

Available online at www.sciencedirect.com

Procedia Social and Behavioral Sciences 7(C) (2010) 605–612

Procedia
Social and Behavioral Sciences

International Conference on Learner Diversity 2010

Pedagogical Agents in Interactive Multimedia Modules: Issues of Variability

Lee Tien Tien^a, Kamisah Osman^{a,*}^a*Fakulty of Education, Universiti Kebangsaan Malaysia, 43600 Bangi Selangor, Malaysia.*

Abstract

This paper introduces the pedagogical agents and describes its characteristics and roles in multimedia modules. It will also include examples of the use of pedagogical agents in previous studies and effective use of pedagogical agents on learning. Next, pedagogical agent variability in terms of physical (ethnicity, gender, image, voice) and internal features (roles, communication and competency) will be discussed in the context of its impact on learners' diversity. This is then followed by a discussion and suggestions for further research regarding the effective use of pedagogical agent in multimedia modules.

© 2010 Published by Elsevier Ltd. Open access under [CC BY-NC-ND license](https://creativecommons.org/licenses/by-nc-nd/4.0/).

Keywords: pedagogical agent; diversity; multimedia modules

1. Introduction

The use of ICT in teaching and learning is no longer a new thing in education. Studies on the benefits and advantages of the use of ICT in teaching and learning have been carried out by researchers in various fields. Instructions using multimedia have proved to be effective as it involves the use of various media and has an interactive and cognitive link with the material. Multimedia is effective on tasks related to retention or application (Passerini, 2007), to increase interest and motivation of students (Park & Jung Lim, 2007), reduce and prevent misconceptions (Williamson & Abraham, 1995) in learning activities.

Students who study with the use of ICT are studying in an open learning environment. They are responsible for their own learning, free to choose the units or modules that they wish to learn and can study at their own pace. However, researches (Hill & Hannafin, 2001; Land, 2000) reported that students lack sufficient metacognitive awareness and comprehension monitoring skills to make effective choices (Clarebout, Elen, Johnson & Shaw, 2002). In addition, students do not always make connections to prior knowledge or daily experience in a way that will enhance learning (Land, 2000). As a solution, the pedagogical agent was introduced in an open learning environment, such as multimedia modules.

Pedagogical agents in multimedia module serve to enhance students' metacognitive awareness of what they know and what they should learn in a particular topic. One strategy for providing metacognitive guidance involves embedding support, or scaffolds, for procedural, strategic, or metacognitive control (Land, 2000). Assistance or guidance can be provided through pedagogical agents in multimedia modules. For example, pedagogical agents can make the students aware of the opportunities given to them, give advice on tools that can be used and explain the

* Corresponding author. Tel.: +6-03-8925-4273; fax: +038925-4372

E-mail address: kamisah@ukm.my

function of those tools in multimedia based learning (Clarebout & Elen, 2007). Without the help of pedagogical agents, students will be lost in determining information relating to their needs.

2. Pedagogical agents in multimedia module

Pedagogical agent or intelligent agent (Valetsianos, Yerasimou & Doering, n.d.) is a cartoon character or animated character which is designed to help the learning process in computer aided learning (Chou, Chan & Lin, 2003; Craig, Gholson & Driscoll, 2002; Johnson, Rickel & Lester, 2000; Moundridou & Virvou, 2002; Predinger, Saeyor & Ishizuka, n.d.; Slater, 2000). Pedagogical agent shows human characteristics in terms of appearance such as facial expressions, body movements and gestures while interacting with the user verbally or through on-screen text.

Studies abroad were carried out by several research groups using pedagogical agents in their multimedia software for a variety of subjects such as environmental science (Moreno & Mayer, 2000), language (Maldonado et al., 2005; Predinger et al., n.d.) ecosystems (Biswas et al., 2004), ecology (Clarebout & Elen, 2007), mathematics (Atkinson, 2002; Kim, Flann, Wei & Ko, n.d.), art (Hayes-Roth, Maldonado & Moraes, 2002) and space (Kizilkaya & Askar, 2008). In Malaysia, research related to pedagogical agents has been carried out by Mohd Feham (2006) was applied in Islamic religious education. So, it can be said that the use of pedagogical agents in multimedia modules are suitable for a variety of subjects or fields of education.

2.1 Characteristics of pedagogical agents

Ten key qualities of animated characters consist of identity, backstory, appearance, content of speech, manner of speaking, manner of gesturing, emotional dynamics, social interaction patterns, role and role dynamics (Hayes-Roth et al., 2002).

