A Surrogate Competition Approach to Enhancing Game-Based Learning

ZHI-HONG CHEN, Yuan Ze University, Taiwan
SHERRY Y. CHEN, National Central University, Taiwan

Competition is useful in game-based learning, although it can also generate negative influences. To expand the potential for competition models in game-based learning, this study proposes the notion of surrogate competition, which eliminates direct competition between students. Such surrogates could be employed as buffers so that the competition between students is more relaxed. To explore the possible benefits of a surrogate approach to competition, the My-Pet-My-Arena system has been developed and evaluated. Two empirical studies were conducted to examine the effects of the surrogate competition. The results revealed that surrogate competition enhanced students' learning achievement as well as increased their motivation. Furthermore, the surrogate competition might also assist students in attributing competitive failures to a lack of effort. Working from the results obtained in these two studies, a general model of surrogate competition is proposed to help designers implement forms of surrogate competition in other systems for game-based learning.

Categories and Subject Descriptors: K.3.1 [**Computer Uses in Education**]: Computer-Assisted Instruction

General Terms: Design, Experimentation, Performance

Additional Key Words and Phrases: Competition, game-based learning, surrogate, learning achievement, motivation, attribution

ACM Reference Format:
Zhi-Hong Chen and Sherry Y. Chen. 2013. A surrogate competition approach to enhancing game-based learning. ACM Trans. Comput.-Hum. Interact. 20, 6, Article 35 (December 2013), 24 pages.
DOI: http://dx.doi.org/10.1145/2524264

1. INTRODUCTION

In the design of an interactive interface, the user's motivation should be a key concern. Some approaches have been investigated to address this concern, such as virtual characters as interface agents to affect users [Sharp et al. 2007] and narrative context as an interactive environment to engage users [Dicky 2005]. Recently, digital games have attracted considerable attention to enhance user participation and motivation, especially in game-based learning settings. The interest has been motivated by the fact that digital games could employ various motivational elements to enhance student learning [Dickey 2007], such as imaginary situations, progress difficulties, outcome uncertainty [Prensky 2001], control, curiosity, challenge [Malone and Lepper 1987], goal, cooperation, and competition [Prensky 2007]. Among these game elements, competition, which has been described as promising and powerful, is seldom taken into account [Collins et al. 1989]. A possible explanation for this oversight is that competition as a game

Authors' Addresses: Zhi-Hong Chen, Department of Information Communication, Yuan Ze University, Taiwan; email: zhchen@saturn.yzu.edu.tw; Sherry Y. Chen, Graduate of Network Learning Technology, National Central University, Taiwan; email: sherry@cl.ncu.edu.tw.

DOI: http://dx.doi.org/10.1145/2524264

element emphasizes the process of social comparison, in which student performance is exposed and compared. This exposure process may open students to hurtful or negative influences, such as lack of confidence [Chan et al. 1992] or lower self-efficacy [Stapel and Koomen 2005].

To mitigate possible negative influences, previous studies have proposed various models. One such model is anonymous competition, which provides a scheme to diminish negative impacts resulting from a face-to-face competitive context [Yu et al. 2002]. In anonymous competition, students' failure would not be revealed publicly, thus avoiding any damage to their confidence. A second such model is group competition, in which competition is integrated into small group cooperative activities [Slavin 1990]. Because in this case all group members share responsibilities for the competitive outcome, personal negative influences may be lessened. Nevertheless, these models are limited in their application context. Clearly, anonymous competition is suitable only for anonymous game settings and has no role in face-to-face environments. Similarly, group competition is restricted to group-based learning contexts rather than individual environments. With these limitations in mind, there is a continuing need to develop alternative models that are able to balance the pros and cons of competitive games.

Accordingly, in the present work, we propose the concept of surrogate competition, in which there is no direct competition between individual students. More specifically, each student player is assigned a substitute, and the competition takes place between these substitutes. Since studying issues like competition in game-based settings might provide some insight that would have more general implications, we developed a game-based learning system that implements the surrogate competition concept. Furthermore, we have recruited this system for a set of empirical studies that examine whether students could benefit from surrogate competition. More specifically, the empirical studies seek to answer a general research question: *What are the influences of surrogate competition on student learning in a game-based environment in terms of motivation, achievement, and belief?* This research question includes two research subquestions. Because the notion of a surrogate competition is a new approach, there is a need to collect additional evidence to examine the effects of each element of the surrogate competition. Thus, Experiment One is primarily concerned with answering the first research subquestion, *How does surrogate competition affect students' learning motivation and learning achievement?* Moreover, since one of the design rationales of the surrogate competition is to shape students' positive belief on competition, there is a need to examine its effects. Consequently, Experiment Two is concerned with answering the second research subquestion, *How does the surrogate affect students' views of the competition?*

The rest of the article is organized as follows. Section 2 briefly presents related work about competitive learning. Next, in Section 3, we introduce the design rationale underlying the game design concept of surrogate competition and illustrate its application to My-Pet-My-Arena, a game-based learning system that uses surrogate competition. Section 4 describes Experiment One, which investigates the effects of the My-Pet-My-Arena system on student motivation and learning achievement. Section 5 describes Experiment Two, which examines the effects of the system on student attribution. In Section 6, the findings of the two experiments are employed to develop a model for the design of surrogate competition. Finally, some conclusions and limitations of this study are discussed in Section 7.

2. RELATED WORKS

Competition is regarded as a promising scheme for student learning [Davis et al. 1985] because it sets up a clear goal structure for a student's learning activities, which in turn should be beneficial to his or her learning [Ke 2008a]. Thus, various competitive

models have been employed to implement and examine the influences of competition within game environments in three aspects: individual, group, and agent.

Regarding the individual aspect, two systems have been designed as face-to-face competitive games to help students master computational skills based on the popular Bingo and Mahjong games: EduBingo [Chang et al. 2007] and AnswerMatching [Wu et al. 2007]. EduBingo uses competition as part of a question-and-answer game, where students seek to answer questions faster than other peers in the domain of basic math (e.g., multiplication, division, and fractions). The results revealed that most students improved their accuracy within the limited time provided for answering [Chang et al. 2009]. AnswerMatching applies competition to create an equal-opportunity context, where students compete against peers who have been matched to have similar ability. The results showed that students' perceived performance and self-efficacy were thus enhanced [Cheng et al. 2009]. Furthermore, in addition to these benefits, student preferences and emotional feedback are also investigated under the condition that students' identities are either revealed or not. The results suggested that making competition anonymous may alleviate negative emotion resulting from competition [Yu et al. 2002].

Regarding the group aspect, researchers have incorporated group structure with competition to support student learning. For example, the Teams Games Tournament (TGT) allows students to work together as a learning group to compete against other groups [Slavin 1990]. Another study demonstrated that the TGT was the most effective in facilitating student attitudes toward learning when compared to other individual models [Ke 2008b]. This result seemed to imply that competition is a useful option for increasing member dependency and individual accountability when it is applied to group-based learning.

In addition to the models aforementioned, the role of computer agents has also been explored within either individual or group models—in other words, software entities that serve as additional participants in student learning. Specifically, the agents might play the role of either a "collaborator" or a "competitor" to interact with students. Alternatively, a virtual agent might play the role of "coach" to assist an individual student or a group of students to collaborate or compete against each other, enriching student interaction in game-based environments. For instance, the Distributed WEST system allows students to compete against each other with the help of agents. A preliminary evaluation indicated that students prefer the involvement of agents [Chan et al. 1992], suggesting that this model is an attractive and promising means for competition.

However, the use of competition may also generate negative influences [Stapel and Koomen 2005]. Past studies have reported negative effects of competition situations, with an emphasis on two aspects: one is learning motivation [Butler and Kedar 1990; Clinkenbeard 1989], and the second is learning preferences [Yu et al. 2002]. Regarding learning motivation, a study by Deci et al. [1981] compared students' motivations in competitive and noncompetitive contexts. It was found that students' intrinsic motivation decreased while solving puzzles during competitions. Regarding learning preferences, a study by Yu et al. [2002] compared anonymous and face-to-face competitive models. The results indicated that some students preferred the anonymous competitive model and disliked the face-to-face competitive model. A possible reason is that competition involves a social comparison process, during which participants are compared with each other [Martens 1976].

