A Surrogate Competition Approach to Enhancing Student Learning

Zhi-Hong CHEN, Sherry Y. CHEN, Tak-Wai CHAN

Graduate Institute of Network Learning Technology, National Central University, Taiwan

{hon, sherry, chan}@cl.ncu.edu.tw

Abstract: Although competition is a powerful element to enhance students' motivation, but it still has negative influences on learning. To mitigate possible negative influences, some competition models have been proposed but they are merely suitable for anonymous and face-to-face learning contexts. To address such limitations, there is a need to explore other competition models. To this end, this study proposes the concept of surrogate competition, in which there is no direct competition between each student. Instead, each student has a substitute and the competition takes place between each substitute. Based on this rationale, a My-Pet-My-Arena system is developed and an empirical study was conducted to examine the effects of the surrogate competition. The results revealed that the My-Pet-My-Arena system could help students attribute competitive failures to the lack of effort.

Keywords: user-center design, competition, game-based learning

1. Introduction

Over the past decade, digital game-based learning has attracted more and more research interests. It is motivated by the fact that game elements are utilized to help students achieve their learning goals and improve their knowledge and skills [10]. Thus, game elements play an important role in game-based learning. In this vein, some game elements are investigated, such as control, fantasy, curiosity, challenge [23], imaginary, competition, uncertainty [21], goal, decision, cooperation, and competition [27]. Among these game elements, however, competition is seldom taken into account although it is promising and powerful [9]. A possible explanation is that competition emphasizes on the process of social comparison, in which students are exposed to numerous comparative information, which, in turn, influences students' self-concept [25]. Students might be damaged by negative influences, such as the lack of confidence [4] or lower self-efficacy [31] especially when students frequently fail in the competitions.

To mitigate the possible negative influences, previous works has proposed some mechanisms. One is anonymous competition, which provides a scheme to diminish negative impacts resulting from a face-to-face competitive context [34]. In anonymous competition, students' failure would not be revealed to the public so that the damage on students' confidence could be reduced. The other is group competition, in which competition is integrated into cooperative activities in small groups [30]. Since all of members in the group share the responsibilities for competition results, the possible negative influences are thus alleviated. Nevertheless, these mechanisms are applied in limited contexts. The anonymous competition is suitable for an anonymous-based distributed environment, rather than a face-to-face interactive environment, otherwise the effects of anonymity could not be activated. The group competition is also restricted to a group-based collaborative learning context, rather than an individual environment, otherwise the responsibilities could not be shared by group members.

To this end, there is a need to develop effective and flexible mechanisms to address these limitations. Consequently, this study proposes a game-based competitive mechanism, *surrogate competition*, in which there is no direct competition between each student. More specifically, each student has a substitute and the competition takes place between each substitute. Based on this rationale, this study develops a game-based learning system and conducts empirical studies to examine whether students could benefit from surrogate competition. More specifically, the empirical studies seek an answer for the research question of this study, i.e., "*how surrogate affects students' view to the competition?*".

2. Related work

Competition is regarded as a promising scheme for student learning [12] because competition could reinforce the goal structure of learning activities, which, in turn, enhances students' motivation and academic achievement [16]. However, several researchers also indicate that the use of competition might bring negative influences [31], such as the lack of improving scheme [4] and high degree of stress [35].

This is because competition involves a social comparison process, during which participants are compared with each other [22]. Such acute comparison would affect students' motivation, confidence, attitude, and belief in success [25]. Moreover, most of competitions are a zero-or-sum activity, in which one competitor wins the competition and the other, meanwhile, loses the competition. It implies that such competition always results in one competitor's failure, which might cause some damages to the loser. Once the loser further attributes his/her failure to the lack of abilities, he/she might feel frustrated or even helpless in learning [11; 32; 33].

To alleviate these negative influences, several mechanisms are proposed, including personal improving space, computer-simulated agent, anonymous competition, and group competition. Their design rationales and relevant studies are listed in Table 1. The first two mechanisms emphasizes on positive belief while the last two mechanisms are concerned with negative effects. More specifically, the former makes learners understand that preparation would result in competition success, either via learning efforts by themselves or support from simulated agents. Conversely, the latter is to use anonymous or group protective mechanism to reduce possible negative impacts.

Table 1.Mechanisms to support competitive learning

Mechanisms	Design rationales and function descriptions
Personal improving space	Offering students chances to prepare themselves before the competition takes place can help students easily understand that preparation is the best way to win the competition [5].
Computer-simulated agent	Computer-simulated agents could scaffold students to improve their learning performance for competition, and even shaping their positive belief on effort [5].
Anonymous competition	Anonymity could be as a protective mechanism for students who lose because their identity would not be revealed in public [36].
Group competition	Group competition could share the responsibility for failures, instead of taking the responsibility by an individual [17; 13; 30].

