

Substitutive competition: Virtual pets as competitive buffers to alleviate possible negative influence on pupils

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Abstract

Although competition is regarded as a powerful motivator in game-based learning, it might have a negative influence, such as damage to confidence, on students who lose the competition. In this paper, we propose an indirect approach, substitutive competition, to alleviate such negative influences. The approach is used to develop a My-Pet v3 system, in which pupils master subject materials to make their pets stronger, and compete against each other. Specifically, pupils learn Chinese idioms in a pet-training game scenario, and their mastery of the material is related to the pets' strength to win the competition. The result of the competition is influenced by whether pupils spend enough effort on the learning tasks. This intention is expected to alleviate the negative influence that results from direct competition. A within-subject experiment was conducted to examine the influence of substitutive competition. The results indicated that substitutive competition seems a promising scheme to maximise the power of competition. However, there were no apparent evidences in this study to demonstrate its effect to alleviate pupils' sense of failure, as compared with other two direct competition conditions.

Practitioner notes

What is already known about this topic:

- Competition is a critical factor in technology-enhanced learning.
- The possible negative influences of competitive learning should be a cause for concern.
- Several approaches have been applied to learning successfully, such as anonymous competition and group competition.

What this paper adds:

- This paper proposes a new approach—substitutive competition.
- Students prepare their substitutes, ie, virtual pets, to compete with others' surrogates, instead of direct competition.

- Because of the existence of buffers, students might be protected from the possible damages to confidence when they lose in the competition.
- The result of the experiment showed that substitutive competition lowered students' sense of failure, but the difference was not statistically significant.

Implications for practice and/or policy:

- Classrooms are a social context that has social comparison and competition.
- Competitive learning is powerful but might also be harmful if the possible negative influences are not taken into account.

Introduction

Recently, digital game-based learning has attracted increasing attention from researchers (Alkan & Cagiltay, 2007; Connolly, Stansfield & Hainey, 2007) because it involves a series of critical elements that are also emphasised in the learning process, such as active participation, deep engagement, and learning from exploration and trials (Crawford, 1982). Thus, some researchers believe that gameplaying could be a useful pedagogy when good principles of game design are incorporated in the activity design (Gee, 2003; Norman, 1993). In other words, if students can benefit by the core values of learning theory from digital games, engaging students and teaching them how to play to win the games, digital games can be powerful in the educational settings (Šisler & Brom, 2008).

However, from a review of the characteristics of digital games, 'competition' is seldom taken into account (Yu, Zhang, Ren, Zhao & Zhu, 2010), although it is acknowledged as a significant factor (Lo, Ji, Syu, You & Chen, 2008). This might be due to the fact that ill-designed competition possibly has a negative influence on students' self-confidence (Chan, Chung, Ho, Hou & Lin, 1992), self-efficacy (Stapel & Koomen, 2005), attitude towards failure (Collins, Brown & Newman, 1989) or interpersonal relationships (Dunn & Goldman, 1966).

To overcome these negative influences, two approaches have been investigated. The first one is the *anonymous approach*, which provides an anonymity mechanism to diminish the negative influences resulting from face-to-face competition (Yu, Chang, Liu & Chan, 2002; Yu & Liu, 2009). Anonymity ensures that students' loss will not be exposed to others, which might be helpful in reducing possible damage to students' self-confidence.

The second one is the *group approach*, in which competition is integrated with some cooperative activities. For instance, student team achievement divisions (STAD) and team game tournaments (TGT) are such intra-team cooperation and inter-team competition modes (Ke, 2008a, b; Slavin, 1990). In these modes, students' learning involves competition, but all of the team members share the responsibility for the result. Thus, they could alleviate the possible negative influence of losing the competition. Nevertheless, although these two approaches are helpful to the development of competitive learning, they are not always suitable for certain learning contexts, especially for individual learning contexts without an anonymity mechanism. In other words, there is a need to explore other approaches to make competitive learning be more flexible in educational practice.