In general, literature on competition in learning suggests that the settings in which the competition takes place may greatly affect student learning [Mussweiler 2003]. Applying competition to game-based learning does bring some benefits, including increased performance, positive perception, and preference. However, at the same time, a number of issues have emerged, such as decreased motivation and competition

pressure. This suggests that additional models or design approaches might be needed. Thus, in this article, we propose a new design model that we term *surrogate competition*, grounded on the general rationale that how students react to their competition failures might critically affect their learning behavior. More specifically, most competitions are organized as a zero-sum activity, where one participant is a winner and the other(s) is a loser. In a zero-sum competition, the loser may be hurt by the outcome. Thus, there is a need to consider how students attribute their failures, as this attribution process might affect their self-concept and greatly influence their subsequent behaviors [Weiner 1985, 1986; Dweck 2000]. In particular, ability and effort are two attribution facets that have strong influences on people's subsequent behaviors. Controlling ability attribution is difficult because individuals do possess and apply their different talents during game play. Conversely, effort attribution can be controlled by learners, as each individual may decide how hard or long to work on a problem. This suggests an approach in which learners are encouraged to attribute failures to the lack of effort instead of their abilities. When students focus on effort as an explanation for failure, they are able to face or even overcome these failures instead of feeling frustrated or helpless [Weiner et al. 1976].

When a surrogate mechanism is integrated within a competition, it might benefit students in two ways. First, the surrogate mechanism might offer students an increased level of motivation. This is because students will need to instruct their surrogates concerning what to do and when to do it. This process could make students feel that they are in command and boost their feelings of control; this in turn might enhance their game-playing motivation. Second, the surrogate mechanism might offer students more flexibility in developing positive belief on learning effort. Because the surrogates are directed by students, they should be regarded as actors working on behalf of the "commanding" students. Thus, when students observe their surrogates' presence and participation, the positive linkage between the effort made and competition success should be enhanced, which might contribute to a positive view of learning effort. To further examine the influences of surrogate competition, in terms of motivation, achievement, and view on competition, we have incorporated surrogate competition into a game-based learning system. We describe the game system and two empirical studies in which we investigated the effects of the surrogate competition.

3. SURROGATE COMPETITION

3.1. Concept of Surrogate Competition

Surrogates are substitutes that take the place of someone or something. For example, in the field of library science, the concept of surrogate has been used to refer to an abstract that concisely summarizes the content of a paper. However, the concept of surrogate has seldom been discussed in education and learning. This article thus adapts the general construct and proposes the concept of surrogate competition, in which each student owns and controls a surrogate, and a competition takes place between these surrogates. Unlike students' self-images, surrogates do not involve students' self-identity. In other words, a surrogate is a substitute for a student rather than a self-representation of the student. As a result, we should view a surrogate competition as one that takes places between substitutes, without engaging students' self-identities, instead of a competition that engages students' self-images and their corresponding identities. Figure 1 illustrates the conceptual contrast between surrogate competition and direct competition.

The aforementioned differences lead to our conjecture that surrogate competition might cause students to modify their understanding of competition in a game setting.

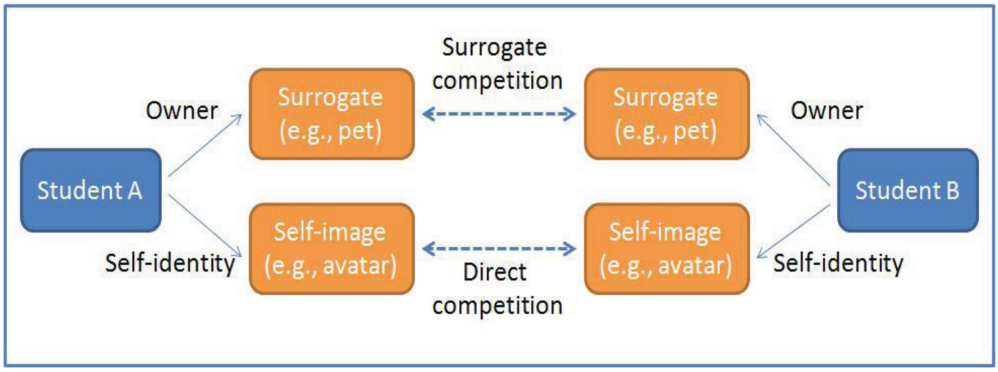

Fig. 1. Concept of surrogate competition compared with direct competition.

More specifically, direct competition is likely to cause students to directly link the game outcomes to their own identities; through this, their relative abilities are exposed. Thus, students might tend to attribute their failures to their own lack of ability, causing negative feelings and possibly demotivating future play. In contrast, surrogate competition might offer a buffer between the competing students, therefore benefiting students by encouraging them to attribute their failure to a lack of effort rather than ability and thus reducing negative influences.

It is due to a conceptual rationale such as this that we decided to investigate surrogate competition empirically. More specifically, we designed virtual pets as surrogates to participate in a competition on behalf of students, who play the role of the pets' masters; the effort spent in training the virtual pets may be regarded as a dominating factor in winning the competition. Additionally, students playing as the masters need to care for the pets and may in fact develop a long-term relationship that may increase the "bond" with the pet-surrogate and further facilitate the attribution dynamics [Chen et al. 2007]. On the other hand, we designed avatars to be used as examples of self-images in this study. The rationale for this is that avatars often have customized looks and personal characteristics that represent students themselves [Waggoner 2009; Gee 2003]. Thus, students tend to regard avatars' behaviors as their own and may even perceive the avatars as their "second self" [Kafai et al. 2007].

3.2. Subject Domain

Historically, Chinese idioms have played an important role in Chinese literature, because they can replace long passages with concise and vivid descriptions [Lee and Tse 1994]. In addition, Chinese idioms contain social, cultural, literary, and moral connotations that are essential in creating good character and cultural identity [Luk and Ng 1998]. Because of such significance, the idioms are considered to be an important element of children's education, and a range of technology-enhanced educational activities have been designed to enhance students' mastery of this content [Wong et al. 2010a; Wong et al. 2010b]. We chose to build on this body of education approach, choosing Chinese idioms as the subject domain of this study. To evaluate student learning of Chinese idioms, we adopted a simple numerical scoring system composed of three aspects: remembering, understanding, and applying. To be completely successful, student participants not only needed to memorize Chinese idioms, but they also needed to understand their connotative meanings in order to demonstrate that they could apply these idioms to real-life contexts.

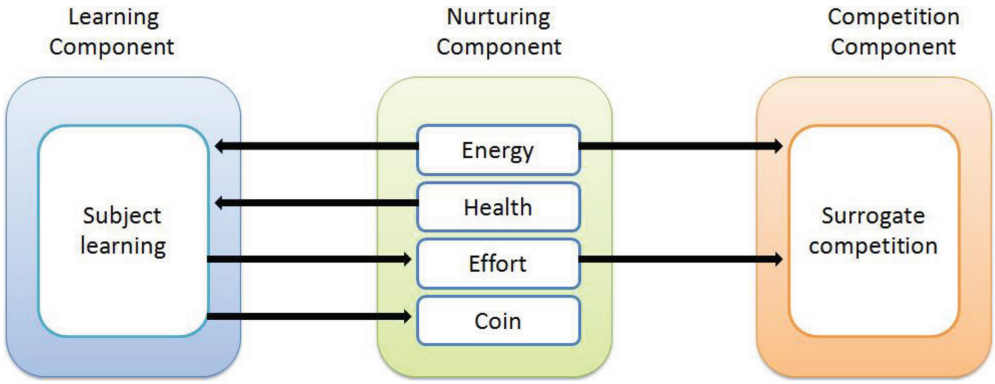

Fig. 2. The relationship among the three components of My-Pet-My-Arena.

Fig. 3. Nurturing component within the My-Pet-My-Arena system.

3.3. My-Pet-My-Arena Version 1

The My-Pet-My-Arena system consists of three related components, as illustrated in Figure 2. The first is a nurturing component, the purpose of which is to develop students' attachment to their pets. To this end, the system allows a student to play the role of master, responsible for satisfying his or her My-Pet's needs. For example, when the My-Pet gets hungry or sick, the system presents students with an "energy" value, which indicates whether the My-Pet is hungry, as well as a "health" value, which reflects whether the My-Pet is healthy (Figure 3). To make the My-Pet energetic and healthy, students need to demonstrate their learning using the second component—learning. When students are able to demonstrate improved learning, they earn "virtual coins" that allow them to buy food (increase energy) or medicine (increase health) for

Fig. 4. Learning component within the My-Pet-My-Arena system.

their pets. At the same time, they may also obtain a higher "effort" value for the surrogate that will be used in the competition; this is accomplished through the third component—competition.

