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Integrating Computer Games with Mathematics Instruction in Elementary School- An Analysis of Motivation, Achievement, and Pupil-Teacher Interactions

Kuo Hung Huang and Chong-Ji Ke

***Abstract*—**The purpose of this study is to explore the impacts of computer games on the mathematics instruction. First, the research designed and implemented the web-based games according to the content of existing textbook. And the researcher collected and analyzed the information related to the mathematics instruction integrating the computer games. In this study, the researcher focused on the learning motivation of mathematics, mathematics achievement, and pupil-teacher interactions in classroom. The results showed that students under instruction integrating computer games significantly improved in motivation and achievement. The teacher tended to use less direct teaching and provide more time for student's active learning.

***Keywords*—**computer games, mathematics instruction, pupil-teacher interaction, technology-enhanced learning

I. Introduction

OVER the last years there has been an increased recognition of the importance of technology enhanced education. A term of "Edutainment", created in 1900's, is mentioned again to encourage combination of education and entertainment. However, the teaching effectiveness of such an educational entertainment needs more researches to confirm [1, 2].

The objective of this research is, therefore, to design, implement a computer game based on the mathematics curriculum. By experimenting in two classes, the researchers expect to find out the benefits of the game-integrated instruction.

II. METHODS

A. Research Design

This study focuses on the influence of computer games integrating with mathematics instruction. The quasi-experimental research design chose two different classes whose teachers used traditional instruction and game-integrated instruction respectively. By comparing the scores on the achievements, attitudes, and pupil-teacher interaction before and after the instruction, the research then would assert the impacts of computer-game integrated instruction based on the statistically significance.

B. Curriculum

According to the existing curriculum of mathematics for elementary school, the concepts of multiple, divisor, common multiple, common divisor, and prime number are arranged in the fifth grade. Therefore, the subjects of the experiment consisted of sixty four students from two fifth-grade classes. The instruction time for this unit is around six weeks.

C. Instrument

In this study, there are mainly three kinds of instruments used in the experiment:

1. Achievement test: A test on the instructed concepts developed by mathematics education researchers. The value of Cronbach's α is0.8785, which indicated a good consistency. The item difficulty index is 0.4 and stand for appropriate difficulty.
2. Attitude measurement: A summated ratings, Likert-style attitude measurement on mathematics learning developed by a scholar was used. The dimensions were defined as confidence, motivation, habits, self-concept, interaction preference, and practical usage.
3. FIAC: A pupil-teacher interaction observation system based on Flander's theory of language interaction. A web-based software was used to collect and analyze data (see Fig. 1, http://diss.tjps.tp.edu.tw/main.htm).

III. Game Design

A. Framework

The game designed for the in-class instruction adopted the framework of situated learning. Brown and Duguid have identified several characteristics of situated learning [3]. First, the learners will actively observe the environment and look for something to learn- possibly irrelevant to what the instructors teach.

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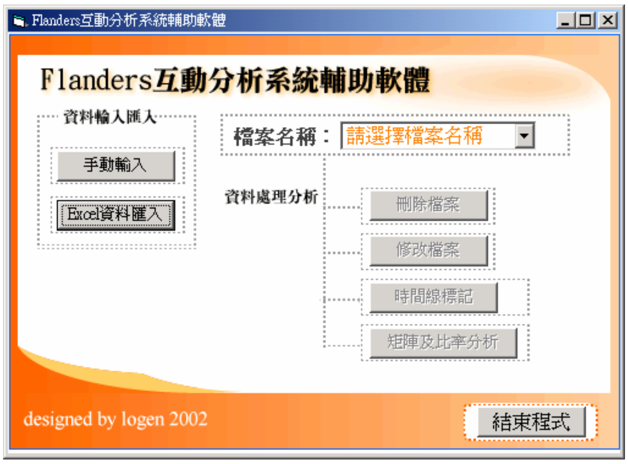