These competitive mechanisms are useful but they are only applied in limited contexts. For example, the personal improving space and simulated learning companions seem to be only suitable for individual learning; the anonymous competition and group competition appear to be suitable merely for anonymity-based and group-based settings. It

is difficult to apply them for more general learning contexts. A possible explanation resulting in these limitations lies within the fact that these mechanisms belong to direct competition: competitors compete against each other by their academic performance directly. In this vein, surrogate competition is thus proposed in this study based on the perspective of indirect competition: each student owns a surrogate, and the competition happens between these surrogates. This is because such surrogate competition offers more flexibility so that the competition between students can be more relaxed. Due to such benefits, we incorporate surrogate competition into a learning system and conduct two empirical studies to investigate whether such an approach is useful to students.

3. Surrogate competition

3.1 Design rationales of surrogate competition

Figure 1 illustrates the differences between direct competition and surrogate competition. Unlike direct competition, where students use avatars to compete against each other, surrogate competition allows students to use surrogates on behalf of them to attend the competition. The main difference between direct competition and surrogate competition lies within the fact that the former involves the participation of two avatars while the latter is mediated by two virtual pets. More specifically, the direct competition involves students' self-image or self-identity to compete against each other. Conversely, the surrogate competition uses agents without self-image or self-identity to attend the competition, instead of themselves.

The aforementioned difference suggests that the surrogate competition is able to change students' views to competition. This is motivated by the fact that students often attribute their failures to the lack of abilities in the direct competition. Thus, the belief that they are "stupid" or "dumb" might be shaped, which, in turn, results in the negative influences. Nevertheless, the surrogate competition could help students shift their failure attributes from the lack of abilities to the lack of effort so that the negative influences might be less damaged.

Due to such benefits, surrogate competition is considered in this study. More specifically, virtual pets attend competition on behalf of students. Students play as the role of master so that effort in training virtual pets could be regarded as the most dominating factor to win in the competition. Therefore, these virtual pets could reflect students' learning status. This is achieved by using an Open Learner Model (OLM) where students' learning status is collected. The OLM is regarded as a manipulated model, which is accessible by students themselves so that they could observe, edit, and even negotiate with computers about their learning status [2; 3]. An additional benefit is that nurturing and caring virtual pets can facilitate human-computer interaction [18] because students play as their masters. By doing so, students could develop a long-term relationship with virtual pets, which could sustain their motivation, and further to facilitate interaction with their OLMs [7].
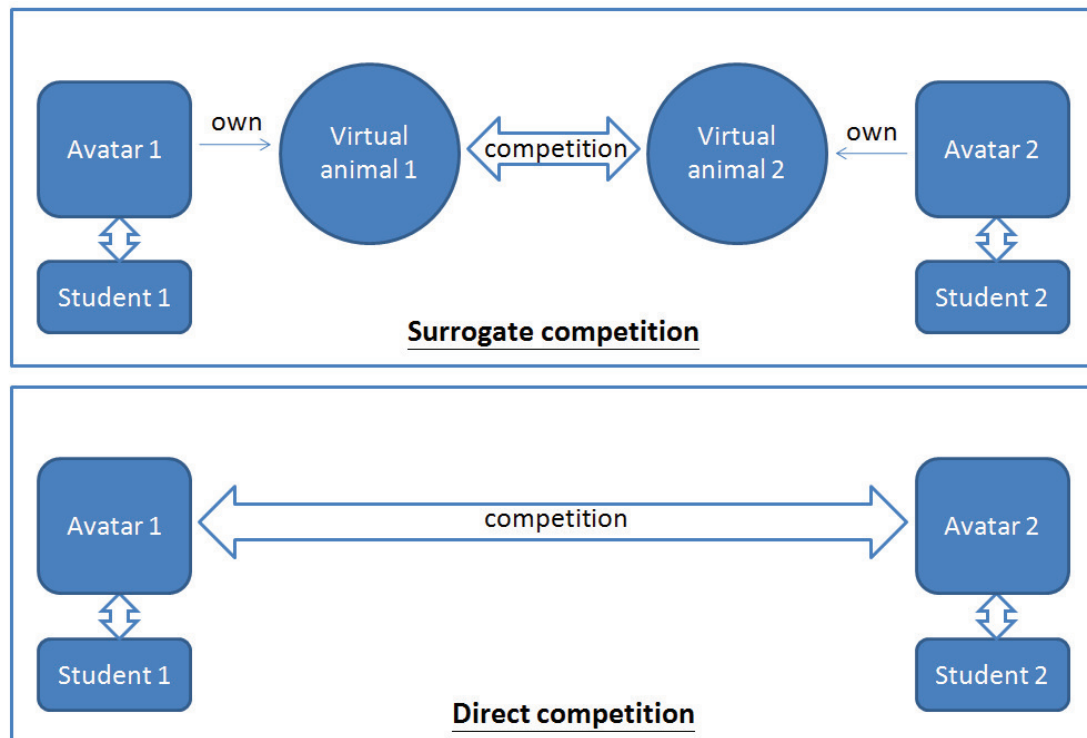
Figure 1. Concept of surrogate competition compared with direct competition