In the learning component, students work with the idioms to earn coins and to increase a pet's effort value; students later can use these coins to take care of their virtual pets or spend the effort value in the competition. More specifically, the learning of Chinese idioms covers three aspects: (1) identifying a correct word from various words with the same pronunciation, (2) sequencing four words to make a meaningful idiom, and (3) applying an idiom to illustrate a specific context. For example, Figure 4 illustrates a scenario in which students must pick out four words one by one in the correct sequence according to the given context, avoiding the selection of similar but erroneous words. During the learning process, students are given feedback on their learning progress so that they can identify whether they have mastered the topics. The system also integrates their learning activities into the pet-training context; students' move toward mastery of the idioms is used to increase the My-Pet's effort value (Figure 2). Thus, when students improve their mastery level, the effort value is also increased. Our design rationale is that by making this link between learning mastery and surrogate effort levels, students might perceive that when learning, they are doing something helpful and meaningful for their My-Pets instead of just completing tasks.

The competition component is designed to promote students' positive belief in the role of effort in competition. More specifically, students are invited to attend a pairwise version of surrogate competition, which is a boxing-like game [Chen et al. 2011]. The game draws on two student-specific variables, namely the energy and effort values of their My-Pets. The former can be viewed like a boxer's energy, and it determines whether a My-Pet is able to participate in the next round of the competition: the first My-Pet whose energy value reaches zero will lose. The second variable is similar to a boxer's punch; the variable controls how much a My-Pet will reduce its opponent's energy value during the competition.

At the beginning of a competition, any student can freely select an opponent from other students who are online and have indicated themselves as ready. After the competition starts, students see their My-Pets, identified by the names of the masters. Each one takes a punch in turn, and the punch strength of each My-Pet is determined by the surrogate's current effort level. The effort determination is visualized by a pie chart (Figure 5); a My-Pet will produce a stronger punch when it has a higher effort value. In other words, pets with higher energy and effort starting values will likely win the competition. For each round, students can see how much their punch depends on the

Fig. 5. Competition component within the My-Pet-My-Arena system.

effort value, and how much energy value their opponents decrease. The competition progresses iteratively until one My-Pet reaches an energy value of zero, thereby losing the competition.

In this context, students who win the competition might be rewarded by the fact that their learning effort in the learning component (i.e., mastering Chinese idioms) has contributed to the success of their surrogate in the competition; this in turn might encourage them to develop a positive attribution toward their own learning effort. On the other hand, students who lose the competition might recognize that their (less intense) learning efforts were not sufficient to lead to the success of the competition. Thus, they might draw the lesson that failure is caused by lack of effort, rather than ability. Such a lesson might enhance their feelings about the competition activity. In short, it is the competition component that attempts to establish a positive link between mastery (e.g., success in the learning tasks) and game playing (e.g., success in the competition) so that students' positive beliefs or views about learning effort might be enhanced.

3.4. My-Pet-My-Arena Version 2

To further explore the role of surrogate competition, a second version of the My-Pet-My-Arena system was developed. In addition to the learning, nurturing, and competition components of Version 1, an avatar component was added. This component offers the function of customizable avatars; students can choose avatar gender and adjust appearances so they feel that these avatars are representing them within the virtual world. In combination with the surrogates in the competition, students may see these avatars playing the role of a "virtual master" who is looking after their My-Pets (Figure 6). The intention of adding this feature was to increase the engagement and feelings of being a master.

Fig. 6. Avatar component within My-Pet-My-Arena Version 2.

4. EXPERIMENT ONE

4.1. Instruments

4.1.1. Learning Systems. To address the first research subquestion with regard to how surrogate competition could affect student learning motivation and learning achievement, three versions of the learning system are used in this experiment. The first version (the control version, CG) presents learning materials only—that is, there is no creation or use of surrogates or competition. This version offers a basic setting for learning Chinese idioms to be compared to the two versions of My-Pet-My-Arena. The second version is the experimental My-Pet system (EG1), which is a subsystem of the My-Pet-My-Arena Version 1. The third version is the complete My-Pet-My-Arena Version 1 (EG2), which consists of learning material, My-Pet subsystem, and My-Arena subsystem. Figure 7 and Table Ilist differences among the three versions.

4.1.2. Achievement Test. An achievement test was developed by the first author of this study and contains three parts: word-identification, word-sequencing, and idiom-apply. More specifically, the word-identification part consists of 20 questions that ask participants to recognize a correct keyword from an idiom in the form of multichoice questions; the word-sequencing part consists of 20 questions that ask participants to order the four words of an idiom in the correct sequence; the idiom-apply part consists of 20 items that ask participants to properly apply idioms to the given contexts in the form of multichoice questions. The question examples are illustrated in the Appendix. To increase its validity, a junior high school teacher further proofread the test items after the preliminary version of the test was designed.

4.1.3. Motivational Questionnaire. A questionnaire was applied because it has the potential to collect data about the learners' experience quickly and easily [Kinshuk 1996]. Several existing questionnaires are available, such as the Motivational Gaming Scale [Dempsey et al. 1994] and the Enjoyment Scale [Fu et al. 2009]. However, our research focus was on student responses to a particular competitive system, namely one that involves an indirect competition that takes place between two surrogates. Therefore, we designed a questionnaire specifically for this study.

The motivational questionnaire consisted of four subscales: Attention, Goal, Enjoyment, and Challenge. Each subscale consisted of four items based on five-point Likert scales. To increase scale validity, one item was negatively worded within each subscale. Example items for Attention are "This system catches my attention" and "I can hardly pay attention to this system"; examples for Goal include "This system offers a goal worthy of pursuit" and "This goal helps me study hard"; examples for Enjoyment include "I enjoy using this system" and "I look forward to using the system in the future"; and

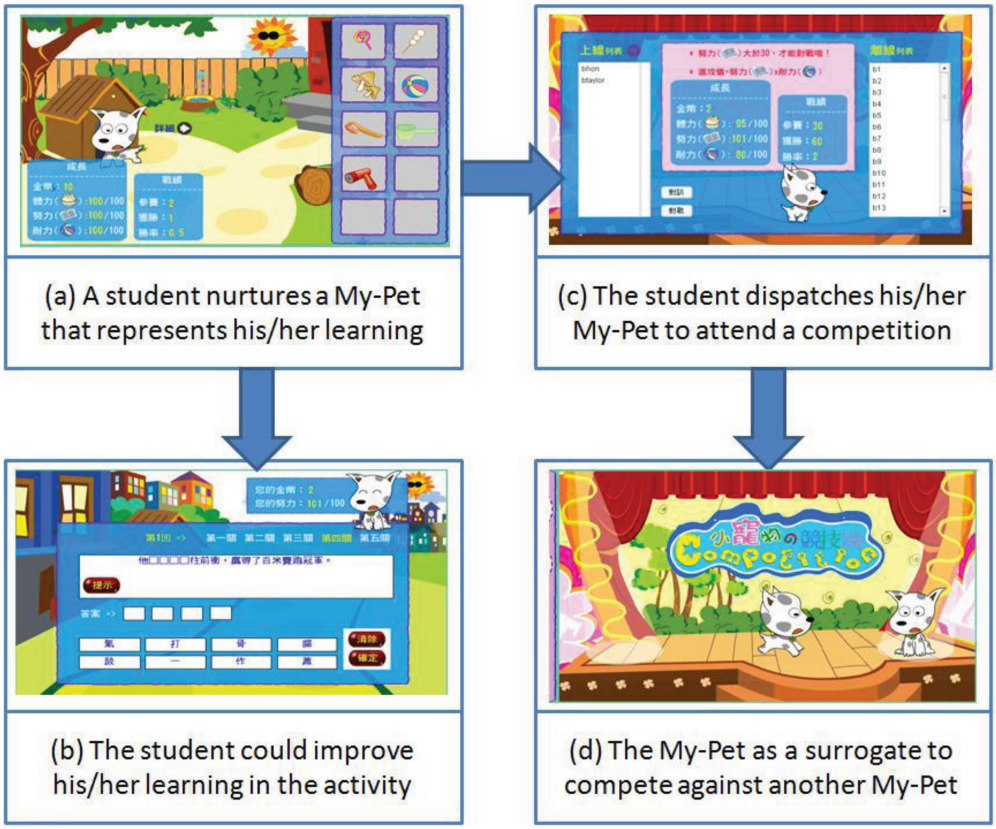

Fig. 7. My-Pet-My-Arena Version 1.

