Active Open Learner Models as Animal Companions: Motivating Children to Learn through Interaction with My-Pet and Our-Pet

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Abstract. This pilot study reports how to portray open learner models as animal companions in order to motivate children to learn in the digital classroom environment. To meet two challenges of motivation and interactivity for open learner models, the concept of open learner models as animal companions is proposed based on the emotional attachment of humans towards pets. Animal companions adopt three strategies and play various educational roles to help children's learning in motivation, reflection and member interactions. A class of students is divided into several teams. A student keeps her own *individual animal companion*, called My-Pet, which holds the open learner model of the student, and each team has a *team animal companion*, called Our-Pet, which owns their open group learner model. A preliminary experiment is conducted in a fifth-grade class with 31 eleven year old students in an elementary school to collect initial feedback in cognitive and affective aspects.

Keywords: open learner model, group learner model, learning companion, motivation, reflection, member interaction.

OPEN LEARNER MODEL: THE BENEFITS AND CHALLENGES

In the Artificial Intelligent in Education (AIED) research field, the learner model is a key inner component of the conventional intelligent system design. The learner model is seated behind the user interface, and internally collects and analyzes the data recorded from the system-user interactions, and then enables the system to adapt to individual learning needs. Self (1999) noted that an educational system requires a learner model to care for, understand and support the student's individual needs. Based on the learner model, the intelligent system is provided with the referenced model towards learners, and further incorporates with pedagogical strategy to offer adaptive interactions. In other words, the learner model increases the ability of system intelligence and adaptation. However, the learner model is not always a black box behind the system. Self (1988) pointed out that "making the contents of learner model open to the learner in order to provoke the learner to reflection". Chan (1996) also indicated that "the learner model can be used in different ways, other than hiding behind the student as an internal component inside the intelligent tutoring systems."

Various systems with open learner models have been proposed over the past two decades (Bull, 2004; Bull & Kay, 2005; Bull *et al*., 2005). Kay (1997) stated that "if the learner model can be helpful in determining how a machine teaches, it should make it available to the learner for improving their own learning through better self-knowledge". This "open" perspective towards learner models extends the original roles from the inner referenced model to fruitful roles that bring various benefits and promising gains, including a basis for planning learning goals, improving communication between system and learners and helping for self-assessment and reflection about learning (Bull & Nghiem, 2002; Mitrovic & Martin, 2002; Zapata-Rivera & Greer, 2002; Bull, 2004).

Nevertheless, two primary challenges have been raised as the content of learner model is open to learners. One challenge is the motivation to use open learner models. Studies have found that some students do not have sufficient interest in using open learner models, although they believe that they

have the right to inspect the learner model (Bull, 2004). Several students also do not use their learner models, even when learner models are available (Kay, 1995; Barnard & Sandberg, 1996). Therefore, stimulating learners to make use of open leaner model in improving their learning is becoming a challenging issue.

Another challenge that open learner models immediately meet is the interactivity between system and learners, particularly when inner constituents have become externally accessible components. Interactivity requires the learners to be involved in the processes of presentation, interpretation and reaction. Therefore, some relative mechanisms for representation and communication are required to foster these processes. Tanimoto (2005) also indicated that presenting learner models to unsophisticated learners may confuse them, since the content of the learner models may be complex and difficult to explain. Although several successful interactive styles, such as inspectable, co-operative, editable and negotiated styles, have been proposed to overcome these difficulties (Bull & Pain, 1995; Bull, 2004; Bull & McKay, 2004; Bull & Kay, 2005), the roles of open learner models should continue to be explored for the human-computer-interaction in order to improve their utility as helpful learning resources.

This paper presents active open learner models as animal companions to eliminate the above two challenges. "Active" open learner model means that open learner model is externalized by an embodied character whose emotion and behaviors are governed by the character's attributes, which wrap up a student's learning aspects in the learner model. As shown in Fig. 1, the character's attributes are classified into two categories: nurturing and learning attributes. The nurturing attributes (attribute a, b, c, d) refer to the attributes that mainly dominate the character's persona, emotional expression and behaviors while the learning attributes (attribute 1, 2, 3, 4) denote the attributes that represent the learner's learning status, and directly wrap up the corresponding learning aspects in the learner model. This wrapping approach is called "instance wrapping". By contrast, to enhance the influence of learning attributes, several nurturing attributes also wrap up the specific learning aspects in the learner model. This wrapping approach is called "transformed wrapping", and this wrapping involves renaming and calculation with specific formulae.

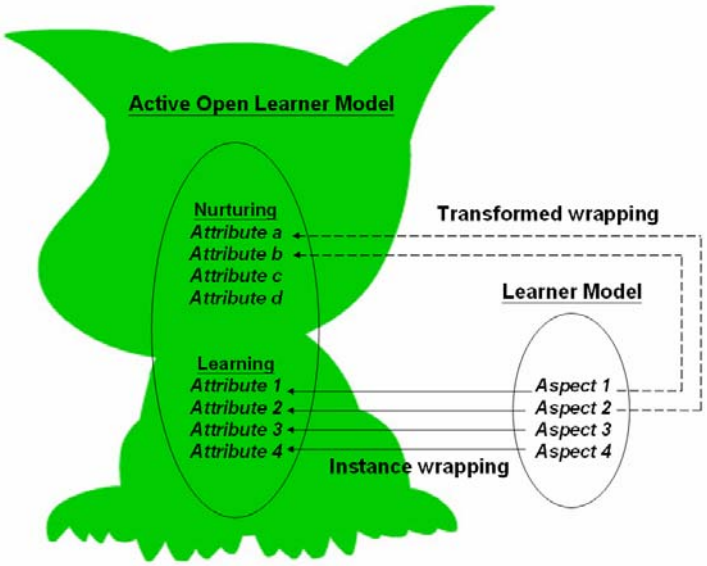


Figure 1. The active open learner model concept

The emotional expression and behaviors of a virtual character are governed by attributes. Hence, the active open leaner model can not only be passively inspected by the learner, but can also actively indicate the learner's learning status through the character's persona, emotional expression or behaviors. This paper refers to the active open learner models, which are portrayed as pet characters as "animal companions". In particular, the learning aspects in cognitive dimension are transformed wrapped by the pet character's "emotion" attribute, further governing the pet character's emotional

expression and behaviors. To maximize the capability of animal companion for children, some studies that focus on the companionship between pets and humans are considered.

Pet keeping has been pervasive in all cultures across gender and nationality over a long period of time. Related investigations have noted that pet keeping is naturally attractive to humans, especially to children, and that children are naturally attracted to pets because they all share the same attributes, such as cute, simple and straightforward behaviors (Melson, 2001). Therefore, the relationships between pets and children are easy to elicit (Beck & Katcher, 1996; Levinson, 1969). Pets further affect the child's development in several ways, including physiological health, psychological support, personality development and social competence. First, several studies have indicated that pets help reduce stress and blood pressure, and that keeping pets can improve the owner's physiological health (Friedmann *et al*., 1983). Second, pets are sometimes used to treat emotionally troubled children who are extremely shy or hyperactive (Levinson, 1969; Katcher, 2000). Moreover, several researchers have argued that children learn about love, loss, loyalty, nurturing and responsibility from animals (Melson, 2001). Additionally, some works have also pointed out that interaction with animals can increase the social competence and learning opportunities for children (Beck & Katcher, 1996; Myers, 1998).

