

Effects of virtual opponents in video game on students with different fluency

Frank S.H. Wu, Hercy N.H. Cheng* , Barry Lee Reynolds

Graduate Institute of Network Learning Technology,

**Department of Computer Science and Information Engineering,*

National Central University, Taiwan

frank@CL.ncu.edu.tw

Abstract: Many researchers are concerned about the effects of video games on learning, especially the games with virtual opponents; therefore, the main purpose of this paper is to investigate the possible impacts. The authors designed Forest Defense, a digital game for practicing mental arithmetic, with two modes: training and challenge modes. In the challenge mode, students have to face virtual opponents which have not been shown in the training mode. A preliminary experiment was conducted to examine the effects of the challenge mode in Forest Defense. The results showed that virtual opponents did not influence the accuracy of the high-ability students, but significantly decreased the accuracy of the low-ability students. The results also suggested that if practicing more, the low-ability students were more able to face virtual opponents.

Keywords: Game-based learning, video games in education, technology enhanced learning, virtual opponent.

1. Virtual Opponents

Although practicing is crucial to enhancing procedure fluency in mathematics [5], it is also boring for students. Researchers have found a well-designed video game can motivate children to learn mathematics [6][7]. In a learning environment with games, students may pay more attention to their learning tasks. However, many researchers are concerned about the effects of video games on learning, especially the games with virtual opponents. A virtual opponent is a virtual character that a player is playing against for the same goal in a video game. If a player defeats the virtual opponent, s/he will feel delight and a sense of achievement. In a sense, virtual opponents provide a form of challenge that could be measured by the number and abilities of opponents that compete with a player [2]. As a result, players can be motivated to reach a goal with reasonable pressure when playing games with virtual opponents.

In fact, virtual opponents are not the only one form of virtual characters; they have varied characteristics and behave in different manners, such as a peer tutor, tutee, collaborator, competitor and troublemaker [3]. Although a computer is able to simulate a tutor in the area of intelligent tutoring system (ITS), which has been explored by a multitude of researchers [8][9], Aïmeur and Frasson [1] proposed the strategy of learning by disturbing, stating that a computer can simulate two agents: a tutor and a troublemaker. The troublemaker has behaviors different from the tutor, for example, giving an incorrect answer in order to force the learner to respond and present the right solution, or waiting for the solution of the learner and offering a wrong solution or suggestion. If the learner cannot give a correct answer, the tutor finally gives him the solution. Virtual opponents can also adopt a strategy to get students' attention and make them think which is right.

Although virtual opponents are similar to troublemakers in that they can increase the challenge and fun, its effects on learning are seldom investigated. Therefore, the purposes of this paper are to examine the effects of virtual opponents on the performance of students with different abilities, and to investigate students' perception and preference about virtual opponents.

2. Game design

Forest Defense, as illustrated in Figure 1, is an educational mini flash shooting game, which was designed to maintain student motivation for arithmetic drill and practice. In the game, learners need to solve 50 mathematical problems generated by the system and “shoot” the correct answers to score points. In this study, the questions are multiplications of a two-digit number and a single-digit number. The goal of learners is to get as high score as they can. There are four candidate answers (“targets”) including a correct answer on the screen. The game has two modes: training mode and challenge mode.

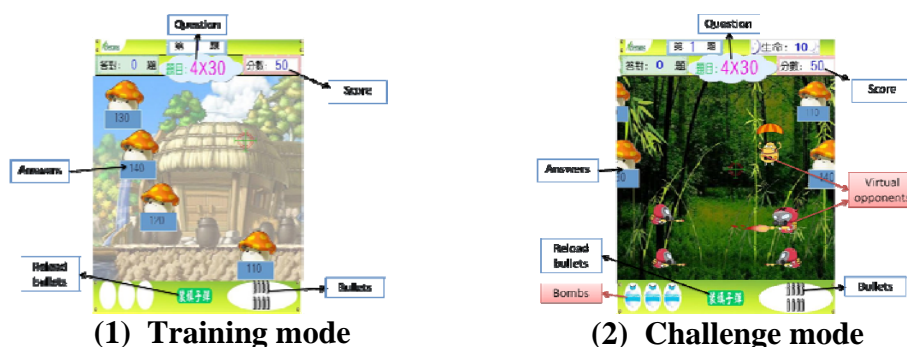


Figure 1. Two modes of Forest Defense

Training mode: Figure 1(1) shows the training mode in Forest Defense. In the training mode, a student has to shoot the correct target without encountering virtual opponents. However, shooting the correct answer is not as easy as clicking a button: all targets are moving horizontally on the screen. Moreover, these targets move in different speeds, some faster and some slower. Students can be drilled on and practice their ability in mental math in order to enhance their procedure fluency [4].

