T. Hirashima et al. (Eds.) (2011). Proceedings of the 19th International Conference on Computers in Education. Chiang Mai, Thailand: Asia-Pacific Society for Computers in Education

The Long-term Influence of Game-based Network Homework on Cognitive Effectiveness and Affective Experience in Math Learning

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Abstract: Homework has been considered an effective strategy in order to help students. However, previous studies indicated many contradictions for this because the effectiveness of homework should be discussed with teachers, parents and students. Hence, this study developed and applied a game-based network homework platform, entitled My-Pet-My-Quest (MPMQ), to explore its potential and to sustain learning in terms of cognitive effectiveness and affective experience. This math game-based network homework was conducted in an elementary after-school club and at home for 29 students over a period of one year. The findings indicated that students can continuously participate in math tasks and maintain the proficiency and fluency of tasks in MPMQ across home and school time. The findings also proved the MPMQ for mostly students can attain self-efficacy.

Keywords: Game-based learning, homework, network homework, sustainable learning

1. Introduction

Generally speaking, most teachers believe that homework can improve students' learning achievement, as well as parents also believe that students completed homework as accomplishing learning activities. However, relevant academic literature did not confirm these statements, because many educational studies indicated that have many conflicts and contradictions about the helpfulness of homework for students [3]. Moreover, previous studies indicated the effectiveness of homework should be considered with teachers, parents and students. In particular, do teachers assign appropriate homework [3]; do parents care about children' homework [9]; do students pay attention to their homework [4]? New technologies can open up new possibilities in learning. Many studies attempt to adopt learning technologies in order to change the contemporary school education [1]. For examples, Kerawalla and his colleagues [5] explored the potential values of network homework for students. Following this idea, the study adopted the My-Pet-My-Quest [2]. This study focuses on the research question: *how are the influences of game-based network homework on students' math learning in terms of* ***cognitive effectiveness*** *(learning portfolio of all students) and* ***affective experience*** *(self-efficacy).* To answer the question, a long-term, approximately one year, experiment was conducted in an elementary school in Taiwan.

2. Methods

2.1 Participants and Settings

The participants were 29 nine-year-old third-grade students (14 males and 15 females) from an elementary school in Taiwan. Each participant had a computing device with wireless capability, i.e. "netbook". Each participant used the netbook to practice math problems about basic computation in a game-based learning environment. Each participant can access Internet whether at school or home; each participant also can bring the netbook back home and school.

2.2 Game-based Network Homework Platform: My-Pet-My-Quest

Previous studies have developed a game-based learning environment for math learning, entitled My-Pet-My-Quest (MPMQ) [2, 7]. MPMQ, targeting elementary students as primary users, is developed according to a three-tier framework. The three-tier framework included learning activities, coupling mechanism, and game world. The top tier embeds learning activities in different subject matters (e.g., math) into the game world. The middle tier provides students with a goal-oriented mechanism for guiding them to undertake learning tasks, increasing time on-task. The bottom tier stimulates and sustains students' participation motivation in learning activities through a virtual game world [2]. MPMQ contains many pet-keeping tasks and learning tasks. More specifically, students play the role of pet-keepers 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. The learning tasks in MPMQ are implemented according to the criteria of the national curriculum for third-grade elementary school mathematics, such as calculation fluency and conceptual understanding.

2.3 Procedure

The experiment using math game-based network homework of the MPMQ environment was conducted in an elementary after-school club and at home over a period of one year. The experiment was divided into three phases: a *summer school* phase, a *after-school club or students' home* phase, and a *students' home* phase. The summer school phase is to make the participants familiar with using their small netbooks and manipulating the game-based learning application, the instruction session was conducted each day forty-minutes during a 5-day period. In the first semester phase, we utilized a ''math game-based network homework'' activity in an elementary after-school club. During a 122-day period of after-school club from September to December in 2009, students could nurture the virtual pet and practice the math problems about basic computation in MPMQ environment. In each day, the students used the netbook for approximately thirty or forty-minute sessions for four months. When the students finished the first semester experiment, we conducted the Math Self-Efficacy Scale. In the second semester phase, we also utilized the math game-based network homework in students' home during February and May in 2010. Students assigned to finish their network homework. When the students finished the second semester experiment, we also conducted the Math Self-Efficacy Scale.

2.4 Measures

2.4.1 Cognitive Effectiveness

In order to examine the cognitive effectiveness of students, the examination of cognitive aspect was composed of learning portfolio. The MPMQ environment automatically recorded the participants' time-on-task (the learning time), attempt frequencies (the number

of math questions they had tried to solve), and correctness frequencies (the number of the questions they had solved correctly).

2.4.2 Affective Experience

In order to investigate the affective experience of students, the investigation of affective aspect was composed of self-efficacy. Self-Efficacy was measured by the sources of self-efficacy scale [10], is a collection of many related and published scales (e.g. [8]) and is most researchers have used adapted versions of Mathematics Self-Efficacy Scale developed by [6]. The Math Self-Efficacy Scale used for this study had 40 items modified from Usher and Pajares's original 30 items, with five items for each component of mastery experiences (ME), vicarious experience-peers (VEP), vicarious experience-adults (VEA), social persuasions (SP), and physiological state (PS) respectively. Students were asked to their self-efficacy on a Likert-type item with five anchors (1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree, 5 = strongly agree). The potential total score range was from 40 to 200. Sample items were, "I got a high grade in last year's math class." (ME); "I had a close friend(s) whom I respected for math achievement." (VEP); "My favorite teachers are usually math teachers." (VEA); "My teacher often encouraged me by praising my math ability." (SP), and "I often felt blue when I thought of math." (PS).