The advancement of technology has created some technological substitutes for pets. One well-known example is Tamagotchi (Bandai, 1996; Webster, 1998; Pesce, 2000). By pressing "feed" buttons, a virtual animated chick grows gradually according to the users' interactions. What are the implications of the Tamagotchi phenomenon for learning? The Tamagotchi can be viewed as an open interaction model that holds the action records for the user, and displays this information in the form of a growing-up status. Research into animal companions was inspired by the concept of applying Tamagotchi from the pure entertainment to the educational field, as well as the works on learning companions. A learning companion is a computer-simulated character that mimics the learner himself, and provides companionship to the learner (Chan & Baskin, 1988, 1990; Chan, 1996; Chou *et al.*, 2003). An animal companion is a learning companion designed especially for children. Specifically, an animal companion is a pet character with an embodied animal appearance, which integrates with the nurturing features into an entity of open learner model. Animal companions adopt the concept of Tamagotchi to represent their owners' learning progress in the form of nurturing status to motivate children to learn. Conversely, animal companions extend the original roles played by the learning companion to a wider spectrum of educational roles that bring various benefits in children's learning.

The active open learner model as an animal companion is a candidate to meet the two challenges for open learner modelling. First, for the motivation challenge, open learner models are designed as embodied pet characters that need the owners' nurturing and care. Nurturing animal companions could provide learners with a reasonable cause to sustain their motivation for a long period of time. Unlike directly opening the content of learner model to learners, portraying open leaner models as animal companions may encourage learners to take actions to initiate their interaction, and thus provides more opportunities to benefit their learning in motivation, reflection, and member interactions. For example, an animal companion's hunger or bad mood may make the learners want to understand what happened to their pets. In the learner's viewpoint, this system calling could be different from the simple system alerts, because it involves more emotional engagement. Therefore, animal companions could motivate learners to utilize open learner models.

Second, in terms of the interactivity challenge, animal companions are active entities with personae, emotional expressions and behaviors, thus allowing animal companions to take active roles in interactivity. Through such additional representation and interaction, the key information can be conveyed and explained to learners to help them understand the content of open student models. Moreover, different animal companions are metaphors that may help learners distinguish the scopes of open leaner models. For example, the learner model is inspected upon the small animal companions, and the group learner model is observed upon the large animal companions. This different design of representation attempts to foster children to interpret the content of open learner models.

MY-PET-OUR-PET

My-Pet-Our-Pet is an animal companion system which portrays open learner models as animal companions. The learners are grouped into several teams, in which each learner is surrounded by two kinds of animal companions, *individual animal companion*, called My-Pet, and *team animal companion*, called Our-Pet. My-Pet is portrayed according to the open individual learner model. My-Pet is modified from an animal companion system, which encourages users to learn individually online materials through nurturing their pet character (Chen *et al.*, 2001; 2002; Chen *et al.*, 2003). Our-Pet is portrayed according to the open group learner model (Chen *et al.*, 2005a; 2005b). The repertoire of activities in My-Pet-Our-Pet consists of four modes, namely pet nurturing, individual learning, game competition and group discussion modes. A simple learner model is adopted for the design of these activities in My-Pet-Our-Pet to serve some educational roles in children's motivation, reflection and member interactions.

My-Pet

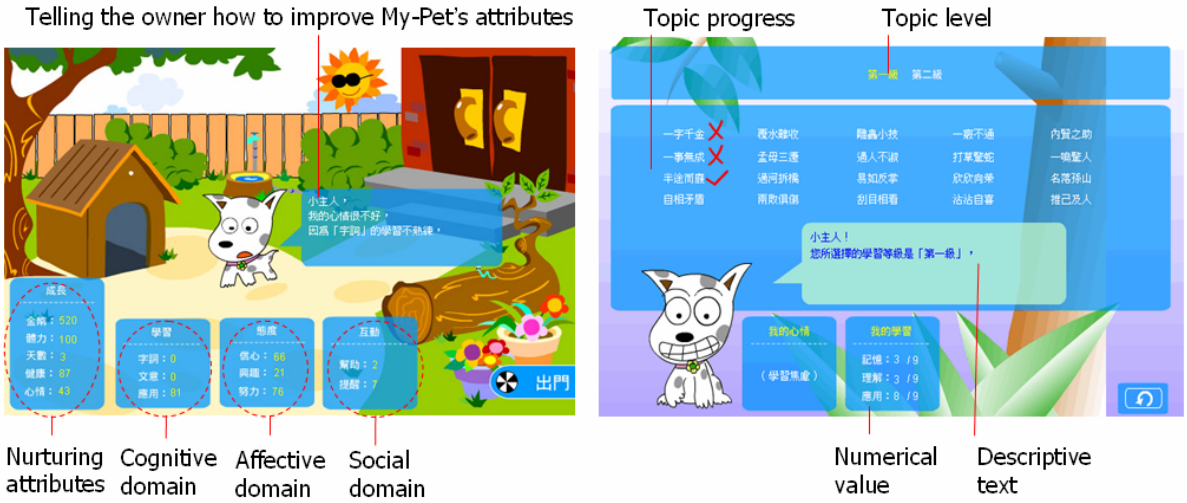
My-Pet consists of pet nurturing and individual learning modes. In the pet nurturing mode, My-Pet is a computer-simulated pet that holds a learner's learner model, and needs the learner's nurture and care. A learner is prompted on how to take good care of her My-Pet according to the result of inspecting My-Pet's attributes. To improve these attributes, the learner is asked to participate in learning activities in the individual learning mode. The open learner model representation is introduced before describing these two modes in detail.

Representation of open learner model

A very simple learner model, as shown in Fig. 2(a), is used in reading activity to allow children to explore the proposed concept and system feasibility. Learning aspects are classified into three dimensions, cognitive, affective and social; these aspects are instance-wrapped as My-Pet attributes. Therefore, the learner can inspect relevant attributes in each dimension, such as "remembering", "understanding" and "applying" in the cognitive domain; "confidence", "interest" and "effort" in the affective domain and "reminding" and "helping" in the social domain. Additionally, the nurturing attributes, such as "hunger", "age", "health" and "emotion", can also be observed. Figure 3 illustrates all of My-Pet's inspectable attributes.