3.2 My-Pet-My-Arena system

3.2.1 Three design perspectives on computer-human interaction

In addition to providing the benefits of surrogate competition, My-Pet-My-Arena system also brings several new design perspectives on computer-human interaction. How much learning effort students made is influential to their achievement [6; 29]. Thus, the first perspective emphasizes on students' effort-making belief. More specifically, virtual pets are used to enhance the computer-human interaction in the My-Pet-My-Arena system so that students can believe that there is a positive relationship between effort and success.

Subsequently, the second perspective lies within the fact that the My-Pet-My-Arena offers several "caring" functions for students to care their virtual pets. Such caring functions, which attach students' emotion, can sustain a long-term "master-and-pet" relationship. By doing so, students' motivation can be maintained, which, in turn, the computer-human interaction can be enhanced. The third perspective lies within the fact that virtual pets and OLMs are integrated as an information representation model within the My-Pet-My-Arena system. Through virtual pets, this model not only could actively remind students of what they have learned and have not mastered, but also be as a motivator to encourage students to interact with the My-Pet-My-Arena system.

3.2.2 System development

The My-Pet-My-Arena system consists of four components. The first one is nurturing component, whose purpose is to develop students' attachment to the My-Pet. This intention can be realized by two functions: feeding, and caring. Regarding feeding, the system allows students to play as a "master", who is responsible for the My-Pet's satiated needs. In particular, the system presents them with a "satiated" attribute, which refers to whether the My-Pet is satisfied or not. By doing so, students can buy pets' food to feed the My-Pet.

Since students are as a giver and their My-Pets act as a receiver, the master-and-pet relationship would be established.

Regarding caring, the system aims to further enhance students' sense of being a "care-giver", who not only satisfies My-Pets' satiated needs, but also their healthy status. To this end, this system provides students with different pets' products. Students could use these products to look after their pets. Likewise, when students take good care of their pets, another "healthy" attribute would be presented. By doing so, students would experience how to take good care of their My-Pets, in which students' attachment to their pets can be enhanced.

The second one is learning component, which is the only part concerning Chinese idiom learning and My-Pet would offer students learning feedbacks (see Fig. 3). More specifically, to improve students' mastery of Chinese idioms, two functions are offered. The first one is to make students understand their learning progress. This function could be realized by presenting the mastery level for a specific Chinese idiom so that students know which topics they have mastered and have not mastered yet. The second one is to encourage students to improve their learning progress in a joyful way. To this end, this system offers a "pet-training" game context, in which students' effort made for improving mastery is further linked to the My-Pet's "effort" attribute. Thus, when students improve their mastery level, the "effort" value would be also promoted. Meanwhile, students can obtain virtual coins as rewards for buying pets' food and products. By doing so, students might feel that they are doing something helpful and meaningful to their My-Pet, instead of boring tasks.

In addition to the two components aforementioned, the My-Pet-My-Arena system contains the third component, i.e., the competition component. The intention of the competition component is to shape students' positive belief in effort-making. To this end, a pair-wise version of surrogate competition is developed so that the "effort" attribute could be regarded as a key factor that determines the competition result [8]. To realize this function, the rule of the surrogate competition is designed as several rounds, each of which a My-Pet can get an effort score based on the "effort" value. It implies that the more "effort" value the My-Pet has, the greater the chance that the My-Pet would win the competition. The surrogate competition continues by turns until one of the My-Pet which obtains the highest score wins the competition.

To further enhance students' sense of being a master, another component is developed. To this end, an avatar component is added in this version 2. This component is realized by offering the function of customizable avatars, in which students can choose virtual characters to adjust their appearances and decorations so that students feel that these avatars are on behalf of them within the virtual world. By doing so, students can see their avatars who play as the master to look after and train their My-Pets. Thus, the sense of being a master can be enhanced.

4. Experiment

Although the results of Experiment One had showed that the My-Pet-My-Arena could enhance students' learning achievement, level of effort-making, and motivation, it was unclear how surrogate affects students' view to the competition when compared to other direct competition mechanisms. To address this issue, Experiment Two was conducted to investigate whether the surrogate competition could bring positive effects as direct competitions and meanwhile alleviate the negative effects.

4.1 Instrument

4.1.1 Two system versions

To answer the second sub-research question, how surrogate affects students' view to the competition, two systems were used in the experiment. One was My-Pet-My-Arena system, which is an example of surrogate competition. The other was My-Competition system, which is an example of direct competition. By comparing these two systems, we can identify the differences between direct competition and surrogate competition.