Design rationale

Competition is a social comparison process involving the direct comparison of students' ability in public (Cheng, Wu, Liao & Chan, 2009; Gilbert, Giesler & Morris, 1995; Mussweiler, 2003). Such direct competition might motivate students to prepare themselves for the competition, but might also result in possible negative effects. For example, the experience of accumulated failures might

damage students' level of confidence, attitudes and even belief in future learning. Consequently, this study proposes an indirect approach, *substitutive competition*, in which students' surrogates attend the competition instead of students themselves. More specifically, according to the relationship of involved competitors with the students themselves, competitive models can be categorised into *direct competition* and *indirect competition*. With regard to direct competition, students compete via different levels of information showing themselves from names, pictures, to embodied avatars. Because involved competitors directly represent some kinds of students' identities in these competitive modes (ie, name-direct, picture-direct and avatar-direct models), students, to some extent, feel that they are directly involved in the competition. Consequently, these models are categorised as direct competition. With regard to indirect competition, students compete via their substitutes, such as their apprentices, students or pets. These substitutes maintain some relationship with students, but the substitutes are not students themselves. Accordingly, students could prepare, coach or train these substitutes and dispatch substitutes to attend the competition for them.

In this study, we investigate the pet-indirect competitive model, of which the research questions are as follows: (1) how to design such a substitutive competition maximizing the power of competition as well as alleviating the possible negative influences; and (2) what are the influences of substitutive competitions on pupils' perceptions when they win and lose the competition. To address the research questions, a learning system, My-Pet v3, was developed based on this approach for examining its influence on pupils. Before the My-Pet v3 system is described, two design rationales for substitutive competition are introduced first.

Indirect competition: virtual pets as buffers to competition

Because indirect competition holds substitutes for students, it might bring a major advantage: the substitutes as competitive buffers alleviate possible damages to pupils' self-confidence or self-efficacy when they lose in the competition. Meanwhile, because pupils are still responsible for preparing their substitutes for competition, they might preserve the sense of achievement when they win the competition.

In this study, we choose virtual pets as substitutes in competition. This is done for two reasons. First, as suggested in previous research, the relationship with virtual pets has the potential to establish deeper bond with pupils (Kusahara, 2000) because pupils tend to form an emotional attachment to their pets (Beck & Katcher, 1996; Melson, 2001). One well-known example of pet-caring is *Tamagotchi*, where virtual pets beep every so often to remind students to feed them (Bandai, 1996; Pesce, 2000; Webster, 1998). Although this interaction design is simple, a number of pupils interact with the virtual for a long period of time. Owing to the pets' close relationship with pupils, we choose virtual pets as competitive substitutes.

Second, previous studies have also suggested that virtual pets could act as learning companions to interact with pupils (Chen, Chou, Deng & Chan, 2007; Chen, Liao, Chien & Chan, 2011). In the concept of the open learner model, students' learning profiles are visible so that they can be reflected by themselves (Bull, 2004; Bull & Kay, 2007; Bull & Nghiem, 2002). Consequently, virtual pets could act as substitutes of open learner model to compete against others, which is helpful to foster the awareness, communication and negotiation of their open learner models.

Shaping positive attribution to the results of competition

Although competition can serve as a powerful motivator to stimulate some students to learn, it is significant to be concerned with what pupils attribute to the results of competition. This is because what pupils attribute to the results will greatly influence their subsequent behaviours (Weiner, 1985, 1992). Two key factors that dominate perceived causes are *ability* and *effort*. From the educational viewpoint, pupils should also be encouraged to make effort in learning instead of

admiring their present abilities. This is because students have opportunities to change the result if they attribute the failure to the lack of effort, which could be controlled by themselves (Weiner, Nicrenberg & Goldstein, 1976).

Other research also emphasises the importance of learning effort based on the belief that intelligence is fixed or malleable (Dweck, 2000). Those people who believe intelligence is malleable tend to attribute their failures to lack of effort. Consequently, they will seek for improvement opportunities. In contrast, those people who believe that intelligence is fixed tend to attribute their failures to the inferiority of intelligence, which could make them feel helpless if they frequently meet with failures.

Moreover, it has been found that not all students realise the importance of effort (Seligman, 1990, 1994), although it is possible to help students to learn to change these beliefs that they hold through some approaches (Dweck, 2000). Accordingly, another intention for the substitutive competition is to help pupils be more aware of the significance of learning effort.

On the one hand, through preparation and training of their virtual pets, pupils are encouraged to be more responsible for their current learning status and the efforts they made. On the other hand, if a pupil loses in a competition, he or she will also have a reason for the failure—ie, I did not spend sufficient time and effort to train my pet; it is not a matter of my ability. In other words, pupils' attribution to their learning abilities has been shifted to the attribution to their effort-making behaviours. Underpinned by such a design rationale, we hope the substitutive competition could help pupils shape their positive attribution and belief in learning efforts.