Several powerful representation formats, such as skill meters (Corbett & Bhatnagar, 1997; Weber & Brusilovsky, 2001), hierarchical trees (Kay, 1997) and concept maps (Dimitrova, 2003) have been proposed for the open learner model. My-Pet-Our-Pet adopts a simple numerical approach. Such representation of an open learner model contains two levels: summary level (topic level and topic progress) and detailed level (descriptive text and numerical value), as shown in Fig. 2(b). The summary level displays the statistical information to represent the overall situation, and makes the learner quickly aware of her own learning status. The highlighted color is used at the topic level, and the topic progress is indicated by three markers, namely mastered, not mastered and never attempted. The detailed level describes the status of one topic in the subject matter, including numerical values (in the form of fractional representation) for each sub-topic, and the descriptive text displayed by My-Pet's dialogue.

In addition, to enhance the learner's perception of learning progress, the three aspects in the cognitive dimension are transformed wrapped by the "emotion" attribute, which drives the My-Pet's emotional expression and dialog to help convey the learning status. For instance, if a learner's "understanding" attribute drops quickly, then the My-Pet's "emotion" attribute also automatically falls lower, and drives My-Pet to soliloquize with a sad-mood face. The attribute urges the learner to initiate active interaction, and My-Pet tells him what causes his sadness, and encourage him to remedy it.



(a) Numerical representation approach (b) Summarized and detailed levels

Figure 2. A simple open learner model used in the My-Pet-Our-Pet system

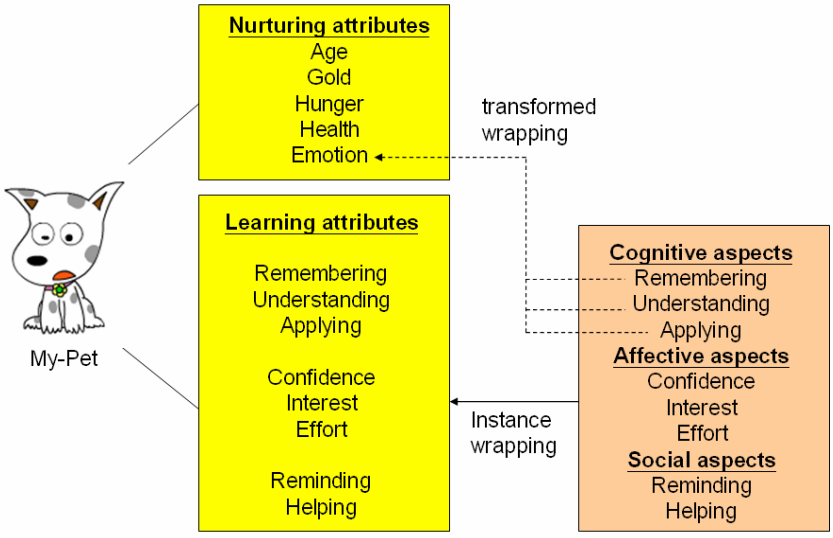


Figure 3. My-Pet's inspectable attributes

Pet nurturing mode

In the pet nurturing mode, a learner owns a My-Pet, and needs to inspect attributes in order to understand it and take good care of it. For example, if My-Pet's "hunger" attribute increases, then the learner needs to buy food to feed it. However, buying food requires virtual coins, which have to be earned according to the efforts made in learning activities in the individual learning mode. In other words, the learner must earn virtual coins in the learning activities to buy pet food or other services in order to take good care of her My-Pet. Figure 4 displays the relationship between the pet nurturing and individual learning modes.

My-Pet plays three educational roles in the individual nurturing mode, namely *reflector*, *motivator* and *sustainer*. First, for the reflector role, the learner needs to frequently observe the attributes in order to feed My-Pet, and make him healthy and happy. By taking good care of My-Pet, the learner does take good care of her learner model. The nurturing process could increase the learner's opportunities to reflect on her learning progress.

Second, for the motivator role, based on the good will and emotional attachment to My-Pet, the learner is motivated to take action to participate in learning activities. The good will is the cause and learning is the effect. Such a design is similar to what Rieber (1996) called "sugar coating". This initial motivation for learning is not for the purpose of learning itself, but if the learner later finds that the subject matter required for learning is an intriguing and rewarding experience, then this initial motivation may change qualitatively into motivation for the learning subject matter itself.

Third, for the sustainer role, pet keeping is a regular and long-term activity. With appropriate reinforcement, My-Pet may be able to sustain some desired learning behaviors to become a habit. Nurturing My-Pet may be the real intention of the learners, with merely a side-effect in the process of pet nurturing. However, the open learner models are portrayed as animal companions, and regular nurturing and taking care may become helpful reinforcements for children to sustain their long-term use of open learner models.

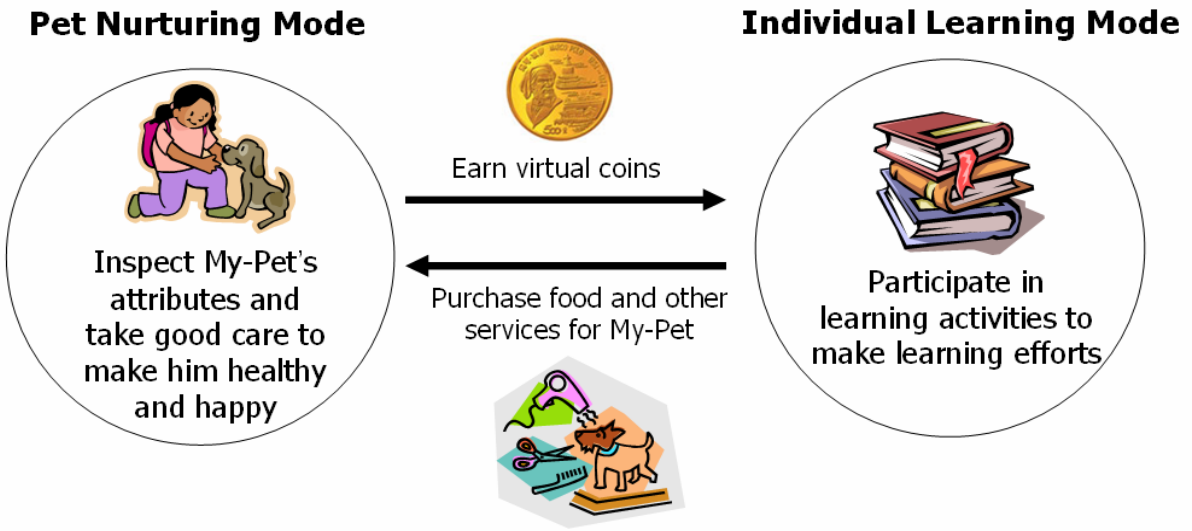


Figure 4. Pet nurturing and individual learning modes in My-Pet

Individual learning mode

Individual learning mode contains a series of individual learning activities, and is the part in where the learner needs to make efforts in the learning activities. This study implemented one simple reading activity on Chinese idiomatic phrases. A learner can read the historical story to understand the original meaning, and practice these phrases in different contexts.

