British Journal of Educational Technology *Vol 42 No 1 2011* 166–180
doi:10.1111/j.1467-8535.2009.01003.x

Animal companions: Fostering children's effort-making by nurturing virtual pets

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Abstract

Virtual character is a significant application in the research field of technology-enhanced learning. In this study, the concept of animal companions, 'non-smart' virtual characters, is proposed as a way to encourage students to promote effort-making learning behaviours. The two underpinning design rationales are first discussed followed by the description of the development of a practical application, the My-Pet v2 system. A preliminary experiment was conducted to examine the system usability in terms of cognitive, affective and time-on-task characteristics. The results reveal that participants in the group using a complete version of My-Pet v2 showed better quality of effort-making learning behaviours. Some implications and future research directions are also discussed.

Introduction

In recent decades, educational virtual characters (or educational/pedagogical agents) have attracted increasing interest in the field of technology-enhanced learning. Such virtual characters are computer-simulated agents with human-like characteristics designed to enrich the individual learning context by acting as virtual participants (Chou, Chan & Lin, 2003). There are two potential benefits to the use of virtual characters as educational agents—they foster *user interface*; and *behaviour cultivation*.

In terms of user interface, such virtual characters take advantage not only of text or symbols but also of appearance to communicate with students. In other words, these characters can be seen as a user-friendly interface to promote student perceptions of ease and comfort (Gulz, 2004, 2005), thereby increasing their motivation (Johnson, Rickel & Lester, 2000; Lester, Stone & Stelling, 1999).

In terms of behaviour cultivation, a number of virtual educational characters have been devised to help stimulate essential learning behaviours, such as exploration (Höök, Persson & Sjölinder, 2000), reflection and articulation (Goodman, Soller, Linton & Gaimari, 1998; Tholander, Karlgren, Rutz, Johannesson & Ramberg, 1999), communication (Lester *et al*, 1997, 1999), and negotiation (Bull & Pain, 1995; Bull & McKay, 2004). Through life-like demonstrations and body language (ie, nodding, eye-gazing and gesturing), these characters increase the communication bandwidth (Johnson *et al*, 2000) and further contribute to the shaping of these significant behaviours.

These potential benefits have led to the development of 'smart' (ie, intelligent and autonomous) virtual characters. There are a variety of ways in which virtual characters can interact with students. In addition to the role of an authoritative tutor (Wenger, 1987), virtual characters can play the role of a learning companion with similar capability to the student (Chan & Baskin, 1988; Chou *et al*, 2003), acting as collaborator (Chan & Baskin, 1988, 1990; Dillenbourg and Self, 1992), competitor (Chan & Baskin, 1990; Chan, Chung, Ho, Hou & Lin, 1992), peer tutor (Chan & Chou, 1997), or troublemaker (Aïmeur, Dufort, Leibu & Frasson, 1997). These smart virtual characters enrich the students' social interaction in relation to their individual learning.

Recently, purposely 'non-smart' virtual characters have also been designed as a means of evoking an active and responsible attitude in the student. These include peer tutees (Biswas, Katzlberger, Brandford, Schwartz & TAG-V 2001; Chan & Chou, 1995, 1997; Davis, Leelawong, Belynne, Bodenheimer, Biswas & Vye, 2003; Leelawong, Davis, Vye, Biswas, Schwartz & Belynne, 2002) and teachable agents (Biswas, Leelawong, Schwartz & Vye, 2005; Brophy, Biswas, Katzlberger, Bransford & Schwartz, 2000). The student is assigned the role of an expert and teaches the less capable peer tutee or teachable agent. In this study, another type of non-smart virtual character is utilised, the animal companion. Animal companions are virtual pets designed to externalise the keepers' learning profiles. Through interacting with animal companions, students become more aware of their learning status (Chen, Chou, Deng & Chan, 2007). An improved version of an animal companion system, named My-Pet v2, is implemented to further foster students' effort-making behaviour. Before introducing the detailed system design, we elaborate on two underlying design rationales.

Underpinning design rationales

Externally representing learning status based on student profiles

The 'open learner model' is attracting more and more research interest as a way to promote the student's self-awareness (Bull & Kay 2007; Bull & McKay, 2004; Bull & Nghiem, 2002). Learner models deal with the 'knowledge of who is being taught' (Self, 1974). Learner models can be treated as digital records of students' learning profiles collected by the educational system. Hypothetically learner models can help educational systems determine appropriate feedback and adjust pedagogical strategies suitable for the students' learning status. This information should make it possible for students to improve their learning by better self-knowledge (Kay, 1997). In other words, when the student's learning profile is accessible to the students, they have increased opportunities to be aware of their learning status and behaviours.

