also found student paper, pen, and calculator in PC to assist the solving question by using observation based on extra-game situation.

7 POTENTIAL RULES GENERATION BY MACHINE LEARNING TECHNIQUE

There are two kinds about generating potential:

1. one activity :Using learning action of Server log to predict motivation/achievement, for example: (simulation data)

```
34 question answering > 72:
:  11 CAI > 47:
:  :...14 peer to talk <= 26: 49 (7/5)
:      14 peer to talk > 26:
:      :...29 challenge you <= 28:
:          :...10 teach mode <= 36:
:          :  :...35 notebook <= 60: 78 (3/1)
:          :  :  35 notebook > 60: 40 (2)
:          :  10 teach mode > 36:
:          :  :...4 decide to PK <= 65: 67 (2)
:          :      4 decide to PK > 65: 62 (2)
:          29 challenge you > 28:
:          :...18 roam(thinking or idle) <= 33: 92 (4/2)
:              18 roam(thinking or idle) > 33:
34 question answering <= 72:
:...5help me > 58:
   :...25shout <= 24:
   :  :...15 express emotion <= 38:
   :  :  :...15 peer to talk <= 16: 89 (3/1)
   :  :  :  15 peer to talk > 16: 44 (2/1)
   :  :  15xpress emotion > 38:
   :  :  :...6 notebook <= 52: 24 (3/2)
   :  :      6 notebook > 52: 11 (3/2)
   :  25shout > 24:
   :  :...9 peer to talk > 63:
   :      :...21 express emotion <= 45:
   :      :  :...34 let me do it show you <= 46: 63 (3/1)
```

From this perspective, we found a problem in using server. The frequency of learning action was not explained the learning meaning related to achievement. For explain: peep to talk so many times why achievement is higher? So, we have to so some strategy to prove the learning action meaning quality in learning.

2. between two activities: Using factors of motivations to predict achievement.

8 RESEARCH LIMITATION

There are two limitations in previous research.

First, because it is difficulty of measuring motivation, using the same questionnaire in only CAI and online game with CAI is the limitation. Second, chidden whether the ability of expression the motivation has or not. Finally, it is difficulty to find the relation between with intrinsic motivation and learning achievement in first stage of education online game learning.

9 CONCLUSTION

This study based on previous study to analyze the Multi-user educational online game applying in instruction of classroom. the motivation as a outcome, we backward to find the cues in the questions of questionnaire. Then, we also analyze the server log. There are some decision about activity theory: learning condition is a potential rule. MSEOG (querying and displaying of NPC and learning companion, questions, chat room, peer talk, note book, represent of role), pen, paper, calculator of computer, CAI are tools.

In order to reduce the obstacle of MSEOG applying in instructional activity in classroom, first, we adopt the factors of motivation as outcome and decided the tools and rule by found the cue in the questionnaires and server log. Second, we consider events of instruction and learning phrases (Gagne) and using Machine Learning Technique to get the

potential rule (activity theory). From these, we want to develop a methodology to get stability of guiding online game applying in instruction of classroom. There are six guide found in the first stage describing before.

Finally, there are two advantages of constructing the education online game community practice. One is the teacher has opportunity to conduct the social learning in the gaming environment so as to avoid the frustration or incorrect action in social interaction. Other is the environment will extend the learning in classroom to out of school and to facilitate student continue learning about knowledge in classroom.

REFERENCES

Amory, A., Naicker, K., Vincent, J. & Claudia, A. (1998). Computer Games as a Learning Resource. *Proceedings of ED-MEDIA, ED-TELECOM 98*, World Conference on Education Multimedia and Educational Telecommunications, Vol. 1, pp. 50-55.

Alexander E. Voiskounsky, Olga V. Mitina, Anastasiya A. Avetisova Playing Online Games: Flow Experience PsychNology Journal, 2004 Volume 2, Number 3, 259 - 281

Chan, T. S., & Ahern, T. C. (1999). Targeting Motivation - Adapting Flow Theory toInstructional Design. *Journal of Educational Computing Research, 21*(2), 151-163.

Gwo-Dong Chen, Gee Yu Shen, Yuan-Jen Tai & Alf Lai (1997) A Multi-User Situated Learning Games on Internet ICCE.

Gagné, R., Briggs, L., & Wager, W. W. (1988). Principles of instructional design (3rd ed.). New York, NY: Holt, Rinehart and Winston, Inc.

Jiawei Han, Micheline Kamber, *Data Mining : Concepts and Techniques*, MORGAN KAUFMANN PUBLISHERS , 2001

Kirriemuir, JK, McFarlane, A, (2003) *Use of Computer and Video Games in the Classroom*. Proceedings of the Level Up Digital Games Research Conference, Universiteit Utrecht, Netherlands. Available from: http://www.silversprite.com/

LEONT'EV, A. N. Activity, Consciousness, and Personality. Prentice Hall, 1978. Available online at http://www.marxists.org/archive/leontev/works/1978/.

Lucia Rohere-Murphy (1999) Activity theory LAWRENCE ERLBAUM ASSOCIATES, Publishers Mahwah, New Jersey p.159

Maria M. Klawe: Computer Games, Education and Interfaces: The E-GEMS Project. Graphics Interface 1999: 36-39

Malone,T.W.&Lepper, M.R.(1987) "Making Learning Fun: A Taxonomy of Intrinsic Motivations for Learning," In R.Snow and M.Farr (Eds.), Aptitude, learning, and instruction , vol.3 , Cognitive and affective process analysis, Hillsdale, NJ: Lawrence Erlbaum Assoc., 1987, ch.10, pp.225-254

Malone, T.W. & Lepper, M.R. (1987)."What makes computer games fun," Byte,6(12),258-277.

Pippin Barr 2005 Play and Work:Investigating the Role of Value in Human-Computer Interaction A proposal submitted to the Victoria University of Wellington

RM Gagne70 The conditions of learning, New York, Holt, Rinehart and Winston

Squire, K. (2002). Cultural framing of computer/video games. The International Journal of Computer Game Research, 2(1), Game Studies Available online:http://www.gamestudies.org/0102/squire/ Retrieved 12-24-02

Rieber, L.P. (1996). Seriously considering play: Designing interactive learningenvironments based on the blending of microworlds, simulations, and games. *Educational Technology, Research and Development, 44*, 43-58.

Westrom M. and Shaban A. (1992) "Intrinsic Motivation in Microcomputer Games"Journal of Research on Computing in Education, vol.24, no.3 Summer 1992, pp.433-445.

Quinn, C.N. (1994). Designing educational computer games. In K. Beattie, C.McNaught, & S. Wills, (Eds.) *Interactive multimedia in university education:Designing for change in teaching and learning*, pp. 45-57, Amsterdam:Elsevier.