Three dimensions of learning (cognitive, affective and social) are collected in the learner model. For the cognitive dimension, a simple overlapping approach is adopted, and some aspects relevant to cognition are quantitatively recorded according to the learner's mastery level, such as "remembering", "understanding" and "applying". For the affective dimension, several affective attributes are numerically represented by a simple simulation approach. For example, "confidence" is measured as the proportion of correct answers given to the questions; "interest" is determined by the frequency in which learners perform learning activities for a topic when they are not required to do so, or after class. "Effort" is measured as the accumulation of time that a learner has spent on a topic. The social dimension describes some social attributes of the learner's helpful interactions with teammates, including "reminding" and "helping". "Reminding" is measured using a simple honor system, in which the learner reports to the classroom teacher how many times she reminds her teammates to study in each session. "Helping" is calculated by the system logs when the learner presses the help-giving button to start the helping session.

In this mode, My-Pet plays an educational role as a *task facilitator*. Based on inspecting My-Pet's attributes, the learner is helped to construct the relationship between the current learning task and the requirement. This relationship could help learners to engage in learning activities and focus their

attention on the current task. Learners thus devote themselves to studying the learning contents, and to passing the assigned assessments.

Our-Pet

Our-Pet is a pet for a team, and is commonly owned and co-nurtured by all members. A significant component of Our-Pet that largely governs behaviors of Our-Pet is the open group learner model. Our-Pet contains two modes, game competition and group discussion. In the game competition mode, attributes of two Our-Pets are compared, and the winner is the team whose Our-Pet attributes are better than those of the other. In the group discussion mode, all teammates in the same team learn together and share comments through group discussion.

Representation of open group learner model

A different number of students can form a team based on the assignment of the team members. In this study, four students form a team, meaning that four My-Pets form an Our-Pet family, as shown in Fig. 5(a). An Our-Pet consists of an open group learner model, which is an aggregate of four My-Pet's open individual learner models. Aggregation can be performed in four ways, "average", "minimum", "maximum" and "variance". These aggregate functions are also called "viewpoints", and can be selected by a teammate to inspect his Our-Pet and observe the content of the open group learner model. For instance, an "average" viewpoint allows the learner to examine the average computation of four teammates' attributes in the cognitive, affective and social dimensions. Figure 6 illustrates all inspectable attributes of Our-Pet via four viewpoints.

(a) Different viewpoints for group learner model (b) Our-Pet team competition

Figure 5. A simple open group learner model used in the My-Pet-Our-Pet system

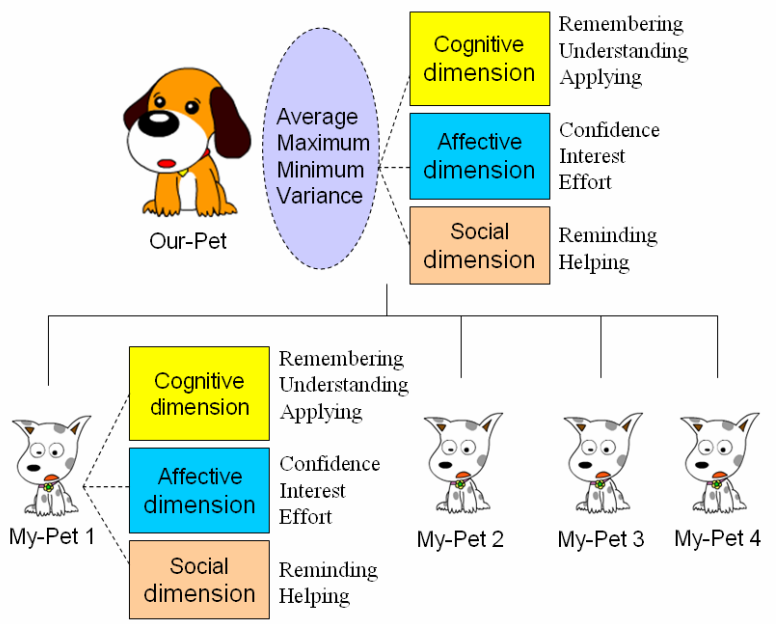


Figure 6. Our-Pet's inspectable attributes

Game competition mode

In the game competition mode, all Our-Pets are involved in a series of competitive games where two Our-Pets compare attributes with each other for the championship. The result of the Our-Pet's comparison is determined by two factors, the group learner model and luck. The luck element is the part that can not be controlled by the learner, but it increases the fun ambiance and enables a less-capable team to win against a more-capable team, rather than the result being determined only by the academic performance. However, the main factor affecting the result is the group learner model, which is the part that can be improved by the teammates.

Initiating the game competition involves viewpoint and attribute selections determined randomly by the system. For instance, when the "average" viewpoint and the "helping" attribute in the social dimension are selected, two Our-Pets start to struggle to determine the game winner by comparing all members' average values on the "helping" attribute as well as some element of luck. The random viewpoint selection means that no attributes of the group learner model in three dimensions can be ignored. Since the winning chance of Our-Pet mainly depends on the group learner model, the whole team has to establish its common goal, and its members must work together in the group learning activities to improve the status of the team's group learner model, and improve its chance of winning.

Our-Pet serves as a *goal setter*. The Our-Pet game competition is held regularly, and learners need to frequently observe the attributes of the group learner model to discover the team's shortcomings and adjust their strategy to win the game competition. For this common goal, the learners can understand their whole group through the four viewpoints of the group learner model, thus further promoting reflection. In addition, positive learning interactions, such as encouraging, monitoring, help-seeking and help-giving, are also encouraged. Figure 7 illustrates the relationship between the group learning and game competition modes.

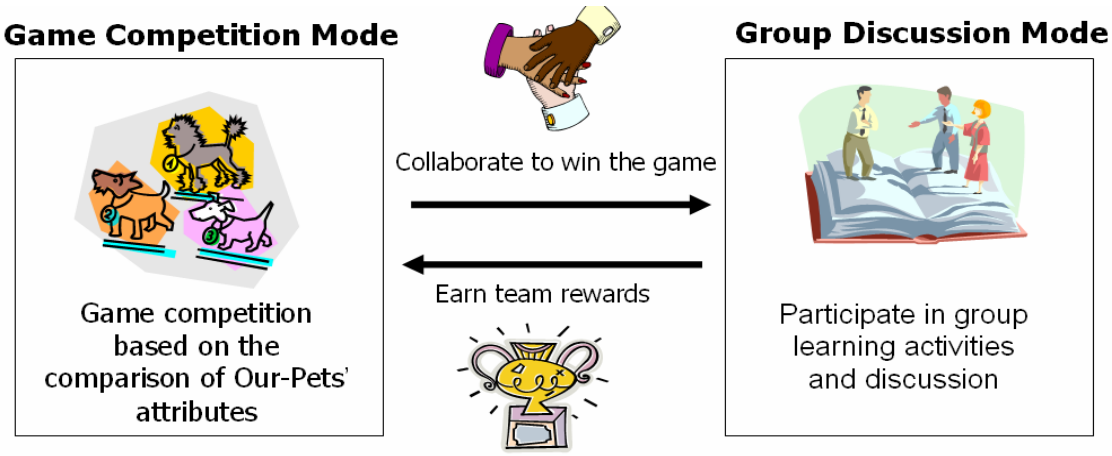


Figure 7. Game competition and group discussion modes in the Our-Pet

Group discussion mode

The group discussion mode consists of group learning activities, in which all teammates can discuss and share ideas with each other for the given learning tasks. In the current version, learners have some time to discuss questions towards Chinese idiomatic phrases with their teammates following individual learning in the individual learning mode.