My-Pet v3 system

A My-Pet v3 system is developed according to the concept of *substitutive competition*. The target users are elementary school students. As shown in Figure 1, the learning flow of the My-Pet v3

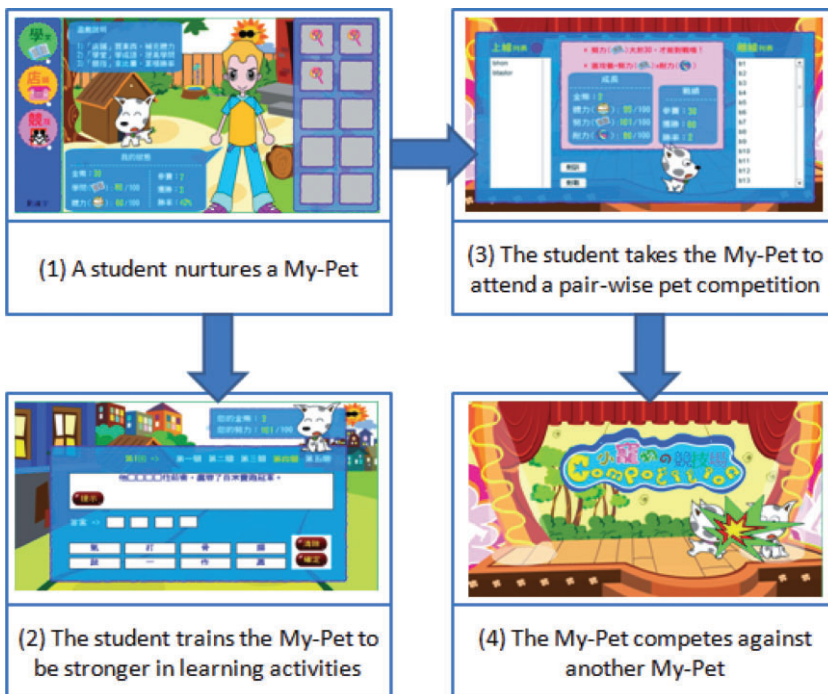


Figure 1: Snapshots from the My-Pet v3 system

system involves three functions: *pet nurturing*, *pet training* and *pet competition*. In the pet-caring function, pupils play the part of masters to look after the pet, named My-Pet; in the pet-training function, the pupils play the part of trainers, who conduct learning tasks in a game scenario for pet training; in the pet-competition function, the pupils play the part of cheerleaders to participate in the pet competition.

Pet nurturing

In the My-Pet v3 system, a pupil is offered an avatar whose appearance, such as gender, hair, eyes, eyebrows, clothes, pants, and shoes, can be customised to the pupil's preferences. The intention to provide pupils with avatars will engage the pupils' interest in the virtual learning environment, a method suggested by previous studies (Feldon & Kafai, 2008). Each pupil owns a My-Pet, and his or her game goal is to take good care of it. The pet's current status is indicated by several numerical attribute values. For example, it can be seen in Figure 1 that the My-Pet inhabits a backyard, and has two attributes, 'energy' and 'learning effort'. The former is related to the hungeriness of the My-Pet, and can be increased by feeding the My-Pet; the latter is concerned about the pupils' learning status, which will further influence the My-Pet's emotions and mood and can be improved with the pet-training function.

To take good care of the My-Pet, the pupil needs to inspect these two attribute values. In a sense, the pupil's taking good care of the pet is exactly taking good care of his or her learning status because the My-Pet reflects its master's learning status (eg, learning effort is one indicator of significant learning status) and will remind their master to improve them. In addition, the pupil also needs to regularly feed the My-Pet to maintain its life. This process could be helpful to maintain pupils' motivation to participate.

Pet training

The pet-training function is directly related to pupil learning. Although the design of learning activities in the My-Pet v3 system is domain-independent, in this study, we use language as the domain subject and Chinese idioms as the learning material. Idioms are important because they play a significant role in Chinese language learning, especially the aspect of writing (Luk & Ng, 1998). Chinese idioms are needed to shorten long passages, making them more concise and vivid. Students require the skill to use Chinese idioms (Lee & Tse, 1994). Thus, the My-Pet v3 provides a series of learning tasks to help the pupil master Chinese idioms, from the basic (word identification and word sequencing) to the advanced level (context\ application). More specifically, the learning tasks in Chinese idioms can be divided into five stages: word identification, advanced word identification, word sequencing, advanced word sequencing, and context application. The pupils need to pick out four words in a specific idiom one by one in the correct sequence, avoiding the selection of similar but erroneous words.