Effort-making behaviour is a vital learning behaviour. According to the attribution theory (Weiner, 1985, 1992), people's behaviours are greatly affected by perceived causes of achievement; two key perceived causes are *ability* and *effort*. If students attribute their failure to causes that cannot be changed (eg, lack of ability), they will expect the same result to occur again. In contrast, if the result is attributed to causes that can be controlled by oneself (eg, lack of effort), this failure might not happen again in the future: the student has the opportunity to change (Weiner, Niernberg & Goldstein, 1976).

Note that not all students realise the importance of effort (Seligman, 1990, 1994), although students can learn to change the learning beliefs they hold (Dweck, 2000). Therefore, we assume that representing the students' learning status externally, particularly learning effort, is the first step to changing student belief to an emphasis on effort.

Two strategies are employed in the animal companion system to represent the student's learning efforts—'*mirror of learning profile*' and '*work-centred learning model*'. In the first, a student keeps an animal companion whose traits and behaviours are governed by the student's learning profile. For example, when the student achieves more, the animal companion will be in a good mood. In other words, the student is apprised of his/her learning status by observing their animal companion's behaviour. In this study, the animal companion's 'effort' attribute is particularly emphasised to promote this awareness. When a student is aware of the learning effort made, as well as its relationship with task achievement, the student shows better self-awareness.

In human society, belief shaping seems to be closely related to the value of societal development. Take for example the value of 'work.' Ransome (2005) indicated that our society is a work-centred society in which the value of work greatly influences people's beliefs, values, norm, position and wealth. Society needs development in different aspects, and this core value gradually shapes the belief that hard work is the path of least resistance for the whole society, physically and mentally. In the animal companion strategy, learning tasks are treated as a kind of work that includes the cycle of exertion and harvest for learning tasks. The animal companions help students in their struggle with laziness to become engaged in this positive type of learning cycle.

Encouraging students to make efforts to improve by game playing

Learning tasks that require the exertion of great effort without joyfulness are forbidding. However, when learning tasks are blended with some game elements, they become more interesting even though they may still require a lot of effort to complete.

It has been shown that the incorporation of good principles of game design can positively facilitate learning, including in formal schooling (Gee, 2003). Along this line of thought, one of the major objectives for technology-enhanced learning seems to lie in incorporating different pedagogical strategies, including game strategy, to help students develop their optimal capabilities.

The potential benefits of game playing on student learning are multi-fold. Crawford (1982) analysed the traits of digital games and pointed out that they have fascinating aspects that engage student interest—the affective aspect. In the cognitive dimension, a number of gains brought about by digital games have also been reported related to problem-solving skills (Rieber, 1996), situated learning (Gee, 2003), exploration behaviours (Prensky, 2001) and critical thinking (Gee, 2003). Note that digital games are also employed to shape the student's attitude (Dempsey, Rasmussen & Lucassen, 1994). In other words, digital games can be regarded as a possible vehicle for changing the student's behaviours, attitudes, even beliefs.

Two strategies are employed to foster student efforts and to improve their learning status in the animal companion system: 'pet nurturing' and 'pet competition'. Pet nurturing involves emotional attachment. Through a series of interactions with the virtual pet (eg, feeding, washing, playing ball, etc), students establish a deeper relationship with it, as well as the learning environment. This deeper relationship is helpful in maintaining a longer educational computer–human interaction. Pet nurturing might also stimulate students to be more independent and more responsible.

The pet competition takes advantage of pet comparisons to strengthen 'effort' attribute values. In other words, the more effort the student makes at the learning task, the greater the chance that their pet will win the competition. The rules imply that dedication of time and effort is a necessary condition for learning. If the student loses the competition, they need to make more effort—making effort at learning tasks replenishes their pets' 'effort' attribute.

