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Exploring Interactive Patterns among Students in Competitive Games by a Mixed Approach

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Abstract: Recently, many researchers are interested in the game-based learning environment. However, few empirical studies investigated the issues of surrounding influence between real classroom context and virtual environment context. Hence, this study examines the interactions among students in the situation of competitive games. We implemented a game-based learning environment, entitled My-Pet-My-Quest, and a study was conducted in an elementary after-school club for 29 students over a four-month period. This study employed a mixed approach for data collection and analysis that contains collecting system records data, observation comments, and questionnaires, as well as adopting social network analysis and regression analyses. The results showed that 1) the students' self-reported friendship states predict the extent to which they interact with their friend in on-line environment; 2) the interactive patterns of schoolboy and schoolgirl differ regarding their genders in game-based learning environment; and 3) an elementary school student in the competitive game not only competed with others, but also enhanced the social interaction and emotional communication. Some suggestions about the results were also discussed. Firstly, researchers could use mixed methods to explore the patterns of interaction on game-based learning environments; secondly, researchers could adopt social network analysis for the design of game-based learning environments; finally, researchers could comprehend the interactive patterns of real classrooms and virtual competitive games.

Keywords: game-based learning environment; competitive game; social network analysis

1. Introduction

Many researchers are interested in the studies relevant to game-based learning environments in recent years, for example, River City [10] for science inquiry learning, exploring embedded guidance and self-efficacy in educational multi-user virtual environments, and Whyville.net [6] for online learning, focusing on a connective ethnography of peer knowledge sharing and diffusion in a tween virtual world. The above-mentioned studies mainly focused on the discussion of happenings in virtual learning environment. In contrast, few empirical studies explored some of the issues surrounding influence between real classroom context and virtual environment context.

Hence, the study explores the interactions among students in situation of virtual competitive games with real classrooms. The study implemented a My-Pet-My-Quest [3, 2] for math learning in an elementary after-school club during the 120-day period. The study would be discussed a part of the entire implementation; we focus on reporting the findings of **"interactive patterns of students"** on competitive games.

2. Method

2.1 Participants and Context

The participants were 29 third-grade students (14 schoolboys and 15 schoolgirls) from an elementary school in Taiwan. Each participant had a small portable laptop computer with wireless capability as “small notebook”. Each participant used the notebook to practice the math problems about basic computation in a game-based learning environment.

2.2 Game-based Learning Environment

Previous study developed the game-based learning environment on arithmetic practice, entitled My-Pet-My-Quest (MPMQ) [3, 2]. The MPMQ is a web-based system, a pet-keeping environment where the virtual characters represent learners’ open learner models [1], supporting the learning tasks, seeing figure 1. Additionally, the MPMQ contains many pet-keeping tasks and learning tasks, while students would play the role of pet-keeper who can interact with virtual pets and solve a series of small quests that sustain students’ motivation and engage them in a game-based learning environment.

Figure 1. Snapshot of the My-Pet-My-Quest environment.

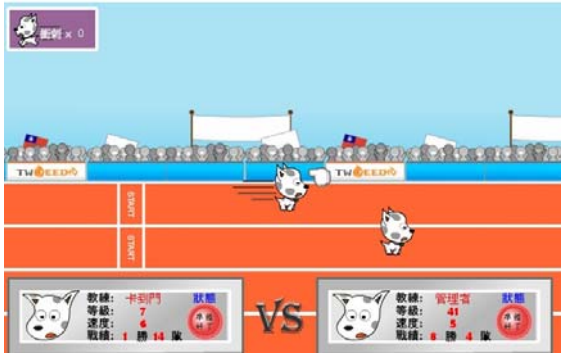


Figure 2. Snapshot of the competitive game.

Students will also play the role of coach who can interact with My-Pet that sustains his/her motivation and engages him/her in learning tasks and competition activities [9]. The coach needs to train My-Pet and to complete the learning task in Quest Island, and the coach has to control the pet to compete against other coach in a competitive game, seeing figure 2. Students can free select the competitor’ pet in each competitive game according to the identification of competitor’ pet in MPMQ. Students could decide to compete with who have relationship of friendship or according to present identification. In other words, the students can find their competitor by themselves while the students also need to learn to pick good strategies for negotiating with other classmates.

