

Level Up, My-Pet: The Effects of Level-up Mechanism of Educational Agents on Student Learning

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ABSTRACT

A number of studies have been devoted to investigating the influence of educational agents on different aspects of student learning. However, little attention has been paid to the effects of the level-up mechanism of educational agents on students although this is a significant issue. Thus, this study develops an educational agent with the level-up mechanism so that the effects of the level-up mechanism can be addressed. The results of a within-subject experiment conducted in an elementary school showed that the level-up mechanism of the educational agents can help students develop a positive relationship with the educational agent, and further enhance their motivation in terms of attention, relevance, and satisfaction.

KEYWORDS

Educational agent, Level-up, Game-based learning

Introduction

In recent decades, one direction of technology enhanced learning that has been attracting increased attention is the study of educational agents, which are human-like virtual characters that play specific educational roles in their interaction with students. There are two reasons for the development of educational agents. First, people are attracted to human-like features, given face and eye contact, humanizing the human-computer interaction (Weinschenk, 2011) and therefore allowing them to treat computers as social actors (Reeves & Nass, 1996). Thus, the educational agents are regarded as friendly interfaces that can facilitate interaction with students, leading to enhanced motivation and the perception of improved ease and comfort (Gulz, 2004). Such features can also be applied to benefit student learning so that they can become engaged in the learning environment (Gulz, 2005).

Second, a number of advantages have been reported to learning with the support of different types of educational agents on specific aspects, such as exploration (Höök et al., 2000), reflection and articulation (Tholander et al., 1999), communication (Johnson et al., 2000), and negotiation (Bull, 2004). This might be because educational agents can serve as learning companions offering virtual participation in an individual environment. By doing so, students are encouraged to interact with the educational agent in a social context and experience an enjoyable learning process, which, in turn, results in the aforementioned learning advantages.

Further looking into the design of educational agents, several pedagogical strategies have been incorporated to promote student learning based on human teaching and learning theory (Woolf, 2009). For example, the AutoTutor system employs dialog in natural language to help students construct answers to difficult questions (Graesser et al., 2008). The Herman system, an insect-styled agent, offers students problem solving advice in the domain of plant structures (Lester, Towns, & Fitzgerald, 1998). In addition, to maximize the influences of educational agents, the affective design of educational agents are also concerned (de Vicente & Pain, 2002), such as empathic responses (McQuiggan & Lester, 2007) and emotional expression (Beale & Creed, 2009; Brave et al., 2005).

Although past studies contribute to our understanding of the development of educational agents, most of them have focused upon fixed-style educational agents rather than incremental ones. For example, the appearance and skills of educational agents can level up gradually while interacting with students. This level-up mechanism is significant because it, on the one hand, is commonly used to promote students' goal-pursuing in digital games, where students' progress and feedbacks on how to improve are clearly offered. Thus, students might benefit from this mechanism while it is incorporated into the design of educational agents. On the other hand, the incremental agent is closely related to the concept that virtual characters as active mirrors to reflect students' learning status (Chen et al., 2007), which gives great educational potential to facilitate the students' self-awareness and self-reflection. Nevertheless, few studies have explored this issue although there have been some emphasizing the influence of educational agents with different characteristics, such as a human-like persona and expressive manners (Beale & Creed, 2009; Groom et al., 2009; Wang et al., 2008). Thus, there is a need for further research on this problem.

To address this issue, this study first develops a level-up mechanism for the educational agent, and then goes on to investigate its influence on student learning. The research question addressed in this study is: “*What are the effects of the level-up mechanism of educational agents on student learning?*” This research question can be further divided into two sub-questions: (1) *What is the influence of the level-up mechanism of educational agents on students’ motivation?* (2) *What is the influence of the level-up mechanism of the educational agent on students’ perceived relationship?*

Literature review

Educational agents are human-like computer simulated characters that are designed to improve student learning in an individual environment through virtual participants (Chou, Chan, & Lin, 2003). In addition to the *cognitive aspects* of the design of educational agents, the *affective aspects* have recently attracted more and more attention. This is because the influence of the educational agent on student learning can be expanded by taking the affective qualities of the virtual character into account in the design (de Vicente & Pain, 2002). Furthermore, these affective concerns can be categorized into three classes: *visual style*, *human-like persona*, and *expressive means*, as illustrated in Table 1.