My-Pet v2 system

Animal companions are non-smart virtual characters designed based on the keeper-to-pet relationship. Pet keeping is a pervasive aspect of culture that crosses gender and cultural boundaries. Since pets possess the trait of loyalty as well as exhibiting simple, cute and straightforward behaviours, it is natural for children to establish an emotional attachment to their pets (Melson, 2001). Since they share the same characteristics, children find it easier to form an attachment to their pets (Beck & Katcher, 1996; Levinson, 1969). As an aspect of subjective reality, most children also show emotion towards virtual pets (Kusahara, 2000). In short, animal companions are non-smart virtual characters that need feeding and caring for. The learning flows of the animal companion system can be divided into three phases: *nurturing, learning* and *competition*. Figure 1 displays a conceptual diagram of the three phases.

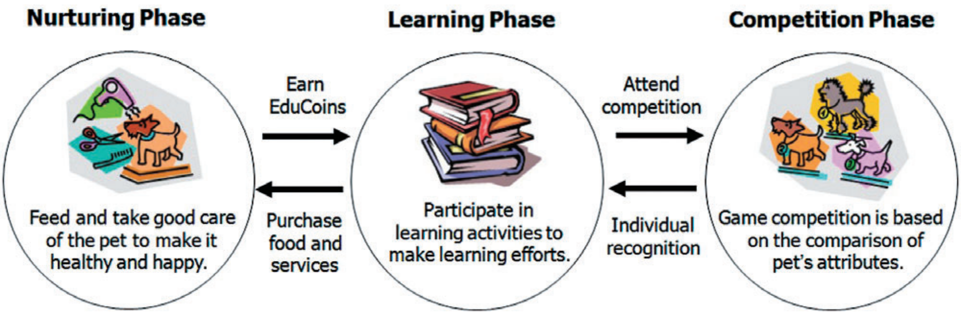


Figure 1: Learning flows in the animal companion system

Figure 2: Screenshot of the nurturing phase

Nurturing phase

In the nurturing phase, the student nurtures their animal companion, named My-Pet. The My-Pet has some attributes that are indicated by numerical values that reflect the student's status. The 'effort' attribute is the focus in this study. As shown in Figure 2, the My-Pet inhabits a backyard. There are three attributes: energy, experience and effort. The 'energy' and 'experience' attributes are related to the interaction between the My-Pet and the student. These two attributes can be improved by feeding and playing with My-Pet respectively. The 'effort' attribute is related to the effort made by the student at learning tasks and can be increased in the learning phase. Learning tasks are regarded as work. The student earns EduCoins by completing the learning tasks. These can in turn be used to buy food and goods to take care of the My-Pet.

Learning phase

In the nurturing phase, the student is offered learning activities in a task-oriented scenario. The subject domain in this study is Chinese idioms. Chinese idioms play a significant role in Chinese vocabulary learning due to the complexity of the written

Figure 3: Screenshot of the learning phase

language compared to the alphabet of other languages. Therefore, proficiency with Chinese characters and idioms is considered fundamental to language acquisition (Luk & Ng, 1998). Idioms are particularly helpful for shortening long passages, making them more concise and vivid (Lee & Tse, 1994). In addition, Chinese idioms contain cultural, literary, moral and social connotations that are regarded as essential for building character and cultural identity (Luk & Ng, 1998). Therefore, the learning activity provides practice-oriented learning stages to help the student master Chinese idioms. Figure 3 shows a screenshot illustrating one of these stages. The students need to pick out the four words in the phrase one by one in the correct sequence and avoid the selection of similar but erroneous words.

Competition phase

The competition phase includes the holding of peer-wise competitive games based on the My-Pets' 'effort' attributes. The game result is mainly dependent upon the 'effort', as well as a minor lucky element. Before starting a performance, the student needs to select an opponent. Then, the My-Pet has an attack round to obtain scores using the following formula: (the 'effort' attribute of My-Pet) multiplied by (a lucky number from a turntable). Thus, the greater the 'effort' attribute that the My-Pet has, the higher the chance that the student will win the competition. The competition goes on until one of the My-Pets wins the game. Figure 4 shows one My-Pet competing against another My-Pet.

Evaluation

A comparative between-subject experiment using the My-Pet v2 system was conducted in an elementary school in Tao-Yuan County. Two aspects of the My-Pet v2 system were focused upon in this experiment: learning effectiveness and affective perceptions.