2.3 Procedure

The study utilized a ‘‘game-based learning’’ activity in an elementary after-school club. The process was divided into two phases. First phase: the period of after-school club was from 9/01 to 12/31 in 2009, and students could nurture one virtual pet, practice the math problems about math basic computation, and compete with other pets in the MPMQ environment. In each day, the students used the small notebook for approximately thirty or forty-minute sessions. During the period, graduate students were as teacher assistants to observe the

students' usage and feedbacks. Second phase: when the students finished the term activities, the questionnaire with relationship was carried out.

2.4 Data Collection and Analysis

This study employed a mixed approach for data collection and analysis. [4] proposed a suggestion that "the quantitative data and results provide a general picture of the research problem; more analysis, specifically through qualitative data collection, is needed to refine, extend, or explain the general picture" [4, p.515]. Data mainly came from students' behaviors recorded in a game-based learning environment, and the relationship among students about real classroom and the questionnaire of competitive game impression collected in end of semester. There were two types data collected. In addition, students' behaviors generated from daily solving a variety of learning task and competitive game activities, each student was also observed to keep the observation comments [11].

Regarding data analysis, first, for the quantitative data, a descriptive analysis and a social network analysis (SNA [5]) were applied to explore students' online behaviors and patterns of social dynamics between friendship in real classrooms and interaction in virtual competitive games. Then, a regression analysis was followed to look specifically into students' relation between a real context and a virtual context. Finally, in order to further explore whether and how students actually deepen their impression of the competitive games, analysis of quantitative data and qualitative data were employed in the study to achieve triangulation verification.

3. Findings

The following four subsections described both quantitative and qualitative results. Firstly, we started with the statistical distribution of students' participations in a virtual competitive game. Secondly, we reported the basis for interpretation of the SNA graphical representation. Thirdly, we further examined and predicted the relationship between the friendship in a real classroom and interaction in a virtual competitive game. Finally, we reported the investigation of a questionnaire about students' opinion and competitive game impression.

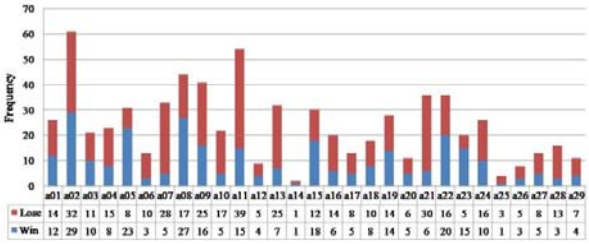
3.1 Distribution of Students' Participations in Virtual Competitive Game

Table 1 shows the period of on-line game-based learning activities, and 702 times competition game was generated among 14 schoolboys (453 times) and 15 schoolgirls (249 times). On average, each student participated 24.21 times and the standard deviation was 14.28; each schoolboy participated 28.31 times and the standard deviation was 16.14; each schoolgirl participated 19.15 times and the standard deviation was 10.01.

As we can see in table 1, schoolboys participated more times in general than schoolgirls. There were four schoolboys (#a02, #a11, #a08, and #a09) and two schoolgirls (#a21 and #a22) who were very active and engaged more than 35 times in game-based learning environment. From this distribution, we noticed that two schoolboys (#a12 and #a14) and two schoolgirls (#a25 and #a26) participated fewer times.

In order to explore how these interactions intertwined among students, we need further examination with SNA to uncover the interactive structure of the students as a competitive game.

Table 1. Distribution of Students' Participation in Virtual Competitive Game.



3.2 The Dynamics of Relationship among Students between Real classroom and Virtual Competitive Game

This initial analysis in table I was very helpful in interpreting the results of SNA in Figures 3 and 4. In Figure 3, the graph shows the entire social network of 29 students on the competitive game. Up triangle with blue represents schoolboy while circle with red represents schoolgirl. Black lines between students indicate that they jointly participated to the same competitive game. Red lines represent that they not only jointly participated to the same competitive game but also its own friendship in real classroom. There were strong ties of interaction between the different nodes indicate roughly which students were more closely linked to others.

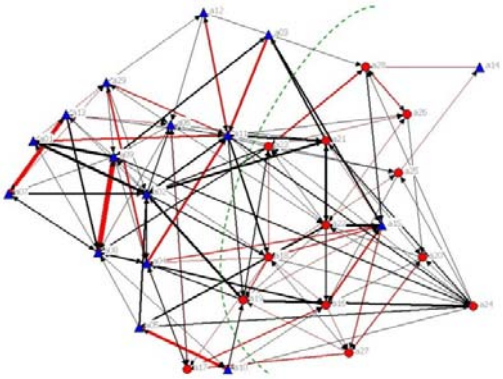


Figure 3. Graphical representation of students' interaction patterns with firendship on virtual competitive game.