More specifically, the My-Pet-My-Arena system is developed to enhance participants' impression: they are playing as the role of masters. Although participants with this version owned their avatars (see Fig. 2a), they used My-Pets to reflect their learning status in Chinese idiom and dispatch their My-Pets to attend the surrogate competition on behalf of themselves (see Fig. 2a, 2b, 2c, &2d). Accordingly, they could prepare these surrogates, and even regard them as buffers of the competition. Due to this fact, the My-Pet-My-Arena system is classified as an example of surrogate competition.

Regarding the My-Competition system, all participants had avatars, which could be on behalf of the participants to participate in the competition. More specifically, the avatars reflect their OLMs in Chinese idiom (see Fig. 3a). Thus, participants could improve the status of Chinese idiom to strengthen their avatars (see Fig. 3b) so that they can compete against each other via their avatars (see Fig. 3c and 3d). Although participants also had My-Pets, these My-Pets could not do anything and just stay there. Thus, the participants still need to be directly involved in the competition. This is the reason why this system is categorized as one example of direct competition.
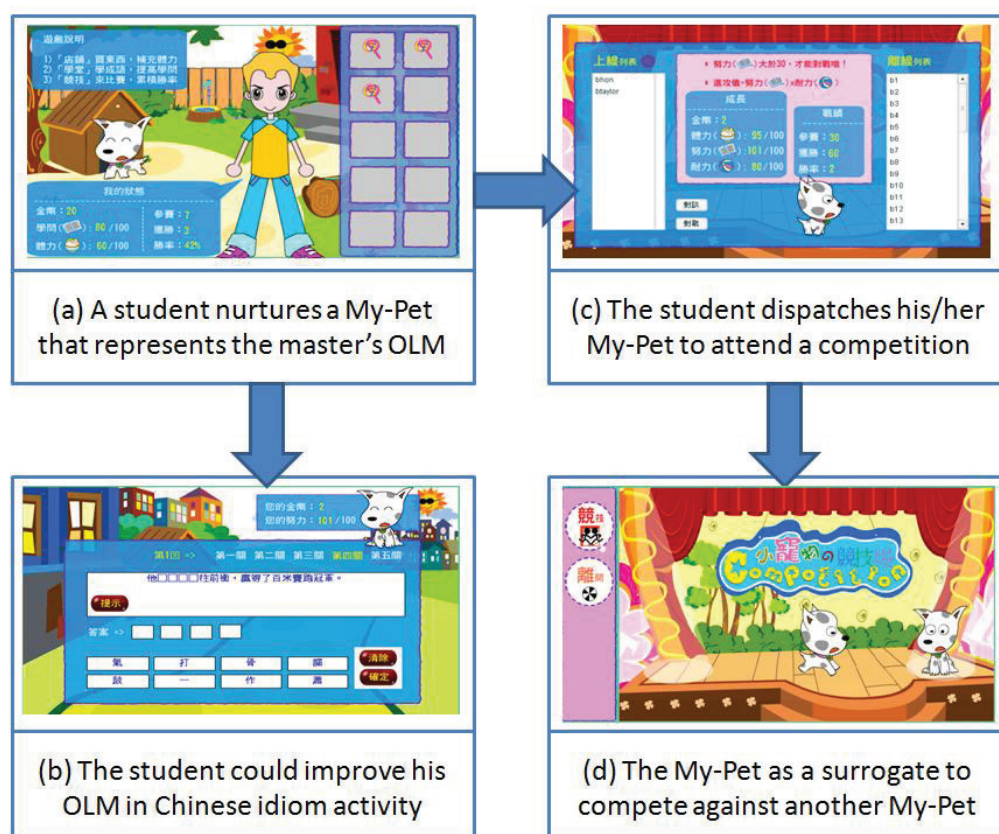