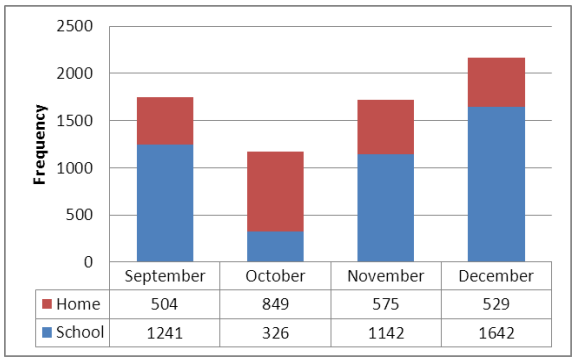
3. Findings and Discussions

3.1 Cognitive Effectiveness

3.1.1 Learning Portfolio of All Students in 1st Semester

Table 1 showed that all students' participation was stable and increased gradually between September and December (approximately has 1500 to 2000 frequencies), except October. Because school has the three cases of H1N1 in October 2009; school shut for a week which led to the decreased frequency of all students' participation at school, but on the other hand, the frequency increased at home. In particular, all students' participation not only increased gradually at school, but was stable at home.

Table 1. Distribution of All Students' Participation between Home and School.



The findings indicated that game-based network homework can possibly support the sustainable learning of students' participation wherever at school or at home. Besides, the most participation of students occurred at school, not at home. In particular, the ratio of all students' participation at school and home was between 2:1 and 3:1. The findings showed that a few students can participate in math game-based network homework at home.

Table 2 showed that all students needed to spend approximate 5 minutes in each task of game-based network homework. In particular, the spending minute of each task was from 4.45 to 3.68. Table 2 also presented that all students participated in approximate 2 frequencies in every day. In particular, the participatory frequency of every day was form 2 to 2.41. The findings not only revealed that the speeds of completion in December showed faster than those in September, but also revealed that the frequencies of participation in December showed more than those in September. This phenomenon implied that the students participated in math game-based network homework possibly increased the proficiency and fluency of task about math learning.

Table 2. Proportion of All Students' Participation in 1st Semester. (n = 29, duration = 122 days)

	Total Number of Tasks (frequency)	Total Time (minute)	Time/Tasks	Average Number of Tasks (month)	Average Number of Tasks (day)
September (30)	1745	7756.95	4.45	60.17	2.01
October (31)	1175	8435.55	7.18	40.52	1.31
November (30)	1717	7279.68	4.24	59.21	1.97
December (31)	2171	7899.22	3.68	74.86	2.41
Average	1702	5020.13	4.89	58.69	1.93

3.1.2 Learning Portfolio of All Students in 2nd Semester

In 2nd semester, all students only practiced math game-based network homework at home. In particular, they participated in tasks approximate 2 frequencies in every day; and they spent approximate 5 minutes in each task, see Table 3. In other words, the results of 2nd semester was similar the results of 1st semester. The findings proved that mostly students can participate in math game-based network homework at home, that is, they could also maintain the proficiency and fluency of task, even at home.

Table 3. Proportion of All Students' Participation in 2nd Semester. (n = 27, duration = 99 days)

	Total Number of Tasks (frequency)	Total Time (minute)	Time/Tasks	Average Number of Tasks (month)	Average Number of Tasks (day)
February (7)	563	1050.03	1.87	20.85	2.32
March (31)	2235	10809.93	4.84	82.78	2.67
April (30)	1544	7262.68	4.70	57.19	1.91
May (31)	1295	6931.55	5.35	47.96	1.55
Average	1409.25	6513.55	4.19	52.19	2.11

3.2 Affective Experience

3.2.1 Self-Efficacy

The one-way ANOVA conducted on overall self-efficacy scores revealed a significant difference for the treatments, $F_{(1, 53)} = 19.09$, $MSE = 5466.95$, $p=.000 < .01$. The pairwise comparison procedures revealed that students in 2nd semester phase ($M = 158.41$, $SD = 13.08$) showed higher self-efficacy than those in 1st semester phase ($M = 138.46$, $SD = 19.94$).

MANOVA indicated that the game-based network homework treatments had an effect on components of self-efficacy, Wilks's Lambda = .373, $F_{(5, 10)} = 16.47$, $p=.000 < .01$. Univariate analyses indicated that differences occurred only for mastery experience and physiological state. For mastery experience, there was a significant difference for the treatments, $F_{(1, 53)} = 17.86$, $MSE = 489.83$, $p=.000 < .01$, partial $\eta^2 = 0.252$. The pairwise comparison procedures revealed that students in 2nd semester phase ($M = 35.15$, $SD = 2.48$)

showed higher mastery experience than those in 1st semester phase (M = 29.18, SD = 6.92). Regarding physiological state, there was a significant difference for the treatments, $F_{(1, 53)}$ = 38.28, MSE = 725.66, $p=.000 < .01$, partial η^2= 0.419. The pairwise comparison procedures revealed that students in 2nd semester phase (M = 30.44, SD = 2.74) showed higher physiological state than those in 1st semester phase (M = 23.17, SD = 5.48). There was not a significant difference for vicarious experience peers, vicarious experience adults, and social persuasions.

4. Conclusions

This is a long-term study of a game-based learning environment to incorporate math learning materials with paper-based homework and network-based homework. This study focused on examining the findings of cognitive effectiveness and affective experience of students. First, the findings indicated that students could continuously participate in math task and maintain the proficiency and fluency of task in game-based network homework platform across home and school time. Second, the findings proved the game-based network homework platform for mostly students could attain self-efficacy.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financial support (NSC 99-2511-S-008-002-MY3, NSC 100-2511-S-008-013-MY3, and NSC 100-2631-S-008-005-), and Research Center for Science and Technology for Learning, National Central University, Taiwan.

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