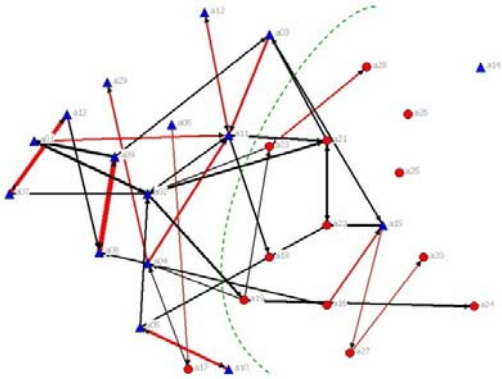


Figure 4. Reduced graphical representation of students' interaction patterns with firendship on virtual competitive game.

From this figure 3 we found two points. Firstly, two subgroups in terms of the roles: one cluster at the left part of the graph is composed mainly of schoolboys, with the exception of one schoolgirl, a17; and the other at the right part is composed mostly of schoolgirls, with the two schoolboys, a14 and a15, appearing about the periphery and one at the center (a15) surrounded by all the schoolgirls. Secondly, mostly of black links based on red links mean that competitive game possible enhanced interpersonal relationship in game-based learning environment. It's very interesting to explore further what happened in this social network.

The graph in figure 4 is identical to figure 3 but shows only co-participation competitive games greater than 5. By comparing all interactions in figure 3 with the strong co- participation in figure 4, we can more easily find better which stronger interactions exist. In this reduced graph, the two subgroups introduced earlier become clearer, seeing figure 4. The smaller one consists mainly of mostly schoolgirls and one schoolboy, while the other bigger one consists of mostly schoolboys.

The insights provided by this reduced graph imply two things. Firstly, the mostly students in the two subgroups either schoolboy play together, or schoolgirl play together. Secondly, the members that bridge two subgroups of social networks are a04, a11, and a15 for the schoolboys and a17, a18, a19, and a21 for the schoolgirls. The SNA shows that their interests cross the boundary between the same genders. Altogether, it is clear that times of co-participation are generated in a mixed fashion by both schoolboys and schoolgirls. This competitive game has successfully interwoven and enhances students into communal relationships of co-participation.

In order to analyze how these interactions of gender among students, we adapt further examined with regression analyses to understand the interactive structure between real context and virtual context.

3.3 The Interactive Structure of Gender among Students

The entities, means, and standard deviations of each variable are presented in table 2. According to the research questions, we investigated whether students' friendship would predict co-participation on competitive game. To examine this, we first carried out a regression analysis in which students' co-participation in virtual competitive game was predicted by students' friendship in real classroom. The results are presented in table 3. The R squares (R^2) for each equation was also calculated and is given in table 3.

Table 2. Descriptive Statistics of Competitive Game.

Competitive Game	E	M	SD
Boy-Boy	196	1.69	4.53
Girl-Girl	225	.85	2.14
Boy-Girl	210	.40	1.71
Girl-Boy	210	.42	1.74
Total	841	0.83	2.78

Schoolboy (n = 14), Schoolgirl (n= 15)

The results showed that students' friendship emerged as a significant predictor (R^2 = .17, $F_{(1, 839)}$ = 174.72, P < .001) of co-participation on competitive game. An analogous analysis was carried out for students' friendship among genders, seeing table 3. These results showed that the friendship about boy-boy (R^2 = .42, $F_{(1, 194)}$ = 140.14, P < .001), girl-girl (R^2 = .11, $F_{(1, 223)}$ = 26.78, P < .001), and boy-girl (R^2 = .05, $F_{(1, 208)}$ = 11.22, P < .001) predicted students' co-participation on the competitive game. There was not significant about the relation of Girl-Boy (R^2 = .00, $F_{(1, 208)}$ = 0.92, P > .001).

3.4 The Opinion and Competitive Game Impression

Table 4 presents the statistical results of the 5-scaled questionnaire regarding student opinions. Opinions of "strongly agreed" and "agreed" are regarded as positive responses. The questionnaire indicated 29 (100%) students had the experience on playing computer games. In terms of students' interest and motivation, 28 (96.55%) students showed that MPMQ raised their attraction to the learning subjects, and 21 (72.41%) students expressed that My-Pet-My-Quest enhanced their willingness to practice in learning activities. For the relationships among classmates, 26 (89.66%) students indicated that they like constant compete with others.