Table 1. Affective design of educational agents on student learning

<i>Features</i>	<i>Authors</i>	<i>Descriptions</i>
Visual styles	Gulz & Haake (2005)	Different visual styles (e.g., realistic or iconic) of virtual characters influence students’ choice preferences.
	Baylor et al. (2003); Baylor (2005)	Different visual appearances (e.g., ethnicity and gender) of virtual characters influence students’ choice preferences.
	Groom et al. (2009)	Behavioral realism (e.g., consistent high/low realism and mixed realism) of virtual characters influences students’ responses.
Human-like persona	McQuiggan & Lester (2007)	Empathy characteristics of virtual characters influence students’ perception.
	Wang et al. (2008)	Politeness characteristics of virtual characters influence students’ perception.
Expressive manners	Baylor & Kim (2003)	Different expressive styles (e.g., limited intonations, enthusiastic or calm) of virtual characters influence students’ perception and choice preferences.
	Beale & Creed (2009); Bartneck & Reichenbach (2005);	Different emotional expressions (e.g., present/absent self-oriented emotion and present/absent empathic emotion) of virtual characters influence students’ attitudes, perceptions, and behavior.
	Brave et al. (2005)	

Regarding visual style, the focus is on the representation of the educational agents, and investigating the effects of its visual appearance on the students (Gulz & Haake, 2005). A human-like persona with human-like characteristics, such as empathy and politeness allow the educational agent to have an impact (Wang et al., 2008; McQuiggan & Lester, 2007), although the effects of the expressiveness of different expressive styles, such as expressions of enthusiasm or calmness should also be emphasized (Baylor & Kim, 2003).

However, although past studies contribute to our understanding of the development of educational agents, most emphasize the influence of fixed-style educational agents rather than incremental ones, whose visual appearance changes according to the student’s achieved learning levels. Few studies have investigated the influence of the level-up mechanism of the educational agent based on the student’s learning, leaving a gap in the literature that needs to be filled. To address this research question, this paper first develops a level-up mechanism, which is embedded in an educational agent system, named trainable My-Pet. The trainable My-Pet system is introduced in the next section. We then conduct and discuss an empirical study of the impact of the level-up mechanism on student learning. Subsequently, the findings of the empirical study are further used to answer the research question.

Trainable My-Pet

Conceptual diagram

Trainable My-Pet is an educational agent system employing a reciprocal caring strategy with pet-styled educational agents. We employ the reciprocal caring strategy to determine how to encourage students to care for the educational agent so that the educational agent has sufficient opportunities to care for students (Chen et al., 2011). In other words, reciprocal caring involves integration of the affective and cognitive aspects of the educational agent to benefit student learning.

More specifically, each student nurtures an educational agent, the My-Pet, and are required to take good care of it (Chen et al., 2007), including *feeding* it and *training* it to learn skills. The purpose of feeding is to develop a close relationship with the My-Pet. This is supported by the finding that enhanced human-computer interaction is helpful to developing a relationship between the educational agent and the student, which further contributes to sustaining the students' participatory motivation. In addition, the purpose of training is to align game-playing with learning through the pedagogy of *learning-by-demonstration*. More specifically, within the pet-training game context, students are able to demonstrate knowledge of the subject domain to their My-Pet, to assist the My-Pets to learn and to raise their level up to a higher one. A conceptual diagram of the process is illustrated in Figure 1.