(a) A student nurtures a My-Pet that represents the master's OLM

(c) The student dispatches his/her My-Pet to attend a competition

(b) The student could improve his OLM in Chinese idiom activity

(d) The My-Pet as a surrogate to compete against another My-Pet
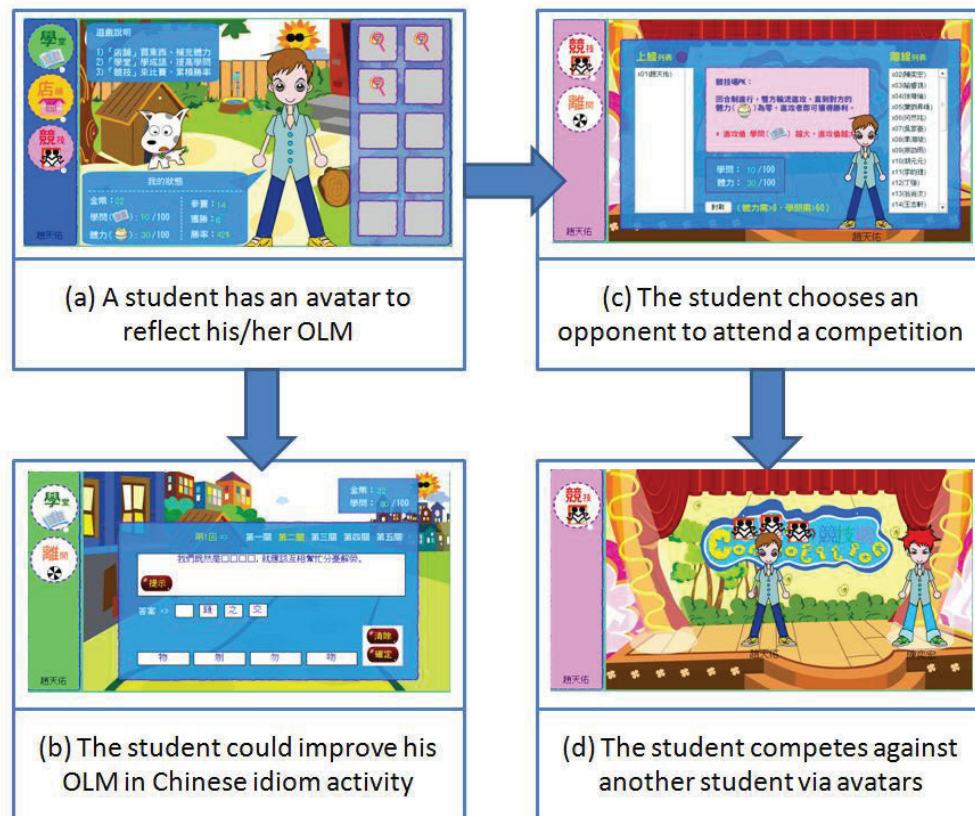
Figure 2. My-Pet-My-Arena system

Figure 3. My-Competition system

4.1.2 Attribution questions

As described previously, it is difficult to find a suitable questionnaire for surrogate competition. Thus, two attribution questions developed by the first author of this paper were used to measure students' attribution for the two groups. As shown in Table 2, one question was used when students win the competition, and the other one was used when students lose the competition. Each question provided four options and the participants chose the one matching with their thought.

Table 2. The two attribution questions

The attribution question when winning
I win the competition because (1) I have good luck (2) I spend more effort in learning Chinese idiom (3) I spend more effort in improving pets (4) I actually have better learning ability in learning Chinese idiom
The attribution question when losing
I lose the competition because (1) I have no good luck (2) I do not spend more effort in learning Chinese idiom (3) I do not spend more effort in improving pets (4) I actually have worse learning ability in learning Chinese idiom

4.2 Participants

A between-subject quasi-experiment was used in the experiment and the participants consisted of two classes in an elementary school. The two classes are randomly assigned to two groups. Table 3 shows the different interventions and the distribution of participants in each group.

Table 3. The setting of the two groups

	Intervention	Participants	Gender (male: female)
CG	My-Competition system	29	19:10
EG	My-Pet-My-Arena system	31	17:14

4.3 Procedure

Each group had two 50-minute sessions to use the system over the period of two weeks. At the beginning of the session, participants were told that they could freely use the system. This allowed participants to use the system in a natural condition. During each session, each participant approximately had six to ten times to attend the competition so that each one could have both winning and losing experience. This could be helpful to increase the validity of the collected data. During each competition, students were able to freely choose their opponents so that their choices were based on their preferences. In other words, students know whose avatars or pets they are competing against. At the end of each competition, both groups need to answer the attribution questions to express their attributions.

4.4 Data analysis

The independent variable of the experiment is the different settings of the two systems whereas the dependent variables of the experiment are participants' attribution when they won and lose the competition. To obtain a stable attribution, we calculate the mode (i.e., the number that appear most frequently) of their attribution as the primary attribution. For example, if a student' attributions are "luck", "luck", "luck", "ability", and "luck", the mode is "luck" because it appears four times. Besides, the mode could ignore the extreme or unstable data caused by participants' mistaken operation or other reasons.

In addition, participants' attribution should be stable during such a short period of time. Thus, when a participant's mode finally has multiple numbers, the used data analysis method is described as follows: (1) If the student's mode contains two numbers, it implies that the student has a *relatively* unstable attribution status. Since this is not an extreme case when compared to others, we still accept this case and count the two numbers, respectively. (2) If the student's mode contains three numbers or more, it implies that the student has a *very* unstable attribution status because there is a lack of careful consideration. Thus, we exclude these students from our data analysis. The Chi-squire test, which is suitable to analyze categorical data, is further conducted to validate whether the result has significant difference.