Our-Pet plays two educational roles, *reflector* and *help-giving facilitator*, in this mode. For the reflector role, in contrast to the reflector role played by My-Pet in the individual learning mode, learners can observe other teammates' My-Pets as well as their team's Our-Pet in this mode. Our-Pet provides learners with four viewpoints, namely "average", "minimum", "maximum" and "variance" towards the group learner model to observe attributes.

Through the "average" viewpoint, learners can look at the average status of their teams, enabling them to quickly understand the team's overall learning status. The "minimum" viewpoint allows teammates to find the weakest teammate and consequently help or remind her to do more remedial study. Furthermore, the "maximum" viewpoint identifies the strongest teammate encouraging her to strive for excellence. However, this "maximum" viewpoint increases the variance among teammates, and drives the stronger teammates to help the weaker ones, thus narrowing the gaps of variance among them. Therefore, the design of the "variance" viewpoint further encourages the giving of help. Table 1 summarizes the various educational roles played by My-Pet and Our-Pet in each mode.

Table 1. Educational roles played by My-Pet and Our-Pet

	Modes	Roles	Designs
My-Pet	Pet nurturing	Reflector	Taking care of My-Pet, which is equivalent to taking care of the learner's open learner model
		Motivator	Motivating learners to learn in order to take good care of their My-Pets
		Sustainer	Providing a reasonable "nurturing" reason to long-term use open learner model
	Individual learning	Task facilitator	Engaging learners to increase their effort in the provided learning activities
Our-Pet	Group discussion	Reflector	Providing different viewpoints on open group learner model to help reflection
		Help-giving facilitator	Fostering more-capable team members to help less-capable members, enabling the team to win the game competition
	Game competition	Goal setter	Providing a common game for all teammates to

			pursue

STRATEGIES APPLIED IN BENEFITING CHILDREN LEARNING

In addition to the educational roles described above, the My-Pet-Our-Pet system is designed based on the three strategies. These strategies are adopted to benefit children's learning, and the desired outcomes are examined in the following section.

Strategy #1: using the "learning by taking care of animal companions" strategy to motivate children to interact with open learner models

Although most individuals conceive a computer as a tool, artificial intelligence researchers intend to make a computer more than a tool. Intelligent agents help achieve this goal. An intelligent agent is required to be autonomous so that it can take initiative to interact with learners. By contrast, an animal companion is not an autonomous agent, though in some occasions it can or should be so, and nor is it a tool. Animal companions adopt "taking-care" approaches in order to make learners take stronger initiatives to interact with agents that hold their learner models. In other words, while open learner models are portrayed as animal companions, a learner is required to nurture and interact with it only for the sake of emotional attachment to the pets. Nevertheless, this kind of "user initiation" approach anchors a set of learning activities for the learners to learn, and motivates them to use open learner models in the learning process.

To become an active open learner model, several My-Pet's attributes are designed to react to the learner's nurturing and interactions. Additionally, My-Pet's emotional expressions are designed to reflect the owner's aspects of cognitive dimension in the learner model by simple heuristic rules, as shown in Table 2. My-Pet automatically shows emotional expression to its owner, and soliloquizes according to the owner's attributes in cognitive domains. These emotional expressions motivate the learners to take action to understand their learner model, and to improve their learning statuses. Figure 8 illustrates My-Pet's different emotional expressions.

Table 2. Simple heuristic rules that govern My-Pet's emotional expressions

No.	Expression	Rule
1	Exciting	Average of attribute in cognitive domain is higher than 90%
2	Happy	Average of attribute in cognitive domain is between 75% and 90%
3	Neutral	Average of attribute in cognitive domain is between 60% and 75%
4	Sad	Average of attribute in cognitive domain is between 40% and 60%
5	Upset	Average of attribute in cognitive domain is lower than 40%

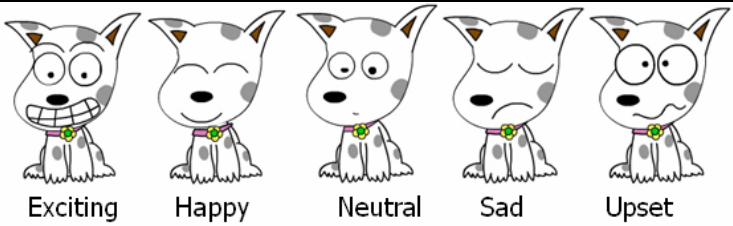


Figure 8. My-Pet's different emotional expressions

Applying emotional attachment in pet-keeping to the open learner model can bring three promising advantages, increasing usage frequency, sustaining usage motivation and long-term profile collection. First, from the viewpoint of system development, one important consideration for system design is the usage frequency of the learning system. Open learner models as embodied pet characters could attract children's attention to use the learning system, and hence increase the available opportunities to raise the system usage. Second, from the viewpoint of usage motivation, nurturing animal companions may offer children an adequate reason to use the open learner model for a long-

term period, and further guide them to participate in learning activities. Third, from the viewpoint of time scale, long-term collection and analysis of user profiles could enrich and solidify research into open learner models. Current research still lacks longitudinal studies for learner models. The taking-care strategy may be helpful to sustain learners' motivation, and establishes a long-term learner model to enable life-long learning companions (Chou *et al*., 2003).

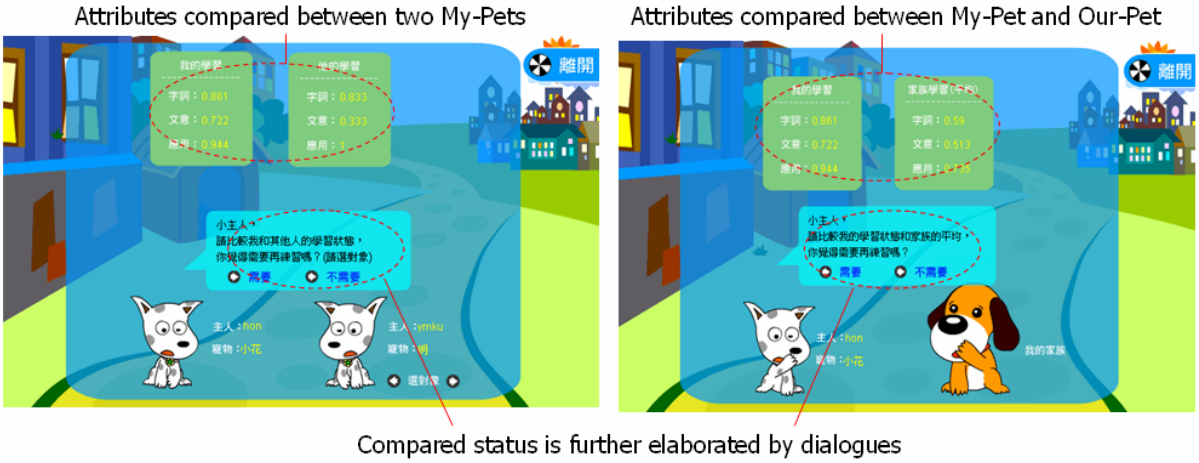
Strategy #2: using the "providing different perspectives towards open learner model" strategy to promote awareness and reflection