Table I. Summary of the Different Settings Among the Three Versions

System Versions	Description
(1) Control version	Learning materials (Fig. 7(b))
(2) My-Pet version	Learning materials (Fig. 7(b)) + My-Pet subsystem (Fig. 7(a))
(3) My-Pet-My-Arena v1	Learning materials (Fig. 7(b)) + My-Pet subsystem (Fig. 7(a)) + My-Arena subsystem (Fig. 7(c) & 7(d))

examples for Challenge include "The tasks provided by this system are challenging" and "This system does not provide any challenging tasks." The four subscales have high reliability (Cronbach's $\alpha = 0.75, 0.85, 0.83$, and 0.87, respectively), so our analyses uses aggregate scores created by averaging the four items for each subscale.

4.2. Participants

This study used a between-subjects quasi-experimental design; three elementary school classes were randomly assigned to use one of the three systems. The number and gender proportion of participants in each class (learning system) was similar and is described in Table II. The elementary school follows a policy of normal distribution so that each class included students with various levels of background, knowledge, and learning capabilities. None of the students had any preliminary understanding of Chinese idioms; thus, we can assume that participants in the three classes have similar levels of prior knowledge in the subject domain.

Table II. The Setting of the Three Groups

	Intervention	Participants	Gender (male:female)
CG	Learning version	20	9:11
EG1	My-Pet version	23	11:12
EG2	My-Pet-My-Arena version	25	10:15

Table III. Mean and SD of the Pre-/Posttests in the CG and EG

	Pretest		Posttest	
	Mean	SD	Mean	SD
CG	35.65	9.90	42.65	11.02
EG1	37.78	9.11	43.22	8.06
EG2	36.12	7.98	46.12	7.54

4.3. Procedure

Each group was given four 30-minute sessions to learn Chinese idioms in a computer laboratory over a period of 5 weeks. The timing of these sessions (i.e., on which day and at what time during the day) was predetermined by us. Prior to the first session, the achievement test was administered as a pretest. At the end of these four sessions, the achievement test was immediately administered again as a posttest, and the motivational questionnaire was employed to collect student feedback. In addition, student interactions with the system were recorded in system logs; this allowed us to calculate time-on-task, so we could calculate a measure of learning effort for each student—the improvement in achievement test score divided his or her time-on-task across all four sessions. This ratio was defined because the improvement scores and time-on-task are two key indicators of the effort that students are spending on the learning task. In other words, we assume that a student who makes relatively large improvement per unit of time is putting more effort into learning than a student whose ratio is smaller.

4.4. Data Analysis

The independent variable of the experiment has three levels (the three system versions), whereas the dependent variables are scores obtained from the achievement test and motivational questionnaire. With regard to the achievement test, a one-way analysis of covariance (ANCOVA) was conducted, with groups as a between-subject variable, pretest scores as a covariate, and posttest scores as a dependent variable. In terms of the motivational questionnaire, four one-way analyses of variances (ANOVAs) were carried out, again using condition as a between-subject variable and each of the four subscale scores as a dependent variable. All of these analyses were conducted with a Statistical Package for the Social Science (SPSS Version 17).

4.5. Results and Discussion

4.5.1. Achievement Test. The mean and standard deviation (SD) for the pretest and the posttest in each group are presented in Table III. The results revealed that the scores of the posttest were all higher than those of the pretest in the three groups. These results suggest that students' learning achievement was improved in all three versions of the system. At the same time, the results of the ANCOVA showed that the posttest scores among the three groups were significantly different ($F(2, 46) = 3.183$, $p < .05$). Further Tukey HSD postcomparison found that the posttest scores for students in EG2 were significantly higher than those for CG and EG1 ($p < .05$), whereas there was no significant difference between the means for CG and EG1. These findings imply that EG2 students made greater improvement than CG and EG1 students. Because participants in EG2 used the full version of My-Pet-My-Arena, the results also imply

Table IV. Level of Effort Making

	Improved Score	Time-on-Task	Level of Effort Making
CG	7 (42.65–35.65)	88 (16+27+24+21)	7.9% (7/88)
EG1	5.44 (43.22–37.78)	72 (12+21+20+19)	7.5% (5.44/72)
EG2	10 (46.12–36.12)	91 (17+25+24+25)	10.98% (10/91)

Table V. Mean and SD of the Motivational Questionnaire in Three Groups

	Attention		Goal		Enjoyment		Challenge	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
CG	3.36	.70	3.55	.72	3.32	.92	3.38	.87
EG1	3.54	.67	3.86	.85	4.00	.73	3.88	.73
EG2	3.77	.76	4.14	.61	4.23	.67	4.20	.66

that this learning tool is beneficial for enhancing learning achievement in the Chinese idiom domain.

A possible explanation for this finding is that My-Pet-My-Arena Version 1 included the surrogate competition component; this element invited participants to observe and compare their learning progress against each other, which in turn may have motivated them to make improvements. Thus, participants who used My-Pet-My-Arena Version 1 made more significant improvements than those in the other two groups. These findings suggest that employing surrogates to create competition between students effectively increases student achievement.

4.5.2. Level of Effort. The aforementioned results suggest that the full My-Pet-My-Arena Version 1 leads to better learning performance than the control version or the version with the nurturing component. To examine these results more deeply, the levels of learning effort among the three groups were calculated based on the formula described below:

Level of effort making = Improved score/Time-on-task
Improved score = Posttest score − Pretest score
Time-on-task = Sum of time that students used the materials in four sessions

As shown in Table IV, the levels of effort making for students were significantly different ($F = 40.128$, $df = 2$, $p < .01$); furthermore, Tukey HSD postcomparison showed that the level of effort making for students in EG2 was significantly higher than those for CG and EG1 ($p < .01$). Because EG2 participants used My-Pet-My-Arena Version 1, the results imply that My-Pet-My-Arena Version 1 may help participants reach a higher level of learning effort. A possible reason is that My-Pet-My-Arena Version 1 involved the surrogate competition that engaged students in a comparison of the learning status among their peers, which in turn motivated them to improve their performance as quickly as possible. This result is consistent with those from the achievement test, which indicated that surrogate competition enhanced the learning outcomes.

To some extent, the level of effort-making behaviors may be regarded as an external indicator of student motivation. Thus, the results also implied that My-Pet-My-Arena Version 1 increased the level of motivation more than the other two systems. The major difference between My-Pet-My-Arena Version 1 and the other versions of the system was the surrogate competition; therefore, we infer that surrogate competition increases student motivation and enhances the effort that they put into the learning process.

4.5.3. Motivational Questionnaire. Table V displays the mean and SD for the four motivational constructs assessed in the questionnaire. Four one-way ANOVAs were conducted to assess the impact of the three versions of the learning system on each of

the constructs. The results showed that three of the measures—Goal, Enjoyment, and Challenge—differed significantly for the three systems ($F_{(2,65)} = 3.573$, $p < .05$; $F_{(2,65)} = 7.909$, $p < .01$; $F_{(2,65)} = 6.459$, $p < .01$, respectively). Tukey HSD postcomparison revealed that Goal, Enjoyment, and Challenge were higher for EG2 than CG ($p < .05$); Enjoyment for students in EG1 was also significantly higher than for those in the CG ($p < .05$).

These results suggest that students whose learning system included the My-Pet component (EG1 and EG2) may have felt greater enjoyment than those without the My-Pet. This is possibly because the presence of the My-Pet activity created a perception of obligation among students to care for their My-Pets; the My-Pets' feedback also indicates both the pets' degree of satisfaction and their desires for care. In other words, students' reactions to their interactions with the My-Pets may activate an emotional attachment and lead to an enjoyable experience. This finding is consistent with Kusahara [2000], which indicates that the development of emotional attachment toward virtual pets is essential for students to perceive that such virtual pets are important, even becoming "real" to them.

In addition, students whose learning system included the surrogate competition component (EG2) had stronger perceptions of goal, challenge, and enjoyment than those without this element (CG, EG1). A possible reason was that the competition mechanism emphasized a specific goal: winning the competition. Such a goal was challenging, but students liked and even enjoyed facing such a challenge. This may have been because they perceived that they would have a chance to win the competition if they simply kept participating in each competition. Such chances of winning were available because students' individual abilities were matched to the challenges that students needed to face. As suggested by Csikszentmihalyi [1990], an optimal experience is reached when students' abilities are matched with the challenges faced, which in turn influences their enjoyment. This is the reason that pursuing such a practical goal can be experienced as challenging, yet students enjoy it. Such issues imply that the design of the surrogate competition systems should be implemented in a way that matches students' abilities to the challenges of the competition so that students enjoy the pursuit of a goal during the competition. In other words, human characteristics (e.g., abilities) are an essential element in the design of surrogate competitions.