4.5 Result and discussion

4.5.1 Students' attribution when winning

This section presents the results of students wining the competition. Table 4 illustrates the final results of students' attribution, which exclude unstable cases described previously. Regarding CG, the number of students' attribution to effort made in learning (n=15) was relatively high than that to luck (n=9), ability (n=5), and effort in training pets (n=2). The result from a Chi-squire test indicated that this difference was statistically significant ($\chi^2 = 12.226$, df=3, p<.01). Since the students in CG used the My-Competition system, it meant

that My-Competition system could facilitate students' major attribution to effort-making in improving learning.

One possible interpretation for this result was that the My-Competition system involved the representation of avatars to enhance their presence and participation. More specifically, because people tend to regard the behavior of their self-images as themselves [26], the avatars enhanced students' feelings of telepresence [28]. In particular, while the students could clearly observe what they did and what the consequence was, the cause-and-effect relationship between effort-making and the competitive success was enhanced, which, in turn, fostered the attribution to their effort in improving learning. To our surprise, two students in CG attributed their success to effort in training pets. Although students owned My-Pet in the My-Competition system, the My-Pet could not do anything and stay there. Thus, such a choice, which is a very small portion (n=2), might be due to the attraction of pet animation or unserious consideration. To this end, there is a need to verify this issue with further works.

Table 4. Students' attribution between two groups when winning

	Luck	Effort		Ability
		Improving learning	Training pet	
CG	9 (29%)	15 (48%)	2 (7%)	5 (16%)
EG	5 (14%)	11 (29%)	16 (43%)	5 (14%)

Regarding EG, the number of students' attribution to effort made in training pets (n=16) was relatively high than that to effort in improving themselves (n=11), luck (n=5), and ability (n=5). This difference was statistically significant (χ^2=9.162, df=3, p<.05). Since the students in EG used the My-Pet-My-Arena system, it implied that My-Pet-My-Arena could facilitate students' major attribution to effort-making, instead of other causes (i.e., luck and ability). One possible interpretation for this result was that the My-Pet-My-Arena system enabled students to play as the role of pet-master, which further enhanced students' sense of being as well as the responsibility of taking care of the pets. This is the reason why they chose this attribution. In addition, some students might be aware of the fact that spending efforts in training pets can actually improve their learning status. This might be the reason why some of students attributed their success to the effort made in improving learning.

Furthermore, when comparing the students' attribution between CG and EG, it could be found that the major attributions in CG were effort in improving learning (48%) and luck (29%), whereas the major attributions in EG were effort in training pets (43%) and effort in improving learning (29%). A Chi-squire test further indicated that this difference was statistically significant (χ^2=12.213, df=3, p<.01). Such a difference implied that the students who used the My-Pet-My-Arena system tended to attribute their competitive success to their effort (72%=43%+29%, in improving learning and in training pets). Conversely, the attribution of the students using the My-Competition system focused on effort (48%, in improving learning) and luck (29%). In other words, My-Pet-My-Arena system could ensure that most of students attributed their competitive success to effort.

A possible reason was that the difference resulted from the different system instruments: My-Competition system only used the avatars whereas the My-Pet-My-Arena system used both the avatars and virtual pets. Previous studies had indicated that the use of avatars could be helpful to self-disclosure [15] because avatars can facilitate the linkage between users and onscreen characters, which, in turn, increased the sense of participation [20]. Nevertheless, the difference between these two systems lie within the fact that My-Pet-My-Arena system also used virtual pets to promote their identity of playing as the role of master, which further motivated students to do something for their pets.

Consequently, the My-Pet-My-Arena system had more influences on students' positive attribution to effort than My-Competition system.

4.5.2 Students' attribution when losing

The results of students losing the competition are illustrated in Table 5, which excludes unstable cases. Regarding CG, the number of students' attribution to effort made in improving learning (n=18) was relatively higher than that to luck (n=8), ability (n=4), and effort in training pets (n=4). A Chi-squire test further showed that this difference was statistically significant (χ^2=15.412, df=3, p<.01). Since the students in CG used the My-Competition system, it meant that most of students who used the My-Competition system majorly attributed their competitive failure to their effort made in improving learning. This result was similar to that in students' success attribution. One possible explanation was that the My-Competition system enabled the embodied avatars to stand for students' presence and participation. In particular, students could clearly observe what they did and what the consequence was, which further reinforced the positive relationship between the effort and competitive outcomes (i.e., whatever they won or failed in the competition). Thus, students tended to attribute the competitive failures to their effort in improving learning. Beyond our expectation, four students in CG attributed their failures to effort in training pets, which should not appear in the My-Competition system because the My-Pet could not do anything and just stay there. Such a choice from a very small portion of students might be due to the attraction of pet animation or unserious consideration, which needs to further verify in further works.