Schunk and Zimmerman (1998) defined self-regulated learning as "learning that occurs largely from the influence of students' self-generated thoughts, feelings, strategies and behaviors, which are oriented toward the attainment of goals", and it contains three general cyclic phases, planning learning strategy, progress monitoring and outcome evaluation. Open learner models such as My-Pet and Our-Pet try to facilitate the execution of self-regulated learning. The planning phase involves strategy selection and resource allocation based on self-efficacy. My-Pet and Our-Pet provide children with a reference model to improve their awareness and self-efficacy.

The monitoring phase monitors the on-line awareness of comprehension and task performance. The regular nurturing and taking care of My-Pet and Our-Pet help children inspect and monitor their learning performance. The evaluating phase assesses the outcomes and regulatory learning processes. My-Pet's emotional expressions are helpful for children to interpret the cause of performance that is not as good as expected, and drives them to re-examine their strategies. The learner frequently reflects her learning status throughout the three phases, and further deliberates the linkage between "what she know about learning" and "what she does about learning", thus promoting self-reflection (Ertmer & Newby, 1996).

Furthermore, My-Pet and Our-Pet provide concrete metaphors for two perspectives towards open learner models: single versus group learner models, and summary versus comparative learner models. First, in My-Pet-Our-Pet system, the single and group learner models are possessed by My-Pet and Our-Pet helping learners, especially children, to distinguish among different scopes of learner models. As shown in Fig. 5(a), through inspecting My-Pet and other My-Pets, the learner knows her own learning progress, and that of other teammates and the team through the "average", "maximum", "minimum" and "variance" viewpoints.

Second, comparative models are supported in a concrete way: two pet characters meet each other, as shown in Fig. 9. Comparing these different perspectives of information (the pair of two My-Pets, or the pair of one My-Pet and one Our-Pet) increases the learner's awareness of what she has mastered, what she has or has not mastered, and what other teammates have or have not mastered. My-Pet's dialogues further explain and elaborate this summary information to improve the comprehensibility of information.



(a) Compared viewpoint between two peers (b) Compared viewpoint between self and team

Figure 9. Snapshot of the Our-Pet system

Strategy #3: using the "inter-team game competition and intra-team collaboration" based on group learner models to encourage positive group interactions.

Making learners work together is an effective pedagogical approach to encourage learners to learn, and to help each other learn (Slavin, 1990). In team work, students are responsible for their learning as well as that of their teammates. The openness of the learner model may be not only helpful to individual learning, but also for developing positive interactions among teammates. Moreover, competition is also an effective element to motivate the learner to learn. However, the competition of the individual's performance may damage the individual. Therefore, the strategy of group competition is recommended by several researchers (Collins & Newman, 1989; Chan *et al*., 1992).

Additionally, several investigations have explored the clever designs for co-learners. For instance, the I-Help system adopts automatic agents to treat the individual learner model as a useful contact resource thus facilitating help-seeking and help-giving behaviors (Greer *et al*., 1998; Vassileva *et al*., 1999; Bull *et al*., 2001; Greer *et al*., 2001; Vassileva *et al*., 2001). Unlike the approach that focuses on the individual learner models, Our-Pet employs a competitive game strategy based on the group learner models to establish a context of inter-team game competition and intra-team collaboration. Figure 5(b) shows the Our-Pet's game competition based on the group learner model.

This game-based application of the group learner model may benefit children's learning in three ways: First, the game element of Our-Pet competition engages children to enjoy pursuing the team goal. Rieber (1996) pointed out that "game play is a useful learning strategy in which children are experts. Having children play games to learn is simply asking them to do something natural." Therefore, the game competition of Our-Pet motivates children to "play" open group learner models. Second, Our-Pet competition promotes two key elements to affect the execution of team work, individual accountability and member interdependency. Our-Pet competitions not only need individual accountability of each teammate, but also increase the member interdependency that encourages helpful behaviors. Hence, the more-capable members are better motivated to help the less-capable members to tackle their learning barriers. Third, opening learner models to other learners has implications for personal privacy and acceptance. Since team members are necessarily interdependent the context of team collaboration based on the Our-Pet game competition, Out-Pet could help reduce the learners' suspicion and hesitation in opening their learner models to other learners.

PRELIMINARY EXPERIMENT

A preliminary experiment using My-Pet-Our-Pet was conducted in a classroom of Wang-Fang elementary school (see Figure 10) from November 2004 to January 2005 in Taiwan. The classroom is a one-on-one classroom environment, where every student has a computing device with wireless capability (see www.g1on1.org). The main objective of this experiment was to evaluate the learning effect and affective influences of My-Pet-Our-Pet. The participants in this experiment were 31 eleven year old fifth grade students. The participants were arranged in 8 teams, each consisting of 4 students (the eighth team had 3 students). Each team contained students with different academic performance with one high-performing student, two mid-performing students and one low-performing student.

The experiment was divided into two phases. Only learning material was provided to the students in the first phase, while both learning material and My-Pet-Our-Pet were provided in the second phase. In each phase, students used the Tablet PCs for 10 fifteen-minute sessions in the class for one and a half months. During this period, two graduate students were employed as teacher assistants to observe the students' usage and feedback. The learning tasks assigned to these students involved learning about Chinese idiomatic phrases. Each student was asked to read the historical story to understand the original meaning, identify the key words and key sentences, and then practice the application of these phrases in different contexts. After individual learning, the students could discuss learning contents with their teammates if they wished.

Figure 10. Snapshots of My-Pet-Our-Pet used in the 1:1 classroom environment

This experiment asked two questions. The first question, concerning cognition, was "What are the learning effects of students' learning with My-Pet-Our-Pet?" the second question, which was about affect, was "What was their affective experience of using My-Pet-Our-Pet in the classroom environment?" Pre-tests and post-tests were administered for 40 minutes in each phase to determine the cognitive effect. For each test, fifty questions were included in the three categories of items, namely memorizing, comprehension and application. Moreover, to collect affective experimental data, the two graduate students provided questionnaires and conducted face-to-face interviews with students. Figure 11 illustrates the experimental setting.