Challenge mode: Figure 1(2) shows the challenge mode in Forest Defense. In challenge mode, a student has to compete with several virtual opponents besides shooting the moving targets. Each student has ten “life points,” representing the chances to be “shot” by the virtual opponents. If virtual opponents fire or throw an obstacle towards students, their life points will reduce by one. Different from the training mode, students are allowed to use bombs or bullets to shoot the virtual opponents to avoid losing life points. In a sense, the virtual opponents make the time constraint more tight, stimulating students to calculate in less time and raising the fun of the game.

3. Preliminary Evaluation

A preliminary experiment was conducted for three purposes. The first purpose was to examine the effects of virtual opponents in a game on students with different procedure fluency; the second was to examine the effects of delayed virtual opponents; and the last was to investigate students’ perception and preference about virtual opponents. The participants for this experiment were thirty-four (20 boys and 14 girls) sixth grade elementary school students. The students ranged in age from 10 to 11 years old.

3.1 Procedure

Figure 2 shows the procedure of the preliminary experiment. Every participant used a desktop computer in a computer laboratory. Before playing Forest Defense, all participants were introduced to the game rules and the procedures of the experiment. In round 1, they played in

the training mode, in which they have to answer fifty arithmetic questions without encountering any virtual opponents. Then they were divided into experimental group and comparison group by using an ad lib matching method according to students' accuracy and efficiency in round 1. One's accuracy was defined as the number of correct trials divided by the number of total trials; efficiency was defined as the total number of correct trials divided by corresponding time. The experimental and comparison groups then played different modes in round 2, in which the order of questions was different from that in round 1. The experimental group played the challenge mode while the comparison group still played the training mode in round 2.

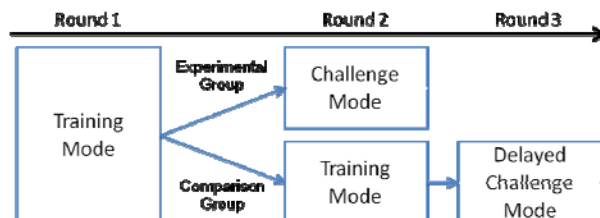


Figure 2. The procedure of the preliminary experiment

After round 2, the experimental group finished the game and filled out a paper-based questionnaire about their preference and perception of virtual opponents. The questionnaire was composed of 11 questions on a 5-point Likert scale and four open-ended questions. Since the comparison group had not played the challenge mode, they continued playing round 3, a delayed challenge mode, while the experimental group filled out the questionnaire. After round 3, the comparison group immediately filled out the same questionnaire. All actions of the participants were observed and videotaped throughout the activity. Additionally, when the participants were playing the game, the data logs were automatically collected by the system.

3.2 Results

Before the experiment, all participants appeared delighted to play a computer game. Once the game started, they immediately became engaged in playing the game. In general, when playing in the challenge mode, they were visibly more excited than in the training mode. Some participants said “*I’m losing life points*” when they met and were “*shot*” by a virtual opponents. Although 34 participants played the game, there were 3 participants whose data were not recorded in the system. Thus only 31 participants were analyzed in this study, including 16 participants in the experimental group and 15 in the comparison group.

3.2.1 The effects of virtual opponents

The results about accuracy are illustrated in Figure 3(a). A $2 \times 2 \times 2$ analysis of variance (ANOVA) was carried out, with group (experimental and comparison group) and ability (high-ability and low-ability students) as between-subject variables, and with time (round 1 and 2) as a within-subjects variable. There was a significant interaction among the three variables ($F(1, 26) = 25.253, p < .05$). For the high-ability students, there was no interaction and no main effects of group and time, suggesting that virtual opponents did not influence the accuracy of high-ability students. Regarding the low-ability students, there was a significant interaction between group and time ($F(1, 13) = 57.175, p < .05$). Although there was no simple main effect in round 1 ($t(13) = -.235, p > .05$), the average accuracy of the experimental group was significantly lower than that of the comparison group in round 2 ($t(13) = -2.343, p < .05$). In other words, virtual opponents decreased the accuracy of low-ability students.