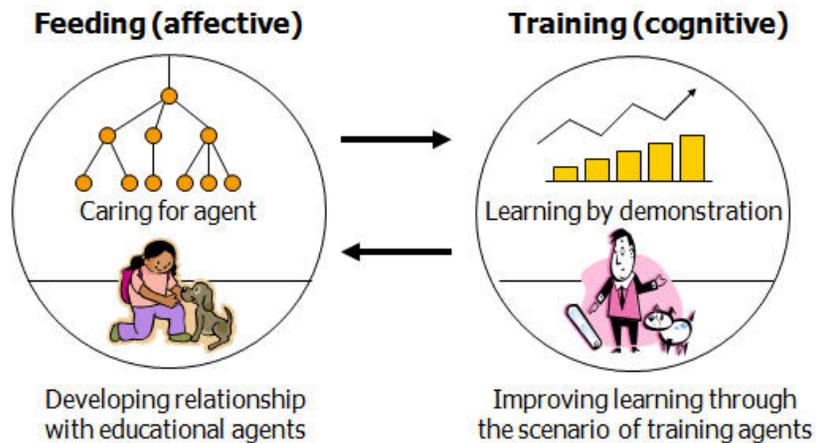


Figure 1. Conceptual diagram of the trainable My-Pet system

System interface

Feeding and training

In the feeding function, students interact with the My-Pet within an interactive environment. The My-Pet's status is represented by a numerical value noted so that the student can take appropriate caring actions. For example, Figure 2(a) illustrates the My-Pet's status, including their age, energy, money, health, mood, and experience. To look after their My-Pets better, students are required to buy food and goods for them with EduCoins, which can be earned from successfully completing learning activities. In this way, the My-Pets play the role of "motivator" so that their habits of pet-nurturing can be aligned with that of subject learning, which might further contribute to the maintenance of the student's participatory motivation for a long period of time.

In the training function, the subject domain of the trainable My-Pet system is to complete fraction operations in elementary math, which includes five categories of learning tasks: "basic operations," "adding fractions," "subtracting fractions," "multiplying fractions," and "dividing fractions." These tasks are chosen because fraction operations are a significant but a difficult subject to master in elementary math. The trainable My-Pet system can be used to support students' math learning. The fill-in-the-blank question is used in the learning tasks in these categories. For example, Figure 2(b) illustrates the learning task for "adding fractions with unlike denominators". Students are requested to fill in

appropriate numbers in the blank prompt box step-by-step. The process enhances the students' procedure knowledge of the fraction operation.



Figure 2. Interface of the trainable My-Pet system

Level-up mechanism

To facilitate learning, a level-up mechanism is incorporated, which is designed to enhance the students' awareness of what they have learned and to motivate them to improve their mastery. This objective is realized in two ways. The first is related to the My-Pet's *representation*, where symbolic marks (e.g., badges) and outside appearance and accessories (e.g., styles) indicate the student's current level of achievement. The second is related to the My-Pet's *skills*, or sets of abilities that the My-Pet can show. Table 2 illustrates these different skills for different levels. In short, the level-up mechanism of the My-Pet provides a continuous ladder leading to the learning objectives, where detailed information is presented to inform the student what their learning progress is along these ladders. By doing so, students are encouraged to complete learning tasks so that the My-Pet can be promoted to the next level. The My-Pet plays the role of "facilitator," which establishes an immediate goal for students to pursue and sustains their willingness and motivation during this process, which in turn fosters student learning.

Table 2. Level-up mechanism

	Level 1	Level 2	Level 3	Level 4	Level 5	Level 6
Badge	Non	★	★★	★★★	★★★★	★★★★★
Style						
Skill	Non	 (Hoop jumping)	 (Ball rolling)	 (Wire walking)	 (Somersault turning)	 (Waltz dancing)
Task	Non	Basic operations	Adding fractions	Subtracting fractions	Multiplying fractions	Dividing fractions

Methodology

To address the research question, a within-subject quasi-experiment was conducted in a one-to-one digital classroom environment, in which every student had access to a computing device with wireless capability to enhance their learning (Chan et al., 2006).

System instrument

Two variant versions of the My-Pet system were used in the experiment but the subject domain of the two versions is the same (i.e., fraction operations). In other words, the major difference between the two versions lies in whether the My-Pet can be trained to change levels according to the students' learning progress. Table 3 summarizes the major differences between the two system instruments.

Table 3. Different system instruments

Version	Description
Trainable version	Students learn fraction operations via training their My-Pets which can level up according to students' learning progress.
Non-trainable version	Students learn fraction operations via training their My-Pets whose levels cannot be promoted according to students' learning progress.

Participants and procedure

The participants were 31 fifth-grade (average age 11 years-old) elementary school students, including 16 boys and 15 girls. Since there was a similar number of boys and girls, it was assumed that the bias effect resulting from gender difference could be prevented. Figure 3 illustrates the experimental procedure. The experiment was divided into two phases. In the first phase students used the non-trainable version of the My-Pet system; in the second phase they used the trainable version. Each phase was completed in 10 fifteen-minute sessions over a period of six weeks.