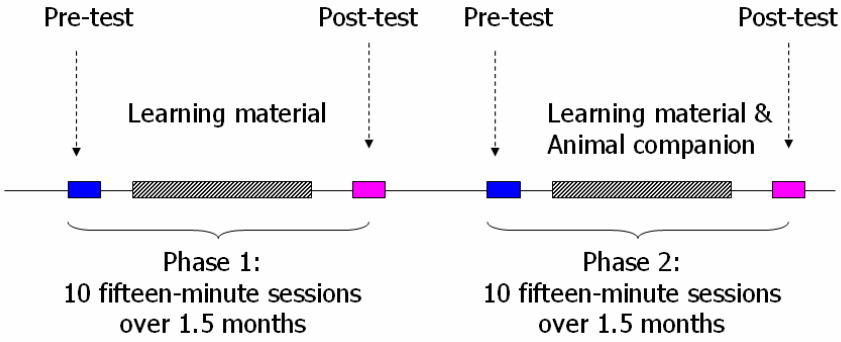
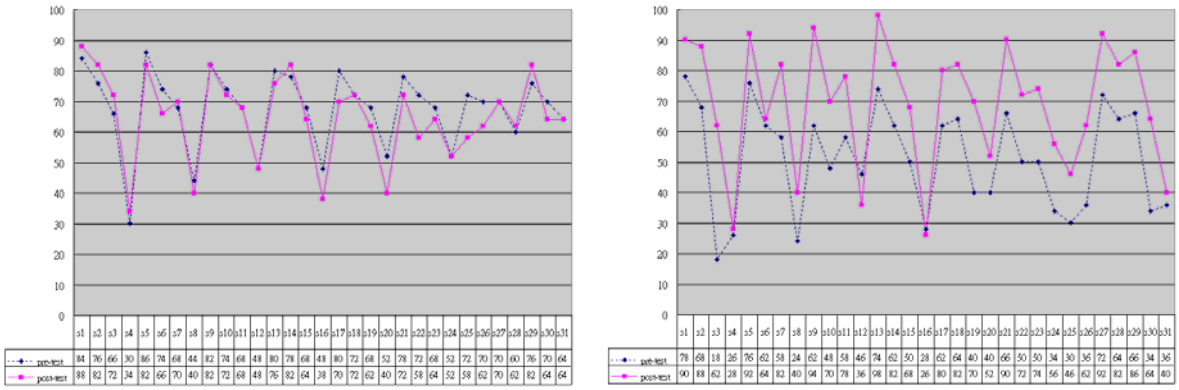


Figure 11. Procedure of My-Pet-Our-Pet preliminary experiment

Cognitive results

Figure 12 shows the pre-test and post-test results in the two phases. Figure 12(a) displays the score distribution of the first phase, where the pre-test (blue dotted-line) and post-test (red concrete-line) are almost the same. Figure 12(b) reveals the score distribution of the second phase, where most of the post-test scores were higher than the pre-test scores. This difference is statistically significant ($p<.01$) in the paired-sample t-test. Table 3 lists the results of paired-sample t-test in two phases.



(a) scores of pre-test and post-test in phase-1 (b) scores of pre-test and post-test in phase-2

Figure 12. Scores of pre-test and post-test in two phases

Table 3. Result of paired sample test in two phases

	Pre-Test Score		Post-Test Score		(p< .01)	
	Mean	Std. Deviation	Mean	Std. Deviation	t	p
Phase-1	67.68	12.82	65.03	14.02	2.54	.016
Phase-2	51.03	17.03	69.23	20.33	-9.5	.001*

Affective feedbacks

Table 4 presents the statistical results of the 5-scaled questionnaire regarding student opinions. Opinions of "strongly agreed" and "agreed" are regarded as positive responses. In terms of student interest and motivation, 28 (90%) students showed that My-Pet-Our-Pet raised their attraction to the learning subjects, and 25 (80%) students expressed that My-Pet-Our-Pet enhanced their willingness to work in learning activities (item 1 & 2). For the self-awareness, 25 (80%) students presented that My-Pet-Our-Pet reflected their learning status, and 26 (84%) students showed that My-Pet-Our-Pet increased their awareness of learning status (item 3 & 4). For the relationships among members, 19 (61%) students indicated that constant competition increased their reliance on each other (item 5).

Table 4. Questionnaire and statistics regarding student opinions

No.	Items	# of S.D.	# of D.	# of N.	# of A.	# of S.A.	Avg. score
1	Am I more interested in learning idiomatic phrases with My-Pet-Our-Pet?	1	0	2	**12** (39%)	**16** (51%)	4.35
2	Do I make more effort to learn idiomatic phrases with My-Pet-Our-Pet?	1	0	5	**11** (35%)	**14** (45%)	4.19
3	Does the learning status given by My-Pet-Our-Pet reflect my own learning status?	0	1	5	**11** (35%)	**14** (45%)	4.22
4	Am I more aware of my learning status with My-Pet-Our-Pet?	0	0	5	**12** (39%)	**14** (45%)	4.29
5	Does the Our-Pet competition urge our team to hold together?	0	1	11	**13** (42%)	**6** (19%)	3.77

(Strongly disagreed=1, Disagreed=2, Neutral=3, Agreed=4, Strongly agreed=5)

Student interviews were conducted to collect further detailed information about students' affective experience. The semi-opened interviews were conducted followed by yes-or-no questions. These interviews are summarized below.

Issue 1: My-Pet's roles as motivator and sustainer

My-Pet plays the roles of *motivator* and *sustainer* in the pet nurturing mode. When students were asked the question, "Compare your feelings towards learning ways in the two phases", the 31 students were all impressed and enjoyed the process of nurturing My-Pets.

"I like pets very much, but I can't keep pets in at home. In the My-Pet-Our-Pet, I can take care of my own pets, and it is very interesting." (student #34)
"It (My-Pet-Our-Pet) uses many ways to make us think of learning idiomatic phrases as an interesting and appealing task." (student #28)
"My learning progress had doubled. I like My-Pet-Our-Pet because I not only can learn idiomatic phrase, but nurture pets." (student #27)
"I worried about My-Pet when his mood was bad, while I felt satisfied when My-Pet was well taken care of." (student #30)

Issue 2: My-Pet's roles as reflector and task facilitator

My-Pet also attempts to act as *reflector* in the individual learning mode. For the students were asked the questions, "How do you treat your My-Pet when he is unhappy?" and "Does the design of My-Pet help you understand your learning status?" Twenty-six students (83.8%) felt that portraying the open learner model as My-Pet is a clever way to discover their learning status, and My-Pet's emotional expression is also an interesting scheme to convey information to them.