The pupils conduct these learning tasks in a pet-training scenario, where progress with the learning tasks can directly raise the value of 'learning effort' to encourage effort-making. Pupils also gain EduCoins as rewards to encourage their learning achievement. These EduCoins can be used to purchase pet food to raise the value of 'energy.' The two attributes (ie, energy and learning effort) further dominate the results of the pet competition.

Pet competition

Game-based learning has potential benefits for learning. In the affective dimension, digital games can engage pupils in a virtual environment, which could be applied in learning settings (Crawford, 1982). A number of cognitive gains are also reported to be brought about by digital games, including problem-solving skills (Rieber, 1996), situated learning and critical thinking skills (Gee, 2003). Note that digital games can also be employed to shape pupil attitudes (Dempsey, Rasmussen & Lucassen, 1994). In other words, digital games could be a possible vehicle to change pupils' behaviours, attitudes and even beliefs.

To this end, we design a peer-wise pet-competition game, whose competitive result is based on the comparison of the two attribute values described above (ie, 'energy' and 'learning effort') following a competition formula. The intention of the competition formula is to make pupils understand that learning effort is the major element needed to win the game. More specifically, pupils are situated in the competition context, in which they are more aware of the fact that the more effort they make in idiom learning, the greater the chance that their My-Pets will win the competition.

The detailed flows of the competition are described as follows: (1) The pupil needs to find another pupil who is online and ready for the pet competition. (2) In each round, the My-Pet is awarded an attack score, which will decrease the opponent's 'energy' value, following the given formula: $\text{attack score} = (\text{the 'learning effort' value of My-Pet}) \times (\text{the number obtained from a dice})$. (3) The setting of the dice is again related to the 'learning effort' value. Thus, a higher 'effort' value implies that the number of the dice obtained would be bigger. In summary, the competition result is greatly influenced by the 'learning effort' value. (4) The competition continues until the 'energy' value of one of the My-Pets becomes empty, losing the game.

Method

The second research question, *what are the influences of substitutive competitions on pupils' perceptions when they win and lose the competition*, is investigated in the experiment. To answer the question, a within-subject quasi-experiment was conducted in an elementary school in Taiwan.

Participants and materials

Participants were 89 fifth grade pupils from three different classes. The pupils were aged either 10 or 11. There were 29 participants aged 10.3 in average from Class A, 29 participants aged 10.4 in average from Class B, and 31 participants aged 10.1 in average from Class C. The elementary school has a policy of normal distribution and randomly assigns students on that basis to classes at the start of the school year. Accordingly, it is our assumption that the children in each of the three groups have uniform learning backgrounds and learning abilities. In addition, Chinese idioms are selected as the learning material because they are regarded as holding a significant role in language learning. The participants in the school are provided with additional learning materials to enhance their abilities.

Procedure

Three different versions of the My-Pet v3 system were prepared for this experiment: *name-direct*, *avatar-direct* and *pet-indirect* versions. As illustrated in Figure 2, the former two versions both feature direct competition, in which pupils master Chinese idioms to make themselves stronger to compete with each other. The major difference between the two versions is the level of self-image

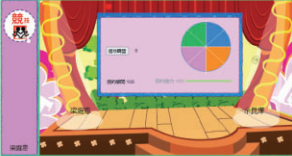


	<i>Name-direct version</i>	<i>Avatar-direct version</i>	<i>Pet-indirect version</i>
System snapshot			
Description	Students compete against the opponent with name shown	Students compete against the opponent via their avatars (also see their names)	Students compete against the opponent via their pets (also see their masters' names)

Figure 2: Settings for the three different versions of the My-Pet v3 system

that the system presents. More specifically, pupils in the name-direct competition see their real names, whereas pupils in the avatar-direct competition see their real names as well as an avatar that they could customise. In the last version, the pet-indirect competition, pupils master Chinese idioms to make their pets stronger so that their pets can compete against each other.