Fig.1 The Flander's observation system

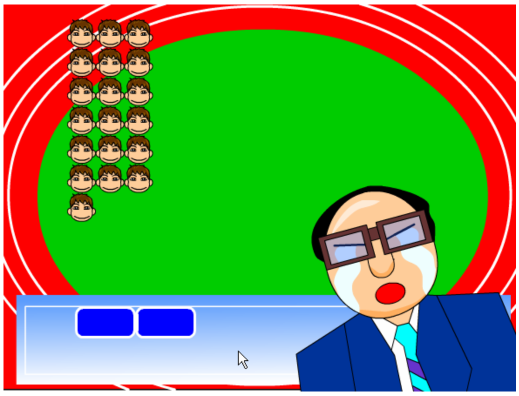

Fig. 2 The game of line-up students

Fig. 3 The game of haunted house

Fig. 4 The game of candy packing

Second, a great deal of actual practice cannot be made the subject of explicit instruction. The learners will develop the implicit knowledge of the practice in the process of engaging the social activities. Third, complex practices can be learned effectively where the social context is evident and supportive. To their needs, the learners will decompose the task and seek appropriate resources in the context of the social practice. And finally, a broader system, which consists of materials, technological artifacts, and social activities, provides the learners with rich resources, meaning, and knowledge to make sense of their tasks.

Pea [4] emphasizes the importance of learning conversation. To have the novice get familiar with the language, computer software can augment discourse of learning.

B. System Design

There several games targeted at difference concepts. The games began with a story or a task and then asked the students to complete the task. For example, the game of line-up students (Fig. 2) would help learners to get familiar with the concept of divisor. And the game of haunted house and candy packing would help to clarify the concept of multiple and common divisor. (Fig. 3 and 4)

The teacher first explained the concept of mathematics and then allowed the students to play the games. At the end of the game, the screen would show the final scores. The teacher would lead the class to discuss the strategy to obtain a high score. After sharing their experiences, the students were allowed to play the game again. The teaching strategy of discussion was important in the process of integrating game with instruction.

C. Implementation

The games were implemented as web-based games. Flash technology was used to implement the games and distributed as swf files. Each student downloaded the file and played within the browser. The plug-in software will execute the games.

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IV. FINDINGS

A. Achievement Test

The scores of game-integrated group improved better than the traditional group. The result of t-test showed that the difference is significant (see Table 1). And the ANOVA result (F 5.9 p=0.018 0.05) indicated the scores on post-test differed in two groups.

TABLE I
ACHIEVEMENT TEST AND T-TEST RESULT

		Experiment group (game)	Control group (traditional)	T
Pre-test	Average	15.46	14.02	.139
	SD	3.91	3.74	
Post-test	Average	78.33	70.03	.033
	SD	13.22	17.32	

B. Attitude Test

The t-test result, as table 2, showed the experiment group had more positive attitude toward mathematics after the instruction.

TABLE II
THE T-TEST RESULT ON ATTITUDE

		Experiment group (game)	Control group (traditional)	T
Pre-test	Average	15.46	14.02	
	SD	3.91	3.74	
Post-test	Average	78.33	70.03	.02
	SD	13.22	17.32	

* p=.002<.05

C. Teacher-Pupil Interaction

The result showed that the game-group students performed much better in actively initiated conversation. The teacher also used less direct commands in game-group. It seemed that the instruction integrating computer game would cultivate a more constructive learning environment. (table 3)

TABLE III
THE INTERACTION COMPARISON

Item	Traditional	Game-integrating
percent teacher talk	79.44%	36.56%
percent pupil talk	13.03%	30.30%
percent silence or confusion	7.53%	33.14%
indirect-to-direct ratio	32.81%	67.92%
teacher response ratio	34.68%	82.24%
teacher question ratio	17.12%	9.75%
pupil initiation ratio	26.87%	65.92%

V. CONCLUSION

Learning in school has been criticized for its decontextual natures. In traditional mathematics classes, students learn to acquire computation skills through rote learning. In this study, we indeed witness these students' dramatic improvements in attitude and achievement. In addition, the students and teachers all benefit from this constructive, joyful, game-integrated instruction.

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