"When My-Pet's mood is observed happy, I felt happy. But when he (My-Pet) was depressed or unhappy, I would think, 'What's wrong?' Then I would take him to buy candies, by learning Chinese idiomatic phrase, and try to make him happy." (student #27)
"While My-Pet was unhappy, I always listened to him. He (My-Pet) said that he wanted to learn something better, so I went to learn again." (student #35)
"If My-Pet is sad, then I also feel unhappy. He seems to be my real pet." (student #13)
"If he (My-Pet) is happy, then my learning status is great!." (student #16)

Additionally, when the students were asked to compare their engagement in the two phases, two students (6.5%) expressed that it was the same in both, because they felt that learning idiomatic phrases is boring. The other 29 students (93.5%) stated that they were more engaged in the reading activity in the second phase than in the first.

"I will take it seriously, because I want to earn coins to nurture my pet." (student #22)
"Of course, I must pass the assessment, and then I can gain the virtual coins." (student #12)

Issue 3: Our-Pet's roles as reflector and help-giving facilitator

My-Pet and Our-Pet play the roles of *reflector* and *help-giving facilitator* in the group discussion mode. The students were asked "Is the inspecting function provided by My-Pet and Our-Pet is helpful to you?" Among the students, 27 (87%) felt that these functions were convenient ways to understand their learning statuses.

"I care about his (My-Pet's) status, because his status shows my learning status." (student #21)
"I frequently saw the average viewpoint of Our-Pet, and it showed me our team's progress. Then I went back to study hard." (student #25)

"When seeing that my value is the highest among four teammeaters, I will encourage them. I had encouraged all of our teammates." (student #27)
"We (students #33 & #22) discussed the Chinese idiomatic phrase together. Sometimes we two girls answered the question together, and sometimes one found out the answer, and the other responded." (student #33)

Additionally, the students were asked the question, "How does the Our-Pet game competition affect interaction with other teammates?" Four students (13%) rarely cared about team competition while 27 students (87%) were influenced by the Our-Pet competition. Among these 27 students, 15 (55.5%) felt that team competition was a matters of honor and solidarity, and hence facilitated their communication and interaction while the other 12 students (45.5%) seldom interacted with other teammates, and they merely improved their individual learning.

"Our team's competitive ranking was initially the last, and then became the fifth. This was because I told them (other two boys) to study more for improving the values." (student #2)
"We will exchange our opinions, for example, by deciding which team is the one we want to compete with in the next turn." (student #23)

Issue 4: Our-Pet's roles as goal setter

Our-Pet serves as a *goal setter* in the game competition mode. For the question of "Does the competition of Our-Pet help you establish a common goal to pursue?" twenty-seven students (87%) stated that it has become all teammates' common objective to enable Our-Pet to win in the team competitions. However, four students (13%) did not care about the Our-Pet competition, and were concerned only about nurturing My-Pet.

"I hope our team will finally be the champion of Our-Pet competition finally." (student #28)
"I always notice the ranking of competitive result. If Our-Pet's ranking is not good, it seems that I did not do well." (student #27)

Discussion

According to the interview results of this preliminary experiment, all 31 students expressed that they were interested in raising their My-Pet, and most students (29/31) expressed that they were also engaged in the learning of Chinese idiomatic phrases. In addition, most students (26/31) showed that the use of animal companions in the open learner model is an interesting way to reflect their learning status, and most students (26/31) also thought that the inspectable functions provided by My-Pet and Our-Pet was useful for them. Consequently, My-Pet-Our-Pet seemed to successfully motivate students to learn, and to improve their academic performance, in which open learner models are significant reflective media to help improve their understanding and hence improving their academic performances. The review of use of the above strategies indicates that both strategy 1 (learning by taking care of animal companions) and strategy 2 (providing different perspectives towards the open learner model) could help children's learning in terms of motivation and reflection.

Furthermore, most students (27/31) were keen to win in the Out-Pet team competition. However, half the students (15/27) tended to observe and encourage each other while learning. By contrast, the other students (12/27) were inclined to improve their own individual performance, rather than having positive interactions with their teammates. The review of strategies reveals that strategy 3 (inter-team competition and intra-team collaboration) was successful only for half the students. Half the students pursued their common team goal through studying harder on their own, rather than through helpful interactions with other teammates.

This finding may be due to three possible factors, the essence of learning activity, group management and student personality. First, the individual learning model of Chinese idiomatic phrases does not have an essential collaborative element. Students can individually learn in both individual learning mode and group discussion mode, and seldom care about the relationships among their teammates. Observations of

students' interactions indicate that the most popular team topics were "what should we name our team?" or "which team should we select as our opponent?" Learning activities that need decisions by all members can trigger member discussion and collaboration, and the group discussion mode lacks this mechanism in the learning activity.

Second, teamwork is facilitated if the roles played by teammates in a team are diversified, and if each role is essential for winning the game competition. The game competition design falls short of this element. Third, the interpersonal interaction and communication in the classroom environment are more immediate and complex than human-computer-interaction. In this experiment, although the ranking of Our-Pet results affected the teammate interactions, some factors, such as students' personality (a student who is shy and introvert may not be very social), gender difference (girls like to play with girls, rather than boys), and friendship (some students asked why they were not allowed to form teams with their good friends) may also have significant influences.

CONCLUSION

This study describes the design rationales of a system based on the human attachment to pet keeping, called My-Pet-Our-Pet, which consists of the My-Pet and Our-Pet animal companions. In My-Pet-Our-Pet, open learner models are designed to play an active role, which are portrayed as animal companions to motive children to learn. My-Pet-Our-Pet not only attempts to motivate learners to improve their academic performance through the open learner model and group learner model, but also to promote reflection and helpful interactions among teammates. My-Pet and Our-Pet employ the three strategies of motivation, reflection and member interaction to maximize their educational roles.

Preliminary analytical results show that the strategy of "learning by taking care of animal companions" and the strategy "providing different perspectives towards open learner models" have positive impacts on students. All 31 students were motivated and engaged in the process of raising their pets, and most of them (29 students) increased effort to improve their learning statuses owing to My-Pet and Our-Pet. However, the strategy "inter-team competition and intra-team collaboration" was successful for only half the students (15/31 students).

Learning achievement is usually the major concern of a student, and helps the student to develop her self-concept and identity. However, the student also cares about her animal companion, thinking of it as her second identity. Open learner models as animal companions provide students with fruitful ways to interact with their open learner models, and attempt to benefit students' learning. Although the preliminary experiment in this study offers initial feedback for reference, more formal evaluations and a more controlled experimental setting are required to further address these issues.

Additionally, two directions (vertical and horizontal) in animal companion research could be investigated. The vertical direction focuses on "trainable" animal companions with different competences, and designs the growing-up statuses of animal companions as a series of stages according to well-structured learning objectives. Trainable animal companions try to foster goal-setting and deeper engagement, and allow the learners to increase their self-monitoring and self-regulation. The horizontal direction concerns multiple animal companions with different personas. For example, the trouble-maker might provide erroneous solutions to disturb learners (Aïmeur *et al*., 1997); the collaborator cooperates with the learner to accomplish their learning tasks; a friend with sense and the other with sensibility provide rich perspectives to elaborate the decision made by the learner in order to facilitate their reflection.

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