Table 5. Students' attribution between two groups when losing

	Luck	Effort		Ability
		Improving learning	Training pet	
CG	8 (23%)	18 (53%)	4 (12%)	4 (12%)
EG	9 (23%)	10 (26%)	17 (43%)	3 (8%)

Regarding EG, the number of students' attribution to effort made in training pets (n=17) was relatively higher than that to effort in improving themselves (n=10), luck (n=9), and ability (n=3). This difference was statistically significant (χ^2=10.128, df=3, p<.05). Since the students in EG used the My-Pet-My-Arena system, these results implied that the My-Pet-My-Arena system could foster students' major attribution to effort-making (both in training pets and in improving themselves), instead of other causes (i.e., luck or ability). The result was also similar to that in students' success attribution. One possible reason was that the students' identity within the My-Pet-My-Arena can be enhanced so as to be a good master and be more responsible for their pets. Thus, they tended to attribute their competitive failures to effort made in training pets. In addition, some students might be aware that the purpose of training pets is actually to improve their learning status. This might be why some of students attributed their failures to the effort made in improving learning.

Moreover, when further comparing the students' attribution between CG and EG, it could be found that the major attributions in CG were effort in improving learning (53%) and luck (23%), whereas the major attributions in EG were effort in training pets (43%) and efforts in improving learning (26%). A Chi-squire test indicated that this difference was statistically significant (χ^2=10.241, df=3, p<.05). It implied that the students with the My-Pet-My-Arena system tended to attribute their competitive failure to their effort (69%=43%+26%, in improving learning and in training pets). By contrast, students using the My-Competition system emphasized on the attribution to effort (53%, in improving

learning) and luck (23%). In other words, My-Pet-My-Arena system allowed most of students to attribute their competitive failure to effort, instead of other factors.

A possible interpretation was that the difference in students' attribution resulted from the different system instruments (i.e., My-Competition and My-Pet-My-Arena). More specifically, although the two systems involved the use of avatars, My-Pet-My-Arena system used virtual pets to promote their identity of playing as the role of master, which further reminded students of being responsible. Previous studies have found that pets play a significant role in children's lives [19], and it is children's instinct to approach these pets, taking good care of them [24]. This might be the reason why the existence of the pets in EG could facilitate students' failure attribution to effort in training pets, instead of another uncertain factor, i.e., luck attribution in CG.

5. Conclusion

With respect to the second sub-research question—*how surrogate affects students' views to the competition?*, Experiment Two was conducted to compare the differences between My-Pet-My-Arena and a direct competition system. The results revealed that the My-Pet-My-Arena system could facilitate most of students to attribute their competitive outcomes to the effort that they put, rather than other factors, no matter when they win or lose in the competition. However, due to the limitations of this study, further studies are required. In particular, although this study showed positive effects of surrogate competition on students, it was merely a short-term study. There is a need to examine the long-term effects of surrogate competition in the future.

Acknowledgements

References

[1] Beck, A. & Katcher, A. (1996). Between pets and people. West Lafayette, IN: Purdue University Press.
[2] 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.
[3] Bull, S., Mabbott, A., & Abu-Issa, A. (2007). UMPTEEN: Named and anonymous learner model access for instructors and peers, *International Journal of Artificial Intelligence in Education*, 17(3), 227-253.
[4] Chan, T. W., Chung, Y. L., Ho, R. G., Hou, W. J., & Lin, G. L. (1992). Distributed learning companion systems - WEST revisited. *The 2nd International Conference of Intelligent Tutoring Systems, C. Frasson, G. Gauthier & G. McCalla (Eds.). Lecture Notes in Computer Science*, 608, Springer-Verlag, 643-650.
[5] Chan, T. W., & Lai, J. A. (1995). Contest-kid: A competitive distributed social learning environment. *In J. D. Tinsley & T. J. Weert (Eds.), World conference on computers in education VI*. New York: Chapman-Hall, 767-776.
[6] Chase, C., Chin, D. B., Oppezzo, M., & Schwartz, D. L. (2009). Teachable agents and the protege effect: Increasing the effort towards learning. Journal of Science Education and Technology, 18, 334-352.
[7] Chen, Z. H., Chou, C. Y., Deng, Y. C., & Chan, T. W. (2007). Active open learner models as animal companions: Motivating children to learn through interacting with My-Pet and Our-Pet. *International Journal of Artificial Intelligence in Education*, 17(2), 145-167.
[8] Chen, Z. H., Liao, C. C. Y., Chien, T. C., & Chan, T. W. (2011). Animal Companions: Fostering children's effort-Making by nurturing virtual pets. *British Journal of Educational Technology*, 42(1), 166-180.
[9] Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive Apprenticeship: Teaching the crafts of reading, writing and mathematics. *In L.B. Resnick (Ed.), Knowing, learning and instruction: Essays in honor of Robert Glaser*, Hillsdale NJ: Lawrence Erlbaum Associates.

[10] Dickey, M. D. (2007). Game design and learning: a conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Education Tech Research*, 55.