5. EXPERIMENT TWO

Although the results of Experiment One indicate that the surrogate competition within the My-Pet-My-Arena system enhances students' learning achievement, level of effort making, and motivation, we were unable to detect how surrogates affect students' views toward competition when compared to other direct competition mechanisms. The first experiment only examined the benefits of surrogate competition compared to other less rich versions of the learning environment. To address this issue, Experiment Two was conducted to investigate whether the surrogate competition would bring positive effects as direct competition while alleviating the negative effects.

5.1. Instruments

5.1.1. Two Different System Versions. Two systems were developed to address the second research question. The first was My-Pet-My-Arena Version 2, which exemplifies surrogate competition in a way similar to what was done in Version 1. The second system was the My-Competition system, which is similar to the other systems but implements a form of direct competition. Specifically, My-Pet-My-Arena Version 2 was developed to reinforce participants' impression of playing the role of masters to their virtual pets. Students using this version created both avatars and virtual pets (Figure 8(a)), but as in Version 1, the pets were used to reflect their learning status of Chinese idioms, and

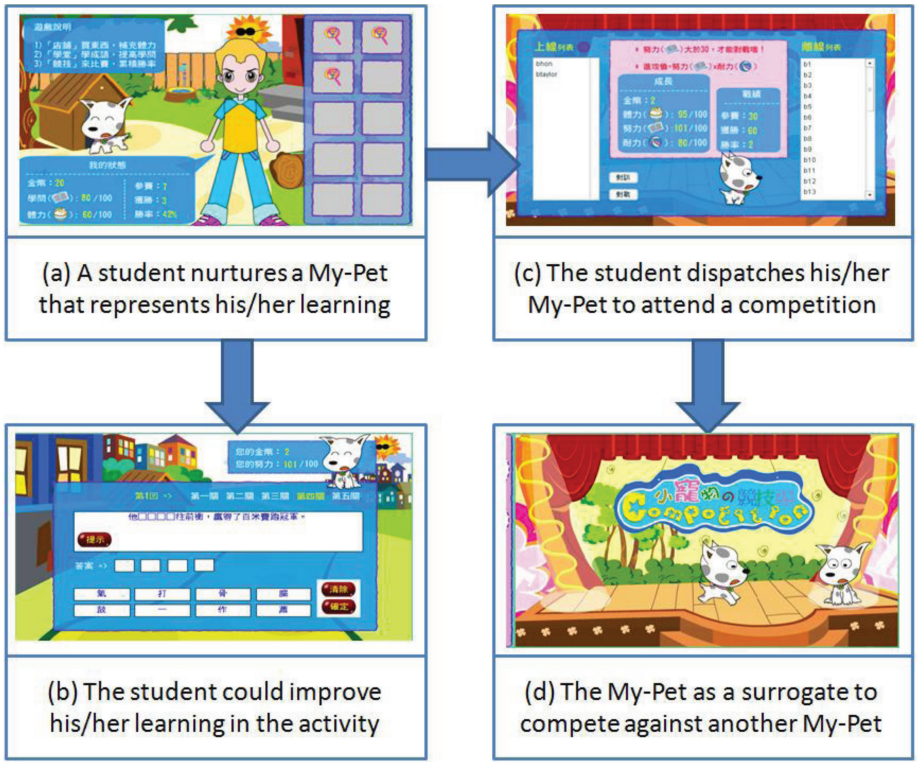

Fig. 8. My-Pet-My-Arena Version 2.

the pets were sent to the surrogate competition on their behalf (Figure 8(a)–(d)). Thus, My-Pet-My-Arena Version 2 is classified as surrogate competition.

Participants using the My-Competition system also possessed avatars; however, in this case, it was the avatars that took part in the competitions on behalf of the participants. As a result, it is the avatars that are tied to students' learning achievement with the Chinese idioms (Figure 9(a)). As is done for nurturing pets in the surrogate competition systems, students using My-Competition add to their learning achievement of Chinese idioms (Figure 9(b)) so that their avatars are able to win the competitions (Figure 9(c) and 9(d)). In this sense, the participants are directly involved in the competitions through their virtual self-representations or avatars. This is why this system is categorized as direct competition.

5.1.2. Attribution Questions. As described in Section 4.5.3, it is difficult to find an existing questionnaire that considers the strengths and weaknesses of surrogate competition. Thus, two attribution questions developed by the first author of this article were used to contrast students' attributions concerning each intermediate outcome in two groups. As illustrated in Table VI, one question was used when students won the competition, and the other was used when students lost the competition. Each question provided four options, and the participants chose the one reflecting their perceptions.

5.2. Participants

In Experiment Two, we used the same approach for selecting participants as we had followed in Experiment One, forming a between-subject quasi-experimental design. The participants consisted of two classes in an elementary school and were randomly

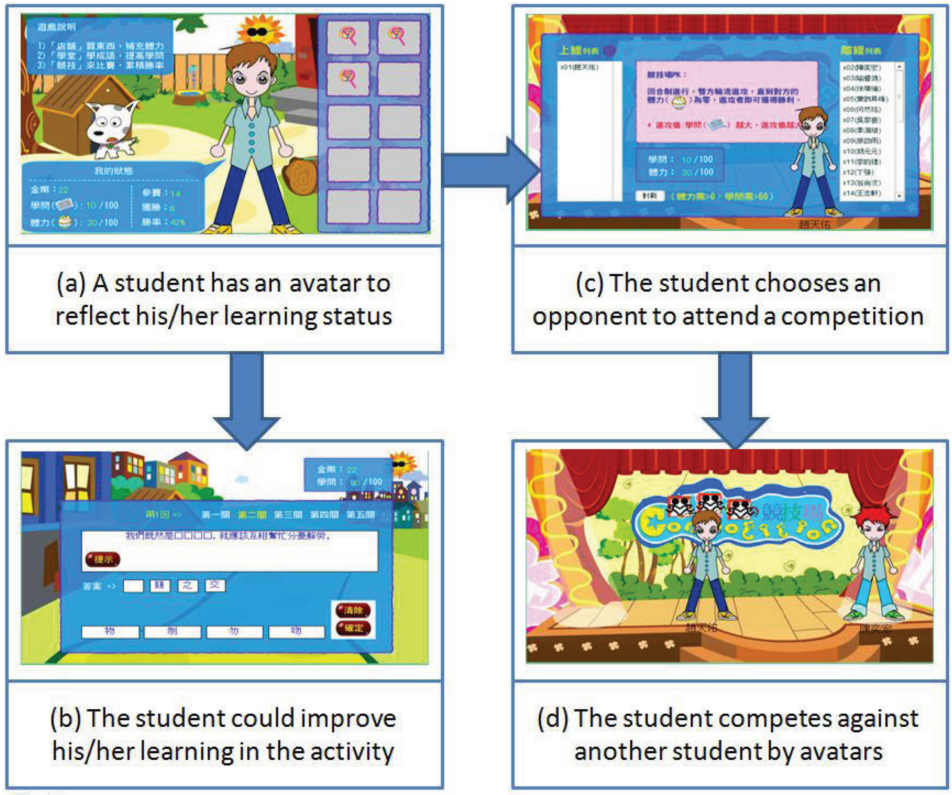

Fig. 9. My-Competition system.

Table VI. The Two Attribution Questions

The attribution question when winning:
I won the competition because (1) I had good luck, (2) I spent more effort learning Chinese idioms, (3) I spent more effort improving the status of the pets, (4) My Chinese idiom learning ability had improved.
The attribution question when losing:
I lost the competition because (1) I had bad luck, (2) I did not spend enough effort learning Chinese idioms, (3) I did not spend enough effort improving the status of pets, (4) My Chinese idiom learning ability had not improved.

Table VII. The Settings of the Two Groups

	Intervention	Participants	Genders (males:females)
CG	My-Competition	29	19:10
EG	My-Pet-My-Arena v2	32	18:14

assigned to one of the two systems. Table VII shows the different interventions and the distribution of the participants in each group.