Participants

The participants included 82 fifth-grade students from three classes. However, some participants were absent from some experimental sessions. There were 68 remaining participants, including 20 students in class A (9 boys and 11 girls), 23 students in class

Figure 4: Screenshot of the competition phase

Table 1: Different interventions and participants in the three groups

Groups	*Intervention (different system versions)*	*Participant (boys : girls)*
L	Learning	20 (9:11)
LN	Learning + Nurturing	23 (11:12)
LNC	Learning + Nurturing + Competition	25 (10:15)

L, learning; LN, learning + nurturing; LNC, learning + nurturing + competition.

B (11 boys and 12 girls) and 25 students in class C (10 boys and 15 girls). The policy of randomised class grouping was adopted in this elementary school. Therefore, it can be assumed that the participants in the three classes had similar background and learning performance in relation to this language subject.

Procedure

Three classes were randomly assigned to three groups: group L (learning), group LN (learning + nurturing) and group LNC (learning + nurturing + competition). Although the learning materials (Chinese idioms) were the same for all three groups, participants learned with different versions of the My-Pet system: participants in group L were only provided with digital materials; participants in group LN learned with an incomplete version of the My-Pet system (nurturing phase); participants in group LNC learned with a complete version of the My-Pet system (both nurturing and competition phases). Each group had four 30-minute sessions in a computer laboratory to learn idioms spread out over a five-week period. Table 1 shows the different interventions and participants in the three groups.

Measurement

Three measurement tools were utilised: achievement tests, motivational scale and system logs. Achievement tests were carried out by pretesting and posttesting the

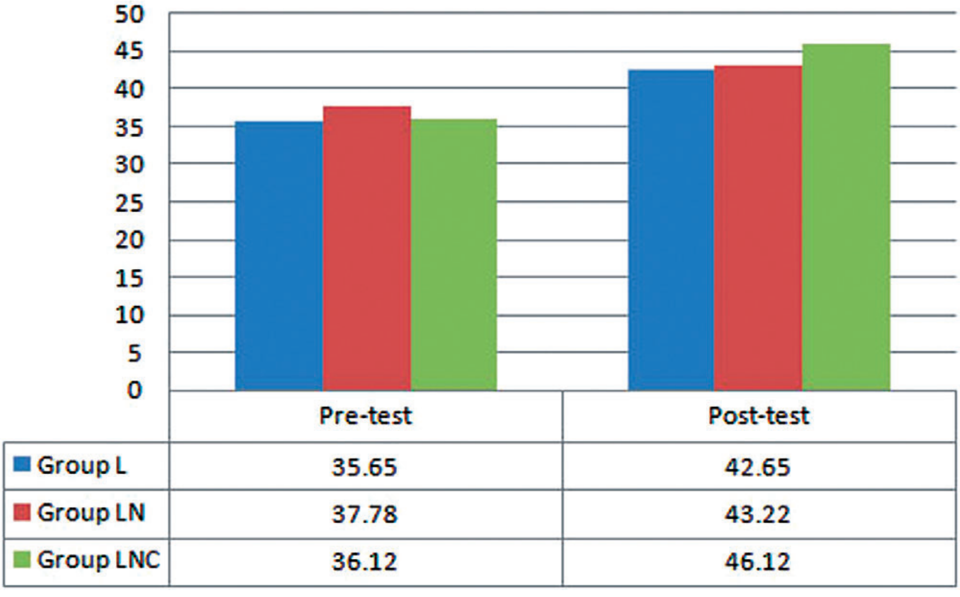


Figure 5: Means of the three groups in the pre- and posttests; L, learning; LN, learning + nurturing; LNC, learning + nurturing + competition

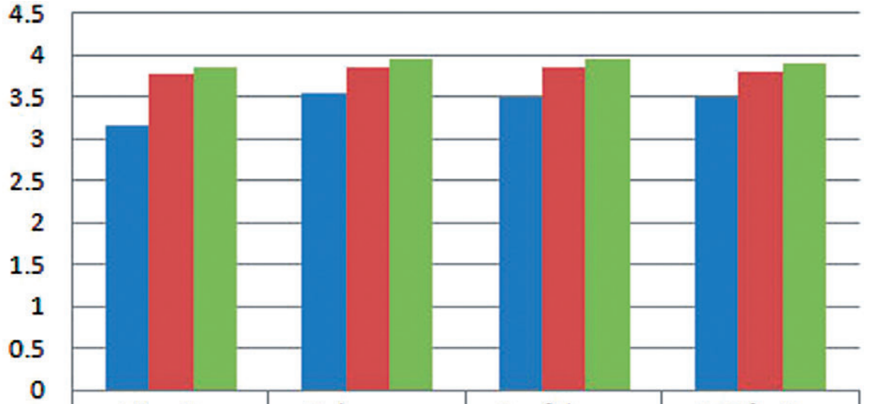
Chinese idioms. The test was comprised of two parts: a basic part (word-identification and word-sequence), and an advanced part (context application). The Attention, Relevance, Confidence, and Satisfaction (ARCS) motivational scale (Dempsey, Lucassen, Haynes & Casey, 1997) was employed to collect participants' affective perceptions. Each participant's time-on-tasks for learning idioms was recorded in the system logs.