[11] Dweck C., (2000). Self-theories：Their role in motivation, personality, and development, Essays in Social Psychology. Philadelphia, PA: Psychology Press.

[12] Davis, G., & Rimm, S. (1985). *Education of the gifted and talented*. Englwwood Cliffs, NJ: Prentice-Hall.

[13] Johnson, D. W., & Johnson, R. T. (1991). Learning together and alone: cooperative, competitive, and individualistic learning (3rd Ed.). Englewood, NJ: Prentice Hall.

[14] Kafai, Y. B., Fields, D. A., & Cook, M. S. (2007). Your second selves: Resources, agency and constraints in avatar design in a tween online world. In Akira Baba (Ed.) Situated Play: Proceedings of the Digital Games Research Association (DIGRA), Tokyo, Japan, 31-39.

[15] Kang, H. S., & Yang, H. D. (2006). The visual characteristics of avatars in computer-mediated communication: Comparison of internet relay chat and instant messenger. *International Journal of Human-Computer Studies*, 64, 1173-1183.

[16] Ke, F. (2008a). Computer games application within alternative classroom goal structures: cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development*, 56(5), 539-556.

[17] Ke, F. (2008b). Alternative goal structures for computer game-based learning. *International Journal of Computer-Supported Collaborative Learning*, 3(4), 429-445.

[18] Kusahara, M. (2000). The art of creating subjective reality: an analysis of Japanese digital pets. *In: Boudreau E., (Ed.), in Artificial Life 7 Workshop Proceedings*, 141-144.

[19] Levinson, B. M. (1969). Pet-oriented child psychotherapy. Springfield, Ill: Charles C. Thomas.

[20] Lim, S. & Reeves, B. (2009). Being in the game: effects of avatar choice and point of view on psychophysiological responses during play. *Media Psychology*, 12, 348-370.

[21] Lo, J. J., Ji, N. W., Syu, Y. H., You, W. J., & Chen, Y. T. (2008). Developing a digital game-based situated learning system for ocean ecology. *In: Pan, Z., Cheok, D.A.D., Müller, W., El Rhalibi, A. (eds.) Transactions on Edutainment I. LNCS*, 5080, 51–61. Springer, Heidelberg.

[22] Martens, R. (1976). Competition: In need of a theory. *In D. M. Landers (Ed.), Social Problems in Athletics*, Urbana, IL: University of Illinois Press, 9-14

[23] Malone, T. W., & Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. *In R. E. Snow & M. J. Farr (Eds.), Aptitude, learning, and instruction, III: Conative and affective process analysis*. Hillsdale, NJ: Lawrence Erlbaum Associates, 223-225.

[24] Melson, G. F. (2001). Why the wild things are: Animals in the lives of children. Cambridge, MA: Harvard University Press.

[25] Mussweiler, T. (2003). Comparison processes in social judgment: Mechanisms and consequences. *Psychological Review*, 110, 472–489.

[26] Nass, C., Kim, E. Y., & Lee, E. J. (1998). When my face is the interface: an experimental comparison of interacting with one's own face or someone else's face. *In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI'98)*. ACM Press, New York, NY, 148–154.

[27] Prensky, M. (2007). Students as designers and creators of educational computer games. *British Journal of Educational Technology*, 39(6), 1004-1019.

[28] Qiu, L. & Benbasat, I. (2005). An investigation into the effects of Text-To-Speech voice and 3D avatars on the perception of presence and flow of live help in electronic commerce, *ACM Transactions on Computer-Human Interaction*, 12(4), 329 – 355.

[29] Seligman, M. E. P. (1994). What you can change and what you can't. New York: Alfred A. Knopf.

[30] Slavin, R. E. (1990). Cooperative learning: Theory, research, and practice. Englewood Cliffs, NJ: Prentice-Hall.

[31] Stapel, D. A. & Koomen, W. (2005). Competition, cooperation, and the effects of others on me. *Journal of Personality and Social Psychology*, 88, 1029-1038.

[32] Weiner, B. (1985). An attributional theory of achievement motivation and emotion. Psychological Review, 92, 548-573.

[33] Weiner, B. (1986). An attributional theory of motivation and emotion. New York: Springer-Verlag.

[34] Yu, F. Y., Chang, L. J., Liu, Y. H., & Chan, T. W. (2002). Learning preferences towards computerized competitive mode. *Journal of Computer-Assisted Learning*, 18, 341-350.

[35] Yu, F. Y. & Liu, Y. H. (2009). Creating a psychologically safe online space for a student-generated questions learning activity via different identity revelation modes. *British Journal of Educational Technology*, 40(6), 1109-1123.

[36] Yu, F. Y., Han, C. L., & Chan, T. W. (2008). Experimental comparisons of face-to-face and anonymous real-time team competition in a networked gaming learning environment. *CyberPsychology and Behavior*, 11 (4), 511-514.