To prevent the order effect of these treatments, the three classes of participants were presented system versions in a different order, as shown in Table 1. Specifically, the participants in Class A first used the pet-indirect version, then the name-direct version and, finally, the avatar-direct version. Participants in Class B used the systems in the following order: name-direct, avatar-direct and pet-indirect versions. Participants in Class C used the systems in the following order: avatar-direct, pet-indirect and name-direct versions. Each class had three 60-minute sessions in a computer laboratory over 3 weeks. During each session, each participant approximately has 6–10 times to compete so that each one could gain experience of winning and losing in the competition. At the end of the sessions, a questionnaire consisting of two questions were employed to collect participants' preferences. They were asked to indicate which version among the three enhanced most their sense of achievement and their sense of failure, respectively. The first question was, *which version provided you with the greatest feeling of achievement when you won the competition?*; and the second one was, *which version made you feel the greatest sense of failure when you lost the competition?* For each question, each participant needed to choose one of the three versions.

Table 1: Participants and interventions in the three classes

	Session 1	Session 2	Session 3
Class A ($n = 29$)	Pet-indirect	Name-direct	Avatar-direct
Class B ($n = 29$)	Name-direct	Avatar-direct	Pet-indirect
Class C ($n = 31$)	Avatar-direct	Pet-indirect	Name-direct

Data analysis

The independent variable of the experiment was the different settings of the three system versions, whereas the dependent variables of the experiment were the pupils' preferences when they won and lost the competition. Two chi-square tests were conducted to further validate its significant difference. All these analyses were conducted with the Statistical Package for the Social Science (SPSS Windows v.13, IBM, Chicago, IL, <http://www.spss.com/>).

Results and discussion

Sense of achievement when pupils won

Figure 3 illustrated pupil preferences for different versions. The y -axis indicated the number of pupils who showed their preferences. The results showed the following two phenomena: first, the avatar-direct ($n = 40$) and pet-indirect ($n = 39$) versions had higher impact on the pupils' sense of achievement than the name-direct version ($n = 10$). The result of the chi-square test indicated that their preference is significant different ($\chi^2 = 19.57$, degree of freedom [df] = 2, $p < 0.05$). One possible explanation for the result was whether virtual characters existed, which were representative of pupil participation. The former two versions involved the embodied representation of virtual characters (ie, avatars or virtual pets) to enhance the presence and participation in the competition context; whereas the latter version showed only the name of the pupil. In other words, when pupils won the competition, their sense of achievement was closely related to the level of representation of their identities. Thus, the avatar-direct version enhanced the pupils'

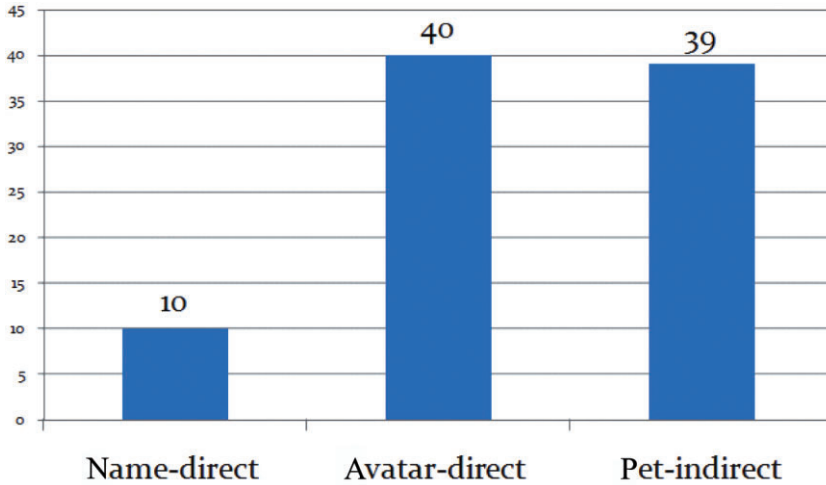


Figure 3: Student preferences for which version enhances the sense of achievement

sense of achievement because the pupils knew that the system revealed their names as well as their avatars, which, in turn, helped their opponents sense the identity of the winner. Similarly, the pet-indirect version also enhanced the pupils' sense of achievement because the system showed both their names and their pets, which also contributed to the recognition of their identities.

Second, the avatar-direct ($n = 40$) and pet-indirect ($n = 39$) versions had similar impacts on the pupils' sense of achievement. In other words, the existence of avatars or pets was able to increase the sense of achievement for pupils winning the competition. A reasonable explanation is that avatars can contribute to the revelation of their representation. This result was consistent with the findings of previous studies, that avatars are helpful with self-disclosure (Kang & Yang, 2006). The use of an avatar facilitates the linkage of pupils to an onscreen surrogate, which, in turn, increases the sense of participation (Lim & Reeves, 2009).