Results

Achievement test

The means for the pre- and posttests are listed in Figure 5. *T*-testing was conducted to examine whether the difference between the pre- and posttest results in each group showed significantly improved scores. The results revealed that the posttest scores were significantly higher than the pretest scores ($t = 4.564$, $P < 0.01$; $t = 3.683$, $P < 0.01$; $t = 10.084$, $P < 0.01$ for groups L, LN and LNC respectively). All participants in all three groups improved their knowledge of Chinese idioms.

In addition, participants' pretest scores were treated as a covariance to conduct a one-way Analysis of Covariance (ANCOVA). The results showed a significant difference between the posttest scores of the three groups ($F_{(2,64)} = 3.183$, $P < 0.05$). Comparison showed that the posttest score of group LNC to be significantly higher than that of groups L and LN; there was no significant difference between the posttest score of group L and group LN. This means that the group LNC (complete version of My-Pet) had the



	Attention	Relevance	Confidence	Satisfaction
Group L	3.16	3.54	3.49	3.49
Group LN	3.78	3.86	3.86	3.8
Group LNC	3.86	3.95	3.95	3.91

Figure 6: Means of three groups in the ARCS (Attention, Relevance, Confidence, and Satisfaction) motivational scale; L, learning; LN, learning + nurturing; LNC, learning + nurturing + competition

highest improvement, higher than that of either of the other two groups. In other words, the complete version of nurturing My-Pet is more effective for Chinese idiom learning.

Motivational scale

The ARCS motivational scale covers four dimensions: attention; relevance; confidence; and satisfaction. Figure 6 displays the means for these four aspects. One-way Analysis of Variance (ANOVA) testing was conducted to validate the difference. The results showed a significant difference in the attention and satisfaction aspects of the three groups ($F_{(2,65)} = 5.654$, $P < 0.01$; $F_{(2,65)} = 3.416$, $P < 0.05$ respectively). In the post-comparison, the attention and satisfaction aspects were found to be higher in groups LN and LNC than in group L. This indicates that participants paid more attention and gained more satisfaction using the animal companions system (both incomplete and complete versions) than those who used only the digital material version. In addition, there was no significant difference between the three groups in the other two aspects (ie, relevance and confidence) of the three groups ($F_{(2,65)} = 2.323$, $P = 0.106$; $F_{(2,65)} = 2.849$, $P = 0.065$ respectively).

Time-on-task

Figure 7 illustrates the average time-on-task spent by participants in the three groups during the four sessions. Except for the five-minute introductory activity conducted in the first session, each session had a 30-minute learning time. The average time-on-task