Table 3. Regression Analyses for Friendship and Virtual Competitive Game (N = 29).

	r	B	SE	β	T
Boy-Boy	.65**	10.13	.86	.65	11.84
Girl-Girl	.33**	1.93	.37	.33	5.18
Boy-Girl	.23**	5.62	1.68	.23	3.35
Girl-Boy	.07	.84	.88	.07	.96
Total	.42**	4.55	.34	.42	13.22

Students' interviews were conducted to collect further detailed information about students' affective experience. Most students like to play the pet-racing game while different students have different reasons, such as, to become a winner (e.g., "*I like to go dog racing, because I can beat someone's dog*", #a02), to obtain reward (e. g., *"I like to play with others , because I can get gold medal"*, #a16), to know who is winner (e. g., *"I want to know who get first prize or second prize"*, #a11), and to be exciting or for fun (e. g., *"I feel game is very fun"*, #a8). Few students don't like to play the pet-racing game because they are afraid to become a loser (e. g., *"I do not like I very much, because I will lose it"*, #a23) and the fear of being laughed at (e. g., *"Because my dog run very slowly, I am afraid of being laughed"*, #a14).

Table 4. Questionnaire and statistics regarding student opinions

Item	# of S.A.	# of A.	# of N.	# of D.	# of S.D.	Avg. score
Do you have played computer games?	**29** (100%)	0	0	0	0	5
Do you like to learn math with game-based learning environment?	**13** (44.83%)	**8** (27.59%)	5	2	1	4.03
Am I more willingness to learn math with game-based learning environment?	**17** (58.62%)	**11** (37.93%)	0	1	0	4.55
Do you like to compete with others in game-based learning environment?	**15** (51.72%)	**11** (37.93%)	0	2	1	4.28

(Strongly agreed=5, Agreed=4, Neutral=3, Disagreed=2, Strongly disagreed=1)

4. Discussions & Conclusion

This is the first study of a game-based learning environment to incorporate students' behavior data with real classroom and virtual competitive game. The study focus on reporting the findings of interactive patterns of students in competitive game by using mixed approach that applied the system records data, observation comments, and questionnaires, and adopted social network analysis and regression analyses. First, the findings indicated that the students' self-reported friendship states would predict the extent to which they interact with their friend in on-line environment. Second, the findings indicated that the interactive patterns of schoolboy and schoolgirl differ regarding their genders in game-based learning environment. Final, the findings indicated the competitive game for an elementary school student not only mans that to compete with others, but also enhance the social interaction and emotional communication. Next, we discuss the academic and practical development of game-based learning, such as *methodology, research and design, and interactive environment.*

4.1 Using Mixed Methods to Explore the Patterns of Interaction on Game-based Learning Environments

In the research field of computer-supported collaborative learning (CSCL), many studies attempted to develop the mixed methods that explored the co-constructive knowledge of

interaction in on-line discussion forums or learning communities [5], because the SNA could process interaction data to present different data representations and to unpack different types of interactions. The SNA allows the relationships between different participants to be illustrated in order to develop new insights or visualizations.

Hence, this study followed the above ideas and adopted mixed methods to investigate the interactive patterns. By the mixed methods of social network analysis with others, it is possible for us to understand deeply the interactions and behaviors among students in a game-based learning environment with a real classroom. In the future, the diversification and plenty of game-based learning environments for learning activity possibly emerged from technology enhanced learning (TEL) or computer assisted learning (CAL) fields, and so on. Therefore, there are enormous potential opportunities how this method could be integrated with existing game-based learning systems while this kind of method also could enhance students' social interaction in game-based learning environments.

4.2 The Design of Game-based Learning Environments

Competition might provide the dimensions of fame, fortune, and power while it makes a great impact on students. This study considered these influences and designs three strategies on game-based learning environment. For reputation strategy, when students' pets won the competitive game, the learning environment gave the title of differ levels for students; for interest strategy, when students solved a series of learning tasks, the learning environment gave the reward (e.g., coins) for students. Students could use coins to buy food for feeding pets, and to buy the racing ticket for competition; for authority strategy, when student completed three learning tasks, the learning environment gave the racing ticket to students and then the students could join in a competitive game.