Nevertheless, the usage of virtual pets has seldom been discussed in the literature on technology-enhanced learning, although emotional attachment to pets plays an important role in our lives (Melson, 2001), whether real pets (Levinson, 1969) or virtual ones (Kusahara, 2000). It seems that the virtual pets are somewhat representative of the participation of their masters. That is, the pet can be regarded as a substitution or agent of the pupil reflecting the image of their masters as well as the level of effort their masters have made in training. Consequently, the existence of the pets in the pet-indirect version could enhance the winning pupils' sense of achievement.

Sense of failure when pupils lost

Figure 4 illustrated pupil preferences for different versions when they lost the competition. The y -axis indicated the number of pupils who show their preferences. It showed that the avatar-direct version ($n = 38$) had a higher influence on pupils' sense of failure than the name-direct ($n = 26$) and pet-indirect ($n = 25$) versions; however, the result of the chi-square test indicated that their preference had no significant difference ($\chi^2 = 3.528$, $df = 2$, $p > 0.05$). This implied that the influence of the three groups on pupils' sense of failure is statistically the same when they lose the competition, although the score of avatar-direct competition version is higher than that of the name-direct and pet-indirect versions. In other words, the pupils had three apparently different perceptions when they lost the competition. Some pupils felt that the name-direct version made them have the greatest sense of failure; some felt the avatar-direct and some felt the pet-indirect.

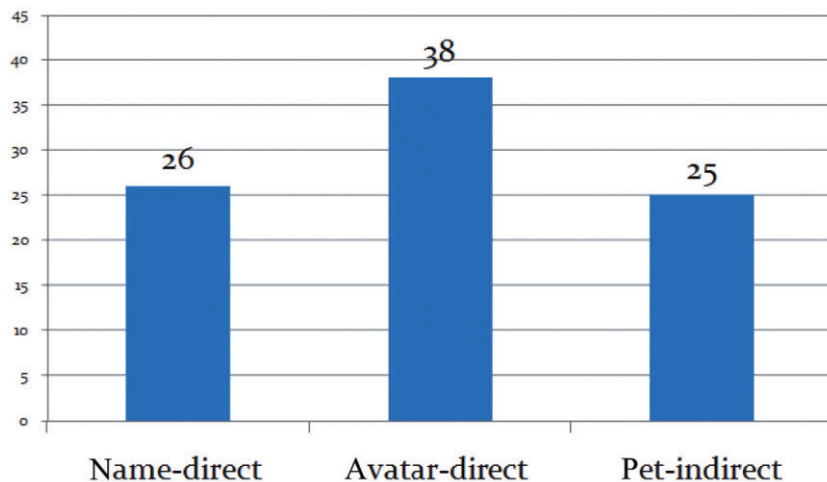


Figure 4: Student preferences for which version brings the sense of failure

For those who chose the name-direct version, a possible reason to explain this was that the name-direct version involved the revelation of pupils' names, which showed their failures to others and thus was harmful to self-image. For those who chose the avatar-direct version, it could be explained by a possible cause that the avatar-direct version not only showed students' names but also their avatars that represented themselves. The result could also be explained by the evidence that the presence of avatars enhances self-disclosure (Kang & Yang, 2006), which, in turn, would increase the feelings of failure. In other words, their perceived failures were reinforced by the two kinds of information. This might be the reason why more students chose the avatar-direct version than the name-direct version. For those who chose the pet-indirect version, a possible reason was that students felt they should be responsible for the failure of the competition, although their pets attended the competition instead of themselves. More specifically, when students lost in the competition, their failure would also be recognised in public via their pets, which was harmful to the image of a successful master. Consequently, some students still felt a strong sense of failure when they lost in the competition.

Conclusions

In response to the first research question, *how do we design a game-based learning environment that can maximise the power of competition while alleviating the negative influences*, this study described the experience in developing the substitutive competition approach. The My-Pet v3 system was developed based on this approach. We further examined its influences on pupil perceptions, especially their sense of achievement and failure. The findings revealed that the My-Pet v3 system had a higher impact on pupils' sense of achievement as compared with the name-direct version, where pupils competed with their name shown. In addition, the My-Pet v3 system also had a similar influence on pupils' sense of failure compared with the name-direct and avatar-direct versions, where pupils competed with their name and their avatars shown, respectively.