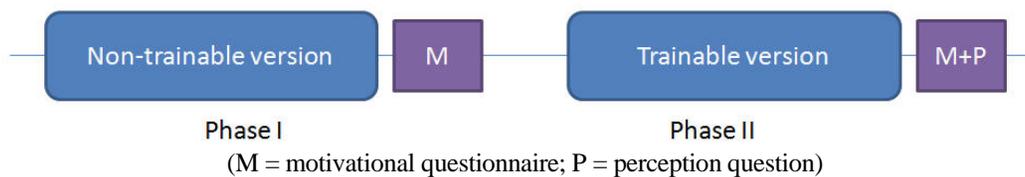


Figure 3. Setting of the within-subject experiment

Measurement

Motivational questionnaire

A motivational questionnaire based upon the 5-point Likert scale developed by Dempsey and colleagues (Dempsey, Rasmussen, Haynes, & Casey, 1997), was utilized to collect comprehensive information in terms of attention, relevance, confidence, and satisfaction dimensions. However, since the questionnaire was originally designed mainly for college students, not all of the items were suitable for the sample in this study, which were elementary school students. In addition, the questionnaire had too many items ($N = 36$) for elementary school students. Thus, we systematically eliminated 12 items so that the simplified version contained 24 items (each dimension contained 6 items). The items used are listed in the Appendix, and the four dimensions of the questionnaire had a relatively high reliability (Cronbach's $\alpha = 0.84, 0.72, 0.78, \text{ and } 0.61$, respectively).

Perception questions

At the end of second phase, all students were asked a semi-structured question about their perception: "Did you feel a close relationship with your My-Pets in the trainable version?" If the answer was "yes," students were further asked to mark the functions provided for deepening this relationship. Students could mark multiple items from the six functions, including naming, feeding, training, playing, exercising, and bathing.

Data analysis

The independent variable for the experiment was the difference in settings for the two system versions, whereas the dependent variables were the motivational questionnaire and perception questions. Regarding the motivational questionnaire, four repeated measurement t-tests were conducted to examine the significance between the two phases in terms of the four aspects. Regarding the perception question, the frequency of students' chosen functions was calculated.

Results

Trainable levels

Table 4 shows the achievement levels obtained by the students in the experiment, which can be regarded as reference information from which to interpret the results from the motivational questionnaire and perception questions. The results show that approximately half of the pupils (52%) trained their My-Pets to the highest level, implying that they experienced all of the learning levels. Inversely, it should be recognized that some students (16%) did not train their My-Pets to any higher levels but simply maintained the initial level.

Table 4. Trainable levels in this experiment

<i>Levels</i>	<i>Numbers (Percentage)</i>
Level 6	16 (52%)
Level 5	3 (10%)
Level 4	4 (13%)
Level 3	1 (3%)
Level 2	2 (6%)
Level 1	5 (16%)

Motivational questionnaire

Table 5 shows the means and SD of the motivational questionnaire in terms of four aspects. A further t-test showed that the aspects of attention, relevance, and satisfaction were statistically significant ($t = 4.19, p < .01$; $t = 2.92, p < .01$; $t = 2.31, p < .05$, respectively), whereas the aspect of confidence was not significant, although it also improved. This implies that the level-up mechanism of My-Pet was worthy of attention, helpful to enhancing the link between learning goals and what the My-Pets do, and reinforcing of student satisfaction.

Table 5. Results of the motivational questionnaire

	Pre-test		Post-test		t
	Mean	SD	Mean	SD	
Attention	20.97	4.62	25.19	2.90	4.19**
Relevance	22.13	3.81	24.84	3.11	2.92**
Confidence	23.81	4.09	24.90	3.30	1.10
Satisfaction	22.23	3.46	24.35	3.47	2.31*

** $p < .01$ * $p < .05$

One possible interpretation is that the level-up mechanism in the game enhanced the human-computer interaction between the My-Pet and the student, evoking perceptual arousal because of the meaningful context: Training their pets. Thus, students were required to pay more "attention" to their My-Pets, and invested a greater effort in learning tasks. Nevertheless, an alternative explanation is that such effect is related to the integration of a new tool in the educational process (i.e., the novel effect). There is a need to clarify the reason for this effect in the future. Moreover, while students used the trainable version, the learning goal and training goal could be aligned with each other so that the aspect of "relevance" was enhanced. In addition, people tend to develop an emotional attachment to their pets (Melson, 2001; Beck & Katcher, 1996). Thus, students might also become emotionally attached to their virtual pets as facilitated by the design of the human-computer interaction (Kusahara, 2000) such as naming, feeding, touching, and training. This would reinforce students' "satisfaction" during the process of training their My-Pets.