5.3. Procedure

Each group was given two 50-minute sessions to use the system over a period of 2 weeks. At the beginning of the session, participants were told that they could use the system freely. During each session, each participant participated in the competition approximately 6 to 10 times to increase the validity of the collected data. The participants

Table VIII. Adjusting Frequency Data by Number of Wins or Losses

The attribution results for each student = (The number of times a particular attribution was selected for win/lose)/(The total number of competitions the student won or lost).
For example, suppose a given student won the competition 4 times and made attributions in the following pattern: Luck = 0, Effort in improving Learning = 2, Effort in training Pet = 1, Ability = 1. The win attribution data for that student would be: Luck = 0/4 or 0.0 Effort in Improving Learning = 2/4 or 0.50 Effort in Training Pet = 1/4 or 0.25 Ability = 1/4 or 0.25

Table IX. Students' Attribution between Two Groups When Winning and Losing

	Luck		Effort in Improving Learning		Effort in Training Pet		Ability	
	Win	Lose	Win	Lose	Win	Lose	Win	Lose
CG	0.10	0.15	0.32	0.21	0.02	0.06	0.05	0.05
EG	0.08	0.06	0.15	0.14	0.19	0.22	0.07	0.05

were able to choose their opponents freely, resulting in choices based on their preferences. In other words, participants knew whose avatars or pets they were competing against. Immediately following the competitions, both groups were required to answer the attribution questions.

5.4. Data Analysis

In this study, the independent variable was competition groups (i.e., EG and CG), and the dependent variables were the frequencies with which participants chose different attribution categories (i.e., luck, effort spent to improve learning, effort spent to train pet, and ability) and competition outcomes (i.e., win or lose). Thus, each student was associated with eight data points represented by the crossing of the four attribution categories with win/lose. Because students varied in how many times they won or lost the competition, these frequencies have been normalized for each student according to total wins or losses. The formula in Table VIII illustrates this calculation using an example.

After calculating attribution scores in this fashion for each student's wins and losses, we used a mixed-methods ANOVA, with one between-subjects variable (condition) and two within-subjects variables (winning or losing, and the four attribution choices) [Stephen and Hornby 1997; Hatch and Lazaraton 1991]. The analyses were conducted with a Statistical Package for the Social Sciences (SPSS Windows Version 17).

5.5. Results and Discussion

Table IX illustrates the result of the means, which were calculated across the normalized student choices described earlier; the table shows the distribution of choices across the four attribution options while winning and losing, broken down by the two groups. The ANOVA revealed that none of the effects concerning competition outcomes (i.e., win or lose) were associated with significant differences, including the main effect of competition outcomes; the two-way interactions between competition outcomes and groups and between competition outcomes and attribution; and the three-way interaction among competition outcomes, groups, and attribution. Although we cannot interpret a null result, it appears that winning and losing did not influence the attribution choice. As a result, we have simplified the means summary in Table X by collapsing across competition outcome.

To investigate the pattern of attributions between the two groups in Table IX, a simpler two-way ANOVA was conducted, with one between-subjects factor (condition) and one within-subjects factor (attribution category). This analysis revealed that a main

Table X. Students' Attribution between Two Groups

	Luck	Effort in Improving Learning	Effort in Training Pet	Ability
CG	0.25	0.54	0.09	0.11
EG	0.14	0.30	0.42	0.12

effect of attributions had significant differences ($F(3, 57) = 11.583$, $p < .01$) as well as an interaction between groups and attributions ($F(3, 57) = 12.223$, $p < .01$). This combination of effects implies that tests of simple main effects are needed. The following subsections examine the simple main effects of groups and attributions, respectively.

5.5.1. Comparison between Four Attributions. Regarding the CG, the result from an ANOVA indicated a significant difference among the four attributions ($F(3, 26) = 10.997$, $p < .01$). A further LSD post hoc test revealed that the number of students' attributions toward effort in improving learning was significantly higher than that attributed to luck, effort in training pets, and ability (i.e., $0.54 > 0.25 = 0.09 = 0.11$, respectively). Because students in the CG used the My-Competition system, this finding might imply that the My-Competition system had its primary impact on students' attributions regarding learning effort.

In other words, students in the CG tended to attribute their results toward effort made in improving learning, regardless of winning or losing. One possible interpretation for this was that the My-Competition system involved the representation of avatars to enhance their presence and participation. Because people tend to regard the behavior of their self-images as themselves [Nass et al. 1998], the avatars might enhance students' feelings of telepresence [Qiu and Benbasat 2005]. In particular, although students could clearly observe what they did and what the consequences were, the cause-and-effect relationship between learning effort and competition outcomes became clearer. This in turn may have fostered the attribution toward their effort in improving learning.

On the other hand, attribution theory [Weiner 1986] may be able to explain why students did not attribute their success or failure to ability. In this study, avatars were used to externally visualize students' learning status in the My-Competition system so that students can clearly observe how much progress they had made toward affecting the outcome of the competition. In other words, students cannot only see the final outcome of the competition, but they also perceive the relationships between the effort they have made and this outcome. By making this relationship more salient, students may come to believe that success or failure is controllable by them, instead of something that is fixed or otherwise uncontrollable. As claimed in attribution theory, a major difference between effort and ability lies within the fact that the former is controllable, whereas the latter is uncontrollable. Accordingly, students would attribute their success or failure to effort, which is a controllable factor, instead of an uncontrollable factor (i.e., ability).

With regard to the EG, the result of an ANOVA indicated that the number of students' attributions was significantly different ($F(3, 29) = 7.151$, $p < .01$), and a further LSD post hoc test revealed that the number of students' attributions toward effort in training pets and in improving learning were significantly higher than that toward luck and ability (i.e., $0.42 = 0.30 > 0.14 = 0.12$, respectively). Because students in the EG used My-Pet-My-Arena Version 2, this implied that the surrogate competition encouraged a larger number of attributions to effort that had been spent on nurturing the pet and improving learning.

In other words, students in the EG tended to attribute their results to effort they had spent either in training pets or in improving learning, regardless of winning or losing.

In addition to the aforementioned reasons explaining their attribution in improving learning, two possible interpretations might explain their attribution in training pets. The first interpretation was that My-Pet-My-Arena Version 2 enabled students to play as the pet-master, which further enhanced their sense of the responsibilities of caring for the pets. This may be why they chose this attribution. In addition, some students may have become aware of the fact that spending effort on training pets can actually improve their learning status and subsequently their competition outcomes. This might be the reason that some of students attributed their success to the effort made in improving learning.

The second potential reason was that My-Pet-My-Arena Version 2 strengthened students' responsibilities to be a good master so that they believed such failures were due to the lack of effort. Thus, they tended to attribute their 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 may be why some students attributed their failures to the effort made in improving learning.

5.5.2. Comparison between CG and EG. The result of ANOVAs revealed that significant differences existed between CG and EG in terms of "effort in improving learning" ($F(1, 59) = 8.643$, $p < .01$) and "effort in training pet" ($F(1, 59) = 34.104$, $p < .01$). Comparing the means in Table X, we observe that the major attribution in the CG was "effort in improving learning," and the major attribution in the EG was "effort in training pet." However, both of these attributions involve beliefs about effort spent rather than luck or ability. This implies that students in both the CG and EG attributed their competitive outcomes to effort. In other words, both of the systems (i.e., My-Pet-My-Arena and My-Competition) seemed to encourage students to attribute their outcomes toward effort.

Overall, the results of this study showed that the surrogate competition and direct competition had similar positive effects on effort attribution. A possible reason for such similar effects was that My-Pet-My-Arena Version 2 introduced two types of visual representations—avatars and virtual pets. Previous studies had indicated that the use of avatars may contribute to self-disclosure [Kang and Yang 2006], because avatars facilitate the linkage between users and onscreen characters; this in turn may increase a sense of participation [Lim and Reeves 2009]. Nevertheless, My-Pet-My-Arena Version 2 used for surrogate competition not only showed participants' avatars but also used virtual pets to promote their identities as masters. Perhaps this combination approach can enhance their feelings of ownership and responsibility even more, motivating them even more strongly to make great effort in caring for their pets. Consequently, My-Pet-My-Arena Version 2 had positive influences on students' attributions toward effort.

Another possible explanation is that the avatars used in My-Competition are perceived as less "direct" as self-identities, even though the avatars are used as a representation of students themselves. The avatars are customizable to look like human beings, but they are deliberately in a cartoon form, and such an appearance may not make students feel they are the real representation of themselves. In addition, both of the two systems (i.e., My-Pet-My-Arena Version 2 and My-Competition) involve some game elements, such as game fantasy, challenge, and reputation. Those game elements might have been mediating factors that influenced students' attributions.