In short, considering both the influence on the sense of achievement and failure, a preliminary conclusion can be drawn among these three different versions, as summarised in Table 2. First, the three versions had similar influence on pupils' sense of failure, where the avatar-direct version was higher than the name-direct and pet-indirect versions. Second, since less information about the pupil's identity was revealed in the name-direct version, it had less impact on the winning pupils' sense of achievement. Third, the avatar-direct version had a greater impact on winning

Table 2: Summary of the influences of the three versions on student perceptions

	Name-direct	Avatar-direct	Pet-indirect
Sense of achievement	Low	High	High
Sense of failure	Similar	Similar	Similar

pupils' sense of achievement because the avatars enhanced their presence and participation. Finally, the pet-indirect version seemed to have the same impact on pupils' sense of achievement as the avatar-direct version. This seemed to indicate that the pet-indirect competition had a significant influence on students' sense of achievement, but had no apparent effect to alleviate students' sense of failure.

However, due to the limitations of this experiment, more investigation is required. First, although this study showed some results of substitutive competition on pupils, it was merely a short-term study. The long-term effects of substitutive competition are still unclear. Next, the major purpose of the quantitative investigation used in this study is to find how pupils perceive pet-indirect competition. More qualitative data are required in the future so that we can gain insightful understanding about the pupils' perception of substitutive competition, especially the reason why they perceived.

The future work would be conducted in three directions. One direction is, based on the research limitation, to clarify the reasons why students perceived when they won and lost. This research would be quite helpful for the development of substitutive competition because it offers the cues how to improve the My-Pet v3 system and further investigate the issues about the substitutive competition. Another direction is, based on the result of this study, to compare the use of an avatar and fictitious name with that of the avatar and actual name. This work would be helpful to clarify the effect of an avatar within a competitive environment. The third direction is, also based on the result of this study, to think whether it is feasible to offer flexible competitive ways for students. This is due to the fact that different students had different preferences in competition. If there is no optimal solution to meet the students' various preferences, a possible way is to offer different solutions for students according to their preferences.

Acknowledgements

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References

- Alkan, S. & Cagiltay, K. (2007). Studying computer game learning experience through eye tracking. *British Journal of Educational Technology*, 38, 3, 538–542.
- Bandai (1996). *Tamagotchi keychain toy*. Retrieved 2011, 02, from: <http://www.bandai.co.jp/e/>
- Beck, A. & Katcher, A. (1996). *Between pets and people*. West Lafayette, IN: Purdue University Press.
- Bull, S. (2004). *Supporting learning with open learner models. Proceedings of 4th Hellenic conference with international participation: information and communication technologies in education*. Athens, Greece: Keynote.
- 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.
- Bull, S. & Nghiem, T. (2002). Helping learners to understand themselves with a learner model open to students, peers and instructors. In P. Brna & V. Dimitrova (Eds.), *Proceedings of workshop on individual and group modelling methods that help learners understand themselves. International Conference on Intelligent Tutoring Systems*. (pp. 5–13). http://hrast.pef.uni-lj.si/~joze/podiplomci/FRI/clanek_adj_a_brna.pdf
- 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. In C.