The reason why “confidence” was not significant might lie in the fact that the development of confidence is closely related to the inner nature of the subject domain, and needs a long period of time to develop. In this study, some students did not reach the top level, so their learning process might have been insufficient to have a significant impact on the improvement of confidence.

Perception question

Table 6 lists students’ self-reported responses to questions asking whether they felt a close relationship to their My-Pets. 74% of the students answered “yes,” and 26% answered “no”. This confirms that using a trainable My-Pet to enhance interaction with educational agents might be a suitable approach for some students, but not all. Furthermore, reasons were analyzed for those students who answered “no,” and these included the lack of time (e.g., “not sufficient time to develop a relationship” from S12 & S5), the lack of reality (e.g., “behaviors are not like those of real dogs” from S6 & S32), and the lack of uniqueness (e.g., “all dogs are similar in appearance” from S13 & S28) and some students felt the My-Pets were “just virtual ones on the screen” (from S3 & S10).

Table 6. Functions for developed relationship

<i>Answer</i>	<i>Numbers (Percentage)</i>
Yes	23 (74%)
No	8 (26%)

Those students who answered “yes” were asked to rank the functions that helped them develop a relationship. The results are listed in Table 7, with “training” being perceived as the most significant function. In addition, students also discussed the impact of the training mechanism on their learning, including enhanced goals (e.g., “My goal is to let my pet learn all of the skills” from S21; “In the second version, I have a clear goal to take actions to achieve” from S3), greater enjoyment (e.g., “It is more fun to learn mathematics in this version” from S16; “It is interesting to learn math with the My-Pet in the dog-training place” from S1; “The function of training My-Pet makes this system more attractive” from S30), and more satisfied (“When my pet has learned the skills, I feel satisfied with the achievement” from S3; “I feel a sense of achievement in My-Pet’s going up a level” from S15; “I am satisfied when I complete these learning tasks even though the tasks are difficult” from S21).

Table 7. Functions for developed relationship

<i>Functions</i>	<i>Ranking (Percentage)</i>
Training	19 (%)
Feeding	17 (10%)
Exercise	17 (13%)
Playing	11 (3%)
Bathing	10 (6%)
Naming	9 (16%)

Discussion

Level-up mechanism: From the motivational perspective

Previous studies have indicated that it is important to discuss long-term influences on students’ motivation, especially when we consider both the cognitive and affective aspects in the educational agent design. This is because the affective design of educational agents (e.g., feeding) might be separated from the cognitive design (e.g., learning). From the perspective of motivation theory, the affective design of the training My-Pet might be useful for some students who are not initially interested in the subject domain. However, for those students who have a strong motivation to learn a subject, they might perceive that such an affective design to be unrelated to the subject domain and regard this as a negative condition, decreasing their intrinsic motivation toward learning this subject domain in the long run (Waterman, 2005).

To avoid this disadvantage, it has been suggested that the aspect of motivation (Brophy, 2008) and a positive view of effort be emphasized (Dweck, 2000; Van Overwalle & De Metsenaere, 1990). Specifically, students should learn not

only to retain content, but to value and appreciate what are taught. By doing so, they will be willing to learn and desire to learn more. From the perspective of game-based learning, the level-up mechanism proposed in this study seems to serve as a game-playing model, in which students are able to enjoy the effort spent on learning tasks, which in turn, might contribute to the alignment between learning goals and gaming goals. In other words, when students exert efforts at training their My-Pets they are not only engaged in the pursuing the process of learning math, but are also pursuing the process of improving their level of achievement. They obtain immediate feedback through the visual representation of the educational agents in an enjoyable and pleasurable way. Thus, level-up mechanism could encourage students to value and appreciate what they have learned, providing the learning goals and gaming goals can be aligned with each other.

Moreover, incorporating game strategy with subject learning through educational agents involves a complex interaction of student motivation. It is argued that motivation is multi-faceted: some facets are directly related to the subject domain (i.e., intrinsic motivation) whereas some are indirectly related to the subject domain (i.e., extrinsic motivation). Although intrinsic motivation is significant, extrinsic motivation is also helpful to foster learning, because many of the tasks that students need to perform are not inherently interesting or enjoyable (Deci & Ryan, 1985). In other words, extrinsic motivation is not always harmful to student learning (Zichermann & Cunningham, 2011). When students can be extrinsically motivated to value tasks, they are gradually able to self-regulate their learning process. Accordingly, it might be good for students to be stimulated by multi-faceted motivation. In particular, if students find that learning is intriguing and rewarding in the long run, this extrinsic motivation might transfer into direct motivation related to subject learning.