The findings indicated that the most students had positive affections about competitive games with learning. Previous studies have shown that schoolgirls were more affected by the social comparison than schoolboys in the relationship between learning goal and students' academic task values [12]. The results verified that schoolboys participated more actively than schoolgirls in terms of comparing with others not only in real classrooms [12], but also in virtual environments [7, 8]. Hence, we should develop a wider range of forms in game-based learning for students, even for schoolgirls.

4.3 The Interaction Patterns of Real Classrooms and Virtual Competitive Games

The findings indicated that the students' friendship emerged as a significant predictor of co-participation on competitive games. The results of regression analysis predicated students' co-participation among genders on competitive game except the correlation of Girl-Boy. Therefore, it would reflect that on-line social interaction is based on relationship of real classroom. The students' interaction relationship with others in a virtual environment was closer to a real classroom.

Additionally, we also found that students stayed with the same genders in on-line competitive game less than in real classroom. In situation of a competitive game emerge more students crossing two subgroups of social networks. In other words, competitive game will provide more interactive opportunities and channels among genders, because the students, no matter boys or girls, need to negotiate and communicate with others. The game-based learning environment should be encouraged to develop interactive elements that will play a leading role in the future.

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References

[1] Bull, S., & Kay, J. (2007). Student Models that Invite the Learner In: The SMILI:() Open Learner Modelling Framework. *International Journal of Artificial Intelligence in Education*, 17(2), 89-120.

[2] Chen, Z. H., Liao, C. C. Y., & Chan, T. W. (2010). Quest Island: Developing Quest-Driven Learning Model by Blending Learning Tasks with Game Quests in a Virtual World. *The 3rd IEEE International Conference on Digital Game and Intelligent Toy Enhanced Learning* (pp.93-100), Kaohsiung, Taiwan.

[3] Chen, Z. H., Tseng, Y. F., Liao, C. C. Y., Wang, J. H., & Chan, T. W. (2009). My-Pet-My-Quest: Utilizing Game Quests to Scaffold Students' Goal Setting for Learning. In S. C. Kong, H. Ogata, H. C. Arnseth, C. K. K. Chan, T. Hirashima, F. Klett, et al. (Eds.), *Proceedings of The 17th International Conference on Computers in Education* (pp.733-737). Hong Kong: Asia-Pacific Society for Computers in Education.

[4] Creswell, J. W. (2005). *Educational research: planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson.

[5] de Laat, M., Lally, V., Lipponen, L., & Simons, R. (2007). Investigating patterns of interaction in networked learning and computer-supported collaborative learning: A role for Social Network Analysis. *International Journal of Computer-Supported Collaborative Learning*, *2*(1), 87-103. doi: 10.1007/s11412-007-9006-4

[6] Fields, D., & Kafai, Y. (2009). A connective ethnography of peer knowledge sharing and diffusion in a tween virtual world. *International Journal of Computer-Supported Collaborative Learning*, *4*(1), 47-68.

[7] Kafai, Y. (1999). Video game designs by girls and boys: Variability and consistency of gender differences. In M. Kinder (Ed.), *Kids' media culture* (pp. 293–315). Durham, NC: Duke University Press.

[8] Ke, F. (2008). Alternative goal structures for computer game-based learning. *International Journal of Computer-Supported Collaborative Learning*, *3*(4), 429-445. doi: 10.1007/s11412-008-9048-2

[9] Liao, C. C. Y., Chen, Z. H., & Chan, T. W. (2009). Designing the game-based environment to facilitate learners' interaction in performance-based learning by virtual pets. In *Proceedings of the 9th international conference on Computer supported collaborative learning - Volume 1* (pp. 429-433). Rhodes, Greece: International Society of the Learning Sciences.

[10] Nelson, B., & Ketelhut, D. (2008). Exploring embedded guidance and self-efficacy in educational multi-user virtual environments. *International Journal of Computer-Supported Collaborative Learning*, *3*(4), 413-427.

[11] Taylor, S. J., & Bogdan, R. (1998). "Participant Observation：In the Field." in *Introduction to qualitative research methods*. pp. 44-86. New York, NY: John Wiley & Sons, Inc.

[12] Townsend, M., & Hicks, L. (1995). Classroom goal structures, social satisfaction and the perceived value of academic tasks. Paper presented at the Annual Meeting and Exhibit of the American Educational Research Association, San Francisco, CA.