- Frasson, G. Gauthier & G. McCalla (Eds.), *Lecture notes in computer science* Vol. 608 (pp. 643–650). Canada: Springer-Verlag.
- 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.
- 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.
- Cheng, H. N. H., Wu, W. M. C., Liao, C. C. Y. & Chan, T. W. (2009). Equal opportunity tactic: lessening negative effect in competition games in classrooms. *Computers and Education*, 53, 3, 866–876.
- 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* (pp. 453–494). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Connolly, T. M., Stansfield, M. & Hainey, T. (2007). An application of games-based learning within software engineering. *British Journal of Educational Technology*, 38, 3, 416–428.
- Crawford, C. (1982). *The art of computer game design*. Berkeley, CA: Osborne/McGraw-Hill.
- Dempsey, J., Rasmussen, K. & Lucassen, B. (1994). *Instructional gaming: Implications for instructional technology*. Paper presented at the Annual Meeting of the Association for Educational Communications and Technology, Nashville, TN, pp. 16–20.
- Dunn, R. E. & Goldman, M. (1966). Competition and noncompetition in relationship to satisfaction and feelings toward own-group and nongroup members. *The Journal of Social Psychology*, 68, 299–311.
- Dweck, C. (2000). *Self-theories: their role in motivation, personality, and development, essays in social psychology*. Philadelphia, PA: Psychology Press.
- Feldon, D. & Kafai, Y. (2008). Mixed methods for mixed reality: understanding users' avatar activities in virtual worlds. *Educational Technology Research and Development*, 56, 575–593.
- Gee, J. P. (2003). *What video games have to teach us about learning and literacy*. New York: Palgrave/Macmillan.
- Gilbert, D. T., Giesler, R. B. & Morris, K. A. (1995). When comparisons arise. *Journal of Personality and Social Psychology*, 69, 227–236.
- 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.
- Ke, F. (2008a). Computer games application within alternative classroom goal structures: cognitive, meta-cognitive, and affective evaluation. *Educational Technology Research and Development*, 56, 5, 539–556.
- Ke, F. (2008b). Alternative goal structures for computer game-based learning. *International Journal of Computer-Supported Collaborative Learning*, 3, 4, 429–445.
- Kusahara, M. (2000). The art of creating subjective reality: an analysis of Japanese digital pets. In E. Boudreau (Ed.), *Artificial Life 7 Workshop proceedings* (pp. 141–144).
- Lee, K. S. & Tse, Y. F. (1994). *Hanyu characteristics and usage*. Hong Kong: Hong Kong University Press.
- Levinson, B. M. (1969). *Pet-oriented child psychotherapy*. Springfield, IL: Charles C. Thomas.
- 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.
- 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 Z. Pan, D. A. D. Cheok, W. Müller & A. El Rhalibi (Eds), *Transactions on edutainment I. LNCS Vol. 5080* (pp. 51–61). Heidelberg, Germany: Springer.
- Luk, R. W. P. & Ng, A. B. Y. (1998). Computer-assisted learning of Chinese idioms. *Journal of Computer Assisted Learning*, 14, 2–18.
- Melson, G. F. (2001). *Why the wild things are: animals in the lives of children*. Cambridge, MA: Harvard University Press.
- Mussweiler, T. (2003). Comparison processes in social judgment: mechanisms and consequences. *Psychological Review*, 110, 472–489.
- Norman, D. A. (1993). *Things that make us smart: defending human attributes in the age of the machine*. New York: Addison-Wesley Publishing.
- Pesce, M. (2000). *The playful world: how technology is transforming our imagination*. New York: Random House.
- Rieber, L. P. (1996). Seriously considering play: designing interactive learning environments based on the blending of microworld, simulations, and games. *Educational Technology Research and Development*, 44, 2, 43–58.
- Seligman, M. E. P. (1990). *Learned optimism*. New York: Pocket Books.
- Seligman, M. E. P. (1994). *What you can change and what you can't*. New York: Alfred A. Knopf.
- Šisler, V. & Brom, C. (2008). Designing educational game: case study of 'Europe 2045'. *Transactions on edutainment I. LNCS Vol. 5080* (pp. 1–16). Berlin, Germany: Springer-Verlag.

- Slavin, R. E. (1990). *Cooperative learning: theory, research, and practice*. Englewood Cliffs, NJ: Prentice-Hall.
- Stapel, D. A. & Koomen, W. (2005). Competition, cooperation, and the effects of others on me. *Journal of Personality and Social Psychology*, 88, 1029–1038.
- Webster, N. C. (1998). Tamagotchi. *Advertising Age*, 69, 26, 43.
- Weiner, B. (1985). An attributional theory of achievement motivation and emotion. *Psychological Review*, 92, 4, 548–573.
- Weiner, B. (1992). Attributional theories of human motivation. *Human motivation: metaphors, theories, and research*. Newbury Park, CA: Sage.
- Weiner, B., Nicrenberg, R. & Goldstein, M. (1976). Social learning (locus of control) versus attributional (causal stability) interpretations of expectancy of success. *Journal of Personality*, 44, 52–68.
- 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.
- 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.
- Yu, X. H., Zhang, M., Ren, J., Zhao, H. F. & Zhu, Z. T. (2010). Experimental development of competitive digital educational games on multi-touch screen for young children. Entertainment for education: digital techniques and systems. In X. Zhang, S. Zhong, Z. Pan, K. Wong, & R. Yun (Eds.), *Lecture notes in computer science* Vol. 6249 (pp. 367–375). Heidelberg, Germany: Springer-Verlag.