Level-up mechanism: From the development perspective

The results of this study provide some reflections related the future development of educational agents. The first reflection asks a basic question: Why and how are close relationships developed with educational agents? It is argued that people tend to treat computers as social actors rather than tools (Reeves & Nass, 1996). People like to develop relationships with the subjects they interact with. This offers a meaningful rationale to create computer-simulated educational agents which can help to maximize their impact on learning. The training My-Pet takes advantage of the close relationship of students with their virtual pets (Melson, 2001). Specifically, pet characteristics are incorporated into the educational agents, and the human-computer interaction is further enhanced through the addition of the level-up mechanism. The findings show that three functions (i.e., training, feeding, and exercising) had the greatest impact on the relationship that developed between the students and their educational agents. Analyzing these three functions, it can be found that they involve more complex interactions that might elicit the personal attachment of students with their pets. This is consistent with the finding that interactivity can be helpful to develop the sense of reality in relation to digital pets (Kusahara, 2000). This result seems to suggest that developing a close relationship (even emotional attachment) with their educational agents might contribute to participatory motivation.

The second reflection follows the first but further focuses on the learning perspective: How can one facilitate student learning underpinned by this close relationship? The results of this study reveal that such design could enhance certain students' motivation, but there are still crucial issues that need to be addressed related to the motivational perspective, as discussed above. A number of pedagogies have been suggested as related to the influence of educational agents, including cognitive apprenticeship (Collins et al., 1989), reciprocal teaching (Palincsar & Brown, 1984), learning by disturbing (Aimeur & Frasson, 1996), and the teachable agent paradigm (Chase et al., 2009). Although the training context of the level-up mechanism is based on the model of "learning by demonstration," its effects on students' learning achievement are not examined in this study. There is a need to further investigate the effects of the level-up mechanism on students' learning achievement, seeking for ever more effective pedagogies, which would help maximize the impact of educational agents on student learning, the ultimate goal of the design of educational agents.

Conclusion

In response to the first sub-research question, what are the influences of the level-up mechanism on students' motivation, the research findings from this study reveal that the level-up mechanism could enhance students' motivation in terms of attention, relevance, and satisfaction. In response to the second sub-research question, what are the influences of level-up mechanism on the students' perceived relationship, the results indicate that the level-up mechanism has a significant impact that could help students develop a positive relationship with the educational agents.

Nevertheless, there are some limitations to this study: (1) This study was merely a short-term research project although it did show the positive effects of educational agents on students. There is a need to further investigate the long-term impact on student learning. (2) Due to the limitations of the quasi-experimental setting in the primary school, the within-subject experiment did not contain two conditions with different treatment orders so that the bias resulting from different treatment orders could be alleviated. Its possible influences should be further clarified in future work. (3) Although this study reported the increased attention on students' attention, it contained the overall effect of the agent and subject domain. More experiments are required to further address the issue that such increased attention is related to the agent or subject domain.

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Appendix

Attention

- 01) The material presented in this game was eye-catching.
- 02) The screen design was boring.
- 03) The game had elements that stimulated my curiosity.
- 04) I didn't really care what happened during the game.
- 05) The variety of screens and interactions helped to maintain my attention.
- 06) The amount of repetition in this game caused me to be bored.

Relevance

- 07) I was able to set my own goals during the game.
- 08) From the beginning of the game the goals were unclear.
- 09) The content of the game is relevant to my interests.
- 10) The content of this game will be useless to me.
- 11) I could relate the contents of this game to things I have seen, done or thought.
- 12) This game was very foreign to my background and interests.

Confidence

- 13) After being given verbal directions, I felt confident that I knew how the game was played.
- 14) After being given verbal directions, I was not confident that I knew what the objectives of the game were.
- 15) As I played the game, I felt confident that I could succeed.
- 16) The game was always too difficult.
- 17) When I did well at this game, I felt it was through my efforts.
- 18) I did not always feel in control in this game.

Satisfaction

- 19) It felt good to successfully complete the game.
- 20) There were few ideas or skills I acquired that I might be able to use in my life.
- 21) I did not get a lot out of playing the game.
- 22) Completing the game gave me a satisfying feeling of accomplishment.
- 23) The competition was fair.
- 24) My opponent (or the computer) had too much of an edge.