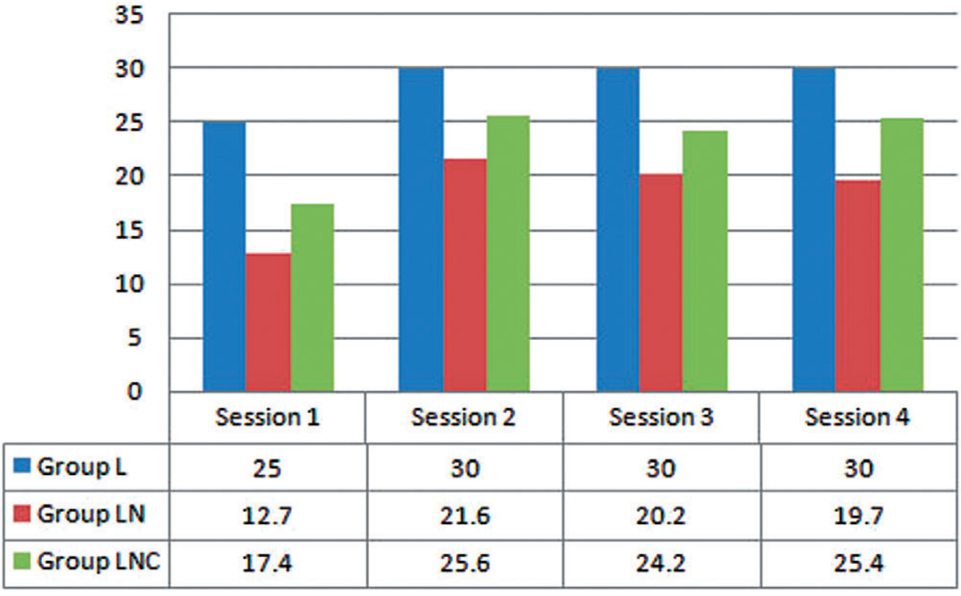


Figure 7: Average time-on-task spent during the four sessions; L, learning; LN, learning + nurturing; LNC, learning + nurturing + competition

Table 2: Time-on-task and quality of effort-making for each group

Groups	*Improved score*	*Time-on-task average*	*Quality %*
L	7 (42.65–35.65)	28.75	24.34 (7/28.75)
LN	5.44 (43.22–37.78)	18.55	29.32 (5.44/18.55)
LNC	10 (46.12–36.12)	23.15	43.19 (10/23.15)

L, learning; LN, learning + nurturing; LNC, learning + nurturing + competition.

is 28.75 [= (25 + 30 + 30 + 30)/4], 18.55 [= (12.7 + 21.6 + 20.2 + 19.7)/4] and 23.15 [= (17.4 + 25.6 + 24.2 + 25.4)/4] in the group L, LN, LNC respectively.

Discussion

Interplay between learning and gaming: quality of effort-making

To assess effort-making behaviours, we further define the quality of effort-making as 'student improved performance divided by time spent'. The qualities of effort-making in the three groups are calculated using this definition as shown in Table 2. Group LNC shows obviously higher quality (43.19%) than either group LN (29.32%) or group L (24.34%). In other words, the addition of different elements into the My-Pet v2 system improved the learning environment and aided students in better quality of effort-making.

The My-Pet v2 system attempts to blend game elements into learning activities through keeping virtual pets. One important issue that needs to be examined ultimately in technology-enhanced learning, including game-based learning, is how to enhance the student's learning performance. We expect the development of such engaging designs and interesting game environments to result in a better learning performance. The My-Pet v2 system emphasises the use of 'non-smart' virtual pets. Learning and gaming are blended to increase effort-making in learning. It is interesting to observe in Table 2 that the time-on-tasks in group LNC was more than that in group LN. This seems to suggest some positive interplay between learning and gaming.

In a sense, it might be expected that students would spend more time in game playing than in learning tasks when they learn in a game-based environment, however, the time-on-task of group LNC (two game elements: pet nurturing and pet competition) was greater than that of group LN (one game element: pet nurturing). Students spent more time in learning tasks. This means more game elements form an environment where students expect to obtain something significant from the learning tasks, so they spend more time in learning tasks. If this assumption is reasonable, some relevant issues arise that could be looked at in the future studies: (1) How to optimise students' time-on-task and quality of effort-making through adjusting the game elements in the My-Pet system. (2) Can students retain stable effort-making behaviours over a period of time long enough to further affect their attitude or even belief?

Potential value of virtual characters and competition in engaging learning

Although there was no significant difference in the cognitive gains between groups L and LN, a comparison of the results of the ARCS motivational scale shows that students in these two groups had a different affective experience. That is, the students in the LN group experienced higher attention and satisfaction than those in group L, although these two groups had similar cognitive gains. This shows that the presence of the My-Pet enhanced student attention and satisfaction. This result tends to support the potential and value of virtual characters in engaging learning (Gulz, 2004).

However, a comparison of the cognitive and affective results between group L and LNC shows that students in group LNC had a better outcome in both cognitive and affective aspects. It seems that the complete version of My-Pet contributed to students' engagement level, particularly in terms of attention and satisfaction, which resulted in better performance in learning Chinese idioms. The major difference between the version used by group LN (incomplete version) and group LNC (complete version) is the competition phase. In other words, the presence of pet competition had a significant influence on students' cognitive and affective gains.