6. IMPLICATIONS OF SURROGATE COMPETITION DESIGN

To summarize the potential impacts of the surrogate competitions, we created a design model (Figure 10) that can also provide guidance for other researchers or educators wishing to implement surrogate competition systems. The design model consists of

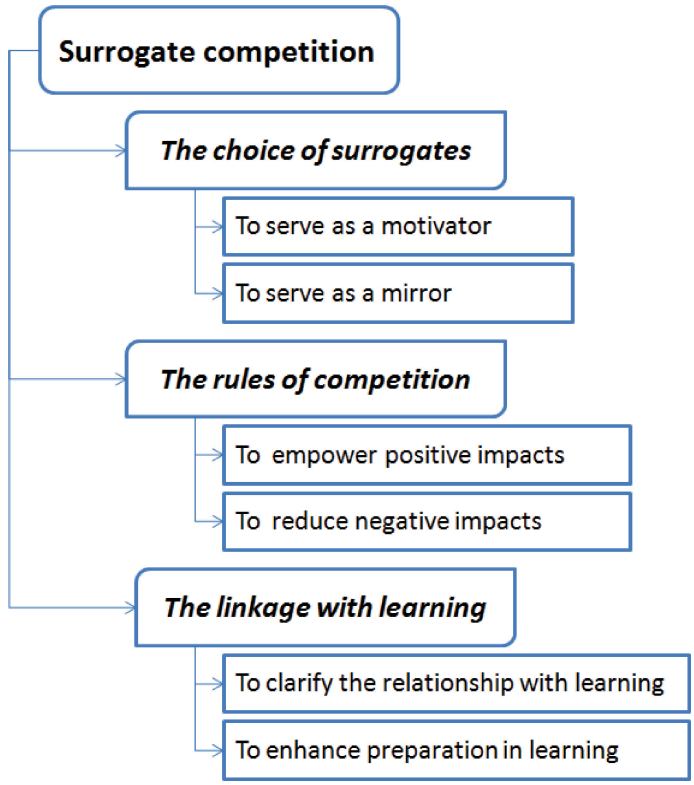

Fig. 10. Model for surrogate competition design.

three elements: the choice of surrogates, the rules of competition, and the linkage with learning.

6.1. The Choice of Surrogates

In this study, virtual pets operated as surrogates for their student-masters in two ways: (1) the student as master was motivated to own and use the surrogates, and (2) the student's surrogate (pet) served a mirror to reflect his or her own learning status. Regardless of their role as either a mirror or a motivator, the usefulness of a surrogate depends on building a specific social relationship between students and virtual pets. For example, the surrogate in the work reported here was used as part of a master-to-pet relationship. However, other social relationships might also be used—for example, tutor-to-tutee, peer-to-peer, mother-to-child, or even gardener-to-plant.

We offer two principles to guide a designer's choice of social relationships. The first principle is concerned with student perception: the surrogates should be attractive to students. This principle is a prerequisite of the surrogate competition because a lack of attractiveness will cause students to be uninterested in the surrogates. The perception of attractiveness might be enhanced even more if students receive feedback from their surrogates. More specifically, students tend to develop social relationships with characters that deliver feedback. They perceive that they are interacting with real characters when the feedback comes from the surrogates via computers. Such interaction motivates students to develop even deeper social relationships with the surrogates so that computer-human interaction is enhanced. For example, the systems

studied here visualized the hungry and ill status of virtual pets to attract students' attention to care for them. This helps students strengthen their intentions to act as good masters who are responsible for the health and success of their virtual pets. A strong sense of such responsibility may cause students to be proud or ashamed of their My-Pets' performance. Such perception further enhances the master-to-pet relationship, with which the interaction between computers and students is greatly improved.

The second principle is concerned with students' learning status: surrogates should reflect what students have learned and have yet to learn. In other words, the surrogates should act as a mirror to inform students of their current learning status. In fact, the use of surrogates to represent students' learning status is at the core of the surrogate competition concept. This intention could also be realized by using surrogates to deliver feedback to students, such as offering messages, hints, or even body language as a reminder of their learning status.

6.2. The Rules of Competition

In this study, the surrogate competition involved the comparison of two virtual pets. The design objectives are (1) to empower positive effects of competition on students' achievement and (2) to alleviate negative effects of competition on students' confidence. To achieve these two objectives, a game-playing approach was integrated with competition scenarios to create a learning game. More specifically, two students train their virtual pets and then dispatch them to compete against each other.

In addition to the aforementioned approach, other game-playing approaches can be incorporated into the competition scenarios by following two principles. The first is that specific game genres should be considered in the surrogate competition to empower positive effects. In addition to the pet-nurturing game genre used in this study, other game genres (e.g., role-playing games, adventure games) might also be taken into account because they engage students with enjoyable learning experiences.

The second principle is that the game-playing approach should work as a protective mechanism to reduce negative effects of competitions. For instance, students play as the pet-master in this study, which offers a reasonable explanation for personal competitive failures: they did not play well within the game, instead of not being able to play the game. Thus, students would not take competitive failures too seriously, resulting in the loss of confidence—after all, the competition is just a game. Therefore, such a game-playing approach serves as a protective mechanism to reduce negative effects.

6.3. The Linkage with Learning

In this study, the surrogate competition regarded learning activities as a necessary component, but the linkage is domain independent. The design rationale is that (1) the domain-independent linkage may reduce the complexity and cost of system maintenance and that (2) students' positive attitudes toward learning effort should be domain independent rather than merely focusing on a specific subject domain. To this end, a loosely coupled relationship was used in this study so that subject domains and competition are separated.

Nevertheless, it is worthwhile to consider more tightly coupled relationships in surrogate competition. Again, we offer two principles to consider more tightly coupled relationships. First, the surrogate competition can be closely incorporated into the knowledge of subject domain. More specifically, the rules of surrogate competition involve the use of domain knowledge. The consequence is that students would be required to use their domain knowledge to win the competition. In addition, the learning of domain knowledge and the participation in the competition happen in synchrony, instead of being two isolated entities. By doing so, surrogate competition

offers students learning opportunities within the competition rather than comparing the scores abstracted from two separate learning entities.

Second, the surrogate competition should provide students with opportunities to prepare themselves before the competition. For example, students, attending the surrogate competition before having sufficient preparation, should be warned of possible failures. Thus, students are required to better prepare themselves before the competition takes place. By doing so, students realize that being well prepared will enhance the chances of winning the competition.

7. CONCLUSIONS

The major research question of this study is *How can a surrogate competition model enhance students' perception and improve their learning performance?* Two research subquestions are included in the major research question. Regarding the first research subquestion—*How does surrogate competition affect students' learning motivation and learning achievement?*—the answer is that surrogate competition may assist students in perceiving the sense of goal, enjoyment, and challenge. Additionally, surrogate competition may also improve students' achievement. In regard to the second research subquestion—*How does surrogate competition affect students' views of the competition?*—the answer is that the surrogate competition may support students' development of positive attitudes toward competition. In brief, this study investigated the notion of surrogate competition, in which virtual pets acted as characters to mediate interaction (competition) between students. Furthermore, this study demonstrates that the employment of character-mediated communication may successfully alter students' attribution of their competition outcomes toward the effort made. As such, character-mediated communication provides new opportunities to the area of computer-human interaction.

In addition to contributing new opptunities, the results from this study also provide design implications in the area of computer-human interaction. The virtual pets are applied on behalf of students in this study, but each virtual pet is associated with an individual student. Thus, the negative comments made through the virtual pets have different effects from those made from the students themselves. These effects are supported by the claim made by Nass et al. [1998], which indicated that the effects of receiving negative evaluation from an image on a computer screen clearly differ from that of receiving negative comments from someone else. In other words, using others or virtual characters as surrogates may improve interaction between individuals, which in turn reflects the significance of character-mediated communication. Due to such significance, it is essential in the future to explore other characters, such as animals and plants, as surrogates to mediate students' interactions. Furthermore, there is a need to investigate the use of character-mediated communication in other applications, such as online shopping and video conferencing.

In summary, this study makes significant contributions in creating new opportunities and design implications of character-mediated communication. Due to the limitations of this study, further studies are required. First, because an author of this article developed the motivational questionnaire used in the first experiment and the attribution questions used in the second, the reliability and validity of these measures should be further examined and improved. Second, the study investigated only one type of surrogate (pets) and relationship to the participant (master-pet) and did so within a single learning domain (Chinese idioms). Further research should explore other types of surrogate characters and relationships and evaluate impacts on learning in other domains. Finally, although this study discovered positive effects of surrogate competition on student learning, it was a short-term study only. Thus, future examinations of the long-term effects of surrogate competition are necessary.