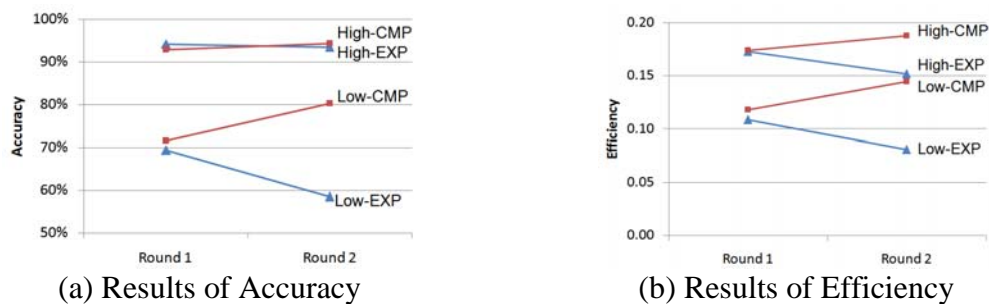


Figure 3. Results of virtual opponents.

The results regarding efficiency are illustrated in Figure 3(b). A $2 \times 2 \times 2$ analysis of variance showed that there were no significant interactions that involved ability, suggesting that the influence of virtual opponents on efficiency was irrelevant to ability. However, there was a significant interaction between group and time ($F(1, 26)=53.796, p<.05$). Furthermore, while in round 1 there was no significant difference between the experimental and comparison group ($t(28)=-.334, p>.05$); in round 2 the average efficiency of the experimental group was significantly lower than that of the comparison group ($t(28)=-3.198, p<.05$). Therefore, regardless of the ability, the efficiency was greatly decreased by virtual opponents.

3.2.2 The effects of delayed virtual opponents

In order to investigate the effects of delayed virtual opponents on accuracy and efficiency, we carried out a 2×2 analysis of variance, with mode (challenge mode and delayed challenge mode) and ability as between-subject variables. The results are shown in Figure 4. There were significant interactions on both accuracy ($F(1, 26)=8.197, p<.05$) and efficiency ($F(1, 26)=4.646, p<.05$). For the high-ability students, although there was no significant difference between the average efficiencies of the challenge mode and the delayed challenge mode ($t(13)=0.749, p>.05$), the average accuracy in the delayed challenge mode was significantly lower than that in the challenge mode ($t(7.996)=2.437, p<.05$). We found that two high-ability students in the delayed challenge mode were distracted when shooting virtual opponents and forgot to answer questions in the beginning of the mode. For the low-ability students, the effects on accuracy ($t(13)=-2.264, p<.05$) and efficiency ($t(13)=-2.050, p=.061$) were both significant. The findings suggest that low-ability students need more practice in the training mode to gain more confidence to face virtual opponents and more difficult challenges.

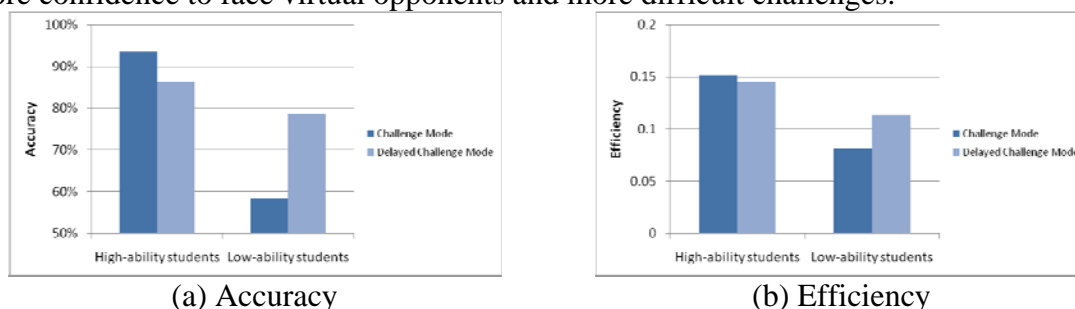


Figure 4. Results of delayed virtual opponents

3.2.3 The perception and preference about virtual opponents

Then we carried out a 2×2 (group \times ability) analysis of variance for each questionnaire item, there were no relationships found and main effects of ability. Furthermore, only item 6 (“In challenge mode I have to calculate faster to avoid defeat”) had a significant effect on the group ($F(1, 26)=6.177, MSE=1.209, p<.05$), indicating that the comparison group, who played in met the delayed challenge mode, agreed more with the statement ($M=4.50, SD=.65$) than the