Competition is regarded as a powerful strategy for stimulating students to learn. The experimental result showed that the pet competition also seems to be an effective strategy for motivating students to learn, particularly in the short-term. In short, the experimental results revealed that game competition is an effective way to motivate students to make effort to improve their learning status. However, some related issues arise: (1)

Although competition is an effective approach to motive students to learn, it has been pointed out that there are some possible negative influences on learning confidence (Chan *et al*, 1992). How to prevent or alleviate these negative influences is vital. (2) Another question that arises is whether there are gender differences in use preference and academic performance related to pet competition. (3) The influence of pet nurturing in the My-Pet v2 system did not seem to be revealed in this experiment. Nevertheless, some biological (Melson, 2001) and psychological studies (Archer, 1997) have shown that real pets have a deeper influence on people. One possible explanation for this is the difference in emotional attachment to real pets and to virtual pets. Another explanation is the lack of a longer evaluation time. The power of nurturing might lie in its sustainability over a long period of time.

Some reflections of educational virtual character/pet design in the classroom

As technology researchers, it is significant for us to further interpret the implications of virtual pets for educational purpose in the classroom, particularly from the perspectives of technology development and pedagogy adoption. With advanced technologies, the appearance and adopted technologies of virtual pets might be quite different. Therefore, it is more important to understand the implications behind these information systems, rather than emphasise only the ones themselves.

While reviewing the phenomenon of Tamagotchi (Pesce, 2000; Webster, 1998), a kind of pet-keeping toy with simple animated pictures and three buttons, we found that the kind of technologies adopted is less important. Instead, it is more crucial whether students could build close emotional relationships with their virtual pets. Tamagotchi adopts simple technologies but make students feel that these virtual pets indeed need their caring through appropriate animation feedbacks and beeps. That is, students could form emotional relationships with Tamagotchi by good computer–human interaction design. Examining the My-Pet v2 system, it could be found that the My-Pet v2 system also attempts to provide functions for establishing such emotional relationship by enhancing keepers' ownership (eg, buying foods to feed them), keepers' responsibility (eg, raising the attribute value) and virtual pets' behaviours and emotions (eg, owning different face expressions). How to establish closer emotional relationships with students is a vital consideration in designing virtual characters/pets. We believe that this is the foundational driving force to empower the design of such 'non-smart' virtual characters for educational purposes.

In addition, another aspect that makes My-Pet v2 system different from traditional 'smart' virtual characters is that the game strategy is seriously considered as a kind of pedagogy in the classroom learning. An important characteristic that makes game playing different from formal schooling is the aspect of control (Crawford, 1982). Games could provide students the feeling of control, which might transform passive participation into engagement as well as enjoyment. Engagement and enjoyment are helpful to enhancing students' willing to accomplish something important for them. Therefore, the game strategy seems to bring more opportunities for technology researchers to enrich the design of virtual characters/pets. We also believe that fostering students' effort-making behaviours in learning tasks by pet-keeping game strategy (eg, pet nurturing and pet competition) is one of applied approaches. There are other approaches that should be explored in the future.

Conclusion

My-Pet v2 system is developed to encourage students to increase effort-making learning behaviours. According to the results of a preliminary experiment, it seems that the presence of animal companions (ie, the My-Pet) influenced students in three ways:

(1) Affective aspect—students who learned with the animal companion system had a statistically better outcome in terms of attention and satisfaction than those who learned without the system.
(2) Cognitive aspect—students who learned with the complete version of animal companions had a better outcome than students in the other groups.
(3) Effort-making aspect—students who learned with the animal companion system made greater efforts than students who learned without the system.

Although this preliminary data seem to indicate that the animal companion is a feasible and useful approach to foster students' effort-making behaviours, more investigation and evaluations are required to contribute to the research field of virtual characters/pets design. In future work, we hope to revise the My-Pet v2 system based on the experimental results and to combine the quantitative and qualitative methods and observe subtle movement in the change of students' effort-making attitudes and beliefs. In addition, we are also planning to develop some design principles or framework for educational virtual characters.

Acknowledgement

The authors would like to thank the National Science Council of the Republic of China, Taiwan for their financial support (NSC-97-2631-S-008-002). The authors also thank the reviewers' valuable suggestion about the perspective of 'concept evaluation' in the discussion section.

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