APPENDIX

Examples of the questions on the achievement test:

	Question item	Answer
Word-identification	請填入正確的字：杯 □ 蛇 影 供 (2) 公 (3) 弓 (4) 攻	弓
Word-sequencing	請排出正確的順序： (1) 為 (2) 狼 (3) 奸 (4) 狽	(2) 狼 (4) 狽 (1) 為 (3) 奸
Idiom-apply	參加辯論賽的同學，各個都是□ □□□，辯才無礙的高手。 (1)方寸已亂 (2)口若懸河 (3)一曝十寒 (4)人面桃花	(2) 口若懸河

ACKNOWLEDGMENTS

The authors would like to thank the National Science Council of the Republic of China, Taiwan, for financial support (NSC-101-2511-S-155-004-MY2; NSC 101-2511-S-008-010-MY3; NSC 102-2511-S-008-002-MY2).

REFERENCES

R. Butler and A. Kedar. 1990. Effects of intergroup competition and school philosophy on student perceptions, group processes, and performance. *Contemporary Educational Psychology*, 15, 301–18.

T. W. Chan, Y. L. Chung, R. G. Ho, W. J. Hou, and G. L. Lin. 1992. Distributed learning companion systems—WEST revisited. In *Proceedings of the 2nd International Conference of Intelligent Tutoring Systems*. Springer-Verlag, 643–650.

S. B. Chang, Y. C. Deng, H. N. H. Cheng, H. C. Liao, F. Y. Yu, and T. W. Chan. 2007. Implementation and Evaluation of EduBingo for Arithmetic Drill. In *Proceedings of the 1st IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning*. 99–103.

S. B. Chang, C. J. Liu, E. Ching, H. N. H. Cheng, B. Chang, F. C. Chen, D. Wu, and T. W. Chan. 2009. EduBingo: Developing a content sample for the one-to-one classroom by the content-first design approach. *Educational Technology and Society* 12, 3, 343–353.

Z. H. Chen, C. Y. Chou, Y. C. Deng, and T. W. Chan. 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.

Z. H. Chen, C. C. Y. Liao, T. C. Chien, and T. W. Chan. 2011. Animal Companions: Fostering children's effort-Making by nurturing virtual pets. *British Journal of Educational Technology*, 42(1), 166–180.

H. N. H. Cheng, W. M. C. Wu, C. C. Y. Liao, and T. W. Chan. 2009. Equal Opportunity Tactic: Redesigning and applying competition games in classrooms. *Computers and Education*, 53(3), 866–876.

P. R. Clinkenbeard. 1989. The motivation to win: negative aspects of success at competition. *Journal for the Education of the Gifted*, 12, 293–305.

A. Collins, J. S. Brown, and S. E. Newman. 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*. Lawrence Erlbaum Associates, Hillsdale, NJ.

M. Csikszentmihalyi. 1990. *Flow: The Psychology of Optimal Experience*. Harper & Row, New York.

G. Davis and S. Rimm. 1985. *Education of the Gifted and Talented*. Prentice-Hall, Englewood Cliffs, NJ.

E. Deci, G. Betley, J. Kahle, L. Abrams, and J. Porac. 1981. When trying to win: Competition and intrinsic motivation. *Personality and Social Psychology Bulletin*, 7, 79–83.

J. Dempsey, K. Rasmussen, and B. Lucassen. 1994. Instructional gaming: Implications for instructional technology. The Annual Meeting of the Association for Educational Communications and Technology, Nashville, TN, 16–20.

M. D. Dickey. 2005. Engaging by design: How engagement strategies in popular computer and video games can inform instructional design. *Educational Technology Research and Development* 53, 2, 67–83.

M. D. Dickey. 2007. Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Education Tech Research* 55, 253–273.

C. Dweck. 2000. *Self-Theories: Their Role in Motivation, Personality, and Development*, Essays in Social Psychology. Psychology Press, Philadelphia, PA.

F. L. Fu, R. C. Su, and S. C. Yu. 2009. EGameFlow: A scale to measure learners' enjoyment of e-learning games. *Computers and Education* 52, 1, 101–112.

J. P. Gee. 2003. What *Video Games Have to Teach Us About Learning and Literacy* (1st ed.). Palgrave Macmillan, New York.

E. Hatch and A. Lazaraton. 1991. *The Research Manual: Design and Statistics for Applied Linguistics*. Newbury House, New York.

Y. B. Kafai, D. A. Fields, and M. S. Cook. 2007. Your second selves: Resources, agency and constraints in avatar design in a tween online world. In *Proceedings of the Digital Games Research Association (DIGRA'07)*. 31–39.

H. S. Kang and H. D. Yang. 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.

F. Ke. 2008a. Computer games application within alternative classroom goal structures: Cognitive, metacognitive, and affective evaluation. *Educational Technology Research and Development* 56, 5, 539–556.

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

Kinshuk. 1996. *Effectiveness of Intelligent Tutoring Tools Interfaces in Relation to Student, Learning Topic and Curriculum Characteristics*. Unpublished doctoral dissertation. De Montfort University.

M. Kusahara. 2000. The art of creating subjective reality: An analysis of Japanese digital pets. In *Proceedings of the Artificial Life 7 Workshop*. 141–144.

K. S. Lee and Y. F. Tse. 1994. Hanyu Characteristics and Usage. Hong Kong University Press, Hong Kong.

S. Lim and B. Reeves. 2009. Being in the game: Effects of avatar choice and point of view on psychophysiological responses during play. *Media Psychology* 12, 348–370.

R. W. P. Luk and A. B. Y. Ng. 1998. Computer-assisted learning of Chinese idioms. *Journal of Computer Assisted Learning* 14, 2–18.

T. W. Malone and M. R. Lepper. 1987. Making learning fun: A taxonomy of intrinsic motivations for learning. In R. E. Snow and M. J. Farr (Eds.), *Aptitude, Learning, and Instruction, III: Conative and Affective Process Analysis*. Hillsdale, NJ: Lawrence Erlbaum Associates, Hillsdale, NJ, 223–225.

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

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

C. Nass, E. Y. Kim, and E. J. Lee. 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.

M. Prensky. 2001. *Digital Game-Based Learning*. McGraw-Hill, New York.

M. Prensky. 2007. Students as designers and creators of educational computer games. *British Journal of Educational Technology* 39, 6, 1004–1019.

L. Qiu and I. Benbasat. 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.

H. Sharp, Y. Rogers, and J. Preece. 2007. *Interaction Design: Beyond Human-Computer Interaction*. Wiley, Hoboken, NJ.

R. E. Slavin. 1990. *Cooperative Learning: Theory, Research, and Practice*. Prentice-Hall, Englewood Cliffs, NJ.

D. A. Stapel and W. Koomen. 2005. Competition, cooperation, and the effects of others on me. *Journal of Personality and Social Psychology* 88, 1029–1038.

P. Stephen and S. Hornby. 1997. *Simple Statistics for Library and Information Professionals*. Library Association, London, UK.

Z. Waggoner. 2009. *My Avatar, My Self: Identity in Video Role-Playing Games*. McFarland, Jefferson, NC.

B. Weiner. 1985. An attributional theory of achievement motivation and emotion. *Psychological Review* 92, 548–573.

B. Weiner. 1986. *An Attributional Theory of Motivation and Emotion*. Springer-Verlag, New York.

B. Weiner, R. Nicrenberg, and M. Goldstein. 1976. Social learning (locus of control) versus attributional (causal stability) interpretations of expectancy of success. *Journal of Personality* 44, 52–68.

L. H. Wong, C. K. Chih, C. L. Tan, and M. Liu. 2010a. Students' personal and social meaning making in a Chinese idiom mobile learning environment. *Journal of Educational Technology and Society* 13, 4, 15–26.

L. H. Wong, C. K. Chih, C. L. Tan, M. Liu, and Y. Zhan. 2010b. Analysis of the learner content creation process in a 1:1 seamless idiom learning environment. In *Proceedings of the International Conference on Computers in Education*. 352–359.

W. M. C. Wu, H. N. H. Cheng, M. C. Chiang, Y. C. Deng, C. Y. Chou, C. C. Tsai, and T. W. Chan. 2007. AnswerMatching: A competitive learning game with uneven chance tactic. In *Proceedings of the 1st IEEE International Workshop on Digital Game and Intelligent Toy Enhanced Learning*. 89–96.

F. Y. Yu, L. J. Chang, Y. H. Liu, and T. W. Chan. 2002. Learning preferences towards computerized competitive mode. *Journal of Computer-Assisted Learning* 18, 341–350.

Received October 2011; revised July 2013; accepted September 2013