experimental group ($M=3.50$, $SD=1.32$). The result implied that students were more willing to face difficulties if they had practiced more. Besides, when they were asked to choose a preferred mode, 7 out of 16 students in the experimental group chose challenge mode, while 7 students chose training mode and 2 chose nothing; in the comparison group, 12 out of 15 students selected challenge mode, while 2 selected training mode and 1 selected nothing. According to their responses in the open ended questions, the 12 students in the comparison group played the training mode longer and started to feel bored.

4. Conclusion

The objective of this paper is to investigate the effects of virtual opponents on students with different abilities. For this purpose, the authors designed Forest Defense, a shooting arithmetic game with a training mode and a challenge mode. After practicing arithmetic in the training mode, a student has to face virtual opponents who try to disturb him in the challenge mode. In video games, virtual opponents can get players' attention and arouse their excitement, which agrees with our observation of student play in Forest Defense. Most students indicated that they liked virtual opponents, implying that virtual opponents could attract students' interests and have potential for encouraging students to study mathematics further. The findings of the preliminary experiment showed that virtual opponents did not interfere with the accuracy of high-ability students, but may lessen the accuracy of low-ability students. Because the students with low-ability were not ready to confront virtual opponents, they required more practice to improve procedure fluency. If they could practice more and face the virtual opponents later, they would possibly perform better.

This study can give teachers insights into choosing the type of games that can be used to encourage mental arithmetic training. In a sense, virtual opponents can be regarded as a form of challenge, which should be adjusted according to the abilities of students. Thus computers should be able to evaluate their performance and assign an appropriate task dynamically. When students can calculate arithmetic problems fluently in the training mode, the game can challenge the students by adding virtual opponents. Finally, the study also suggests that every student needs a unique learning environment that provides appropriate challenges.

Acknowledgements

The authors would like to thank the National Science Council of the Republic of China, Taiwan for financial support (NSC-97-2520-S-008-001).

References

- [1] Aïmeur, E., Frasson, C. "Analyzing a New Learning Strategy according to different knowledge levels", *Computer and Education, An International Journal* , vol 27, no 2 , pp 115-127, 1996.
- [2] Cheng, H. N.H., Deng, Y. C., Chang, S. B., Chan, T.W. (2007). *EduBingo: Design of Multi-level Challenges of a Digital Classroom Game*, *Digital Game and Intelligent Toy Enhanced Learning*, vol 26-28 , 11 – 18.
- [3] Chou, C. Y., Chan, T. W., & Lin, C. J. (2002). Redefining the learning companion: the past, present, and future of educational agents, *Computers & Education*, 40, 255–269.
- [4] Clements, D. H. & Nastasi, B. K. (1993) *Electronic Media and Early Childhood Education*, in B. Spodek (Ed.) *Handbook of Research on the Education of Young Children*, pp. 251-275. New York: Macmillan.
- [5] Gagne, R. M. (1985). *The Conditions of Learning and Theory of Instruction*. New York: Holt, Rinehart and Winston.
- [6] Sedighian, K. & Sedighian, A. S. (1996). Can educational computer games help educators learn about the psychology of learning mathematics in children? Eighteenth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, 573-578. ERIC Clearinghouse for Science, Mathematics, and Environmental Education, Panama City, FL.
- [7] Sedighian, K. (1997). Challenge-driven learning: A model for children's multimedia mathematics learning environments. *Proceedings of ED-MEDIA 97: World Conference on Educational Multimedia and Hypermedia*. Retrieved June 10, 2002, from: <http://taz.cs.ubc.ca/egems/reports.html>
- [8] Sleeman, D., & Brown, J. (1982). *Intelligent Tutoring Systems*. Academic Press.
- [9] Wenger, E. (1987). *Artificial Intelligence and Tutoring Systems*. Los Altos, CA: Morgan Kaufmann.