1. Identity: Identity encodes not only the character's choice in terms of demographics and description, but also the personality traits and qualities of the character, including what she or he likes, dislikes, and the character's signature and idiosyncratic behaviours.
2. Backstory: The term backstory refers not only to cultural variations in individual reactions, but to any self-recognized individual experience and history that had a direct influence on the character's personality, as well as current facts of the character's "life" outside the screen.
3. Appearance: Appearance refers to the demographic characteristics of characters such as age, weight, gender, socio-economic background and so on.
4. Content of speech: Prioritize the importance of language and dialect that matches the character and culture.
5. Manner of speech: Relating to the intonation and pronunciation when speaking.
6. Manner of gesturing: Using the face and body as part of a dialogue with others, regardless of language, cultural background and age.
7. Emotional dynamics: Animated characters' emotional model should impact their behaviour, and in turn be affected by the interactor's comments and actions.
8. Social interaction patterns: How words are pronounced, and how gestures support the utterances, the knowledge of when and how to raise certain topics of discussion, or tact which varies across cultures.
9. Role and role dynamics: Each pedagogical agent has their own role, either to give advice, to entertain, to educate or to guide others.

2.2 The role of pedagogical agents in learning environments

Pedagogical agents are designed with specific roles and objectives in social learning activities.

Pedagogical agents can be classified according to their roles and functions in the learning process as shown in Table 1.

Table 1 Classification of pedagogical agents

Educational agent	Type	Role
Pedagogical agent		Personal assistant
Authoritative teacher	Learning companion, co-learner or simulated student	Teacher's assistant Student's assistant
Tutor Coach Guide	Competitor, Collaborator, Tutee, Peer tutor, Troublemaker, Critic, Clone	

Two common roles of pedagogical agents found in multimedia learning environment are the expert and the learning companion. Experts are pedagogical agents who has knowledge and experiences in a domain and serve to provide guidance and advice to students (Baylor, 2005; Baylor & Kim, 2004; Chou et al., 2003; Hayes-Roth et al., 2002; Kim, Baylor & PALS Group, 2006; Kizilkaya & Askar, 2008; Moreno, Mayer & Lester, 2000; Moreno & Mayer, 2005). Learning companions known as colearners are not experts in a domain but they learn together with the students. A learning companion can serve as a student (colearner) (Chou et al., 2003; Kim et al., 2006; Maldonado & Hayes-Roth, 2004; Maldonado et al., 2005; Xiao, Stasko & Catrambone, 2004) or a motivator (Baylor, 2005; Baylor & Kim, 2004; Kizilkaya & Askar, 2008) who accompany the students while they are studying a topic.

Clarebout and colleagues (2002) in their study had concluded a number of roles commonly found in studies related to pedagogical agents. Some typical agent roles are as below:

1. Supplanting: the pedagogical agent assume responsibility for the tasks and perform them for the learners. The learners observe the pedagogical agents while they are performing the task.
2. Scaffolding: pedagogical agent performs some of the tasks that has not yet mastered by students.
3. Demonstrating: pedagogical agent will perform a task and then observe the student performing the task.
4. Modeling: pedagogical agent shows how a task is performed while explaining the reasoning process. Pedagogical agent explains how a problem can be resolved, what strategies are used and appropriate mental model for understanding the task.
5. Coaching: pedagogical agent provides hints and feedback to students while students are performing a task. Pedagogical agents observe students and provide guidance to them when they have problems in solving the task.
6. Testing: pedagogical agent tests the students' knowledge about certain aspects of the task to assist students in the learning process.

These different roles can be characterized by analytical modalities namely (1) executing, (2) showing, (3) explaining and (4) questioning (Clarebout et al., 2002). Executing means, the pedagogical agent performs the task on behalf of student. Showing refers to the pedagogical agent demonstrating the task to the student. Explaining is the pedagogical agent explaining the task while the students are performing the task. Questioning means asking questions related to the tasks. Overview of the role and modalities of the pedagogical agents are summarized in Table 2.

Table 2 Modalities and roles of pedagogical agents

		Modalities			
		Executing part/whole task	Showing part/whole task	Explaining part/whole task	Questioning part/whole task
Roles	Supplanting/scaffolding	x			
	Demonstrating		x		
	Modeling		x	x	
	Coaching			x	x
	Testing				x

Source: Clarebout et al., 2002

2.3 Examples of pedagogical agents in interactive multimedia modules

Herman is a pedagogical agent that exists in the form of a bug in the discovery-based learning environment used in the study of Moreno and colleagues (2000). Herman showed appealing facial expressions, human-like movements and an amusing voice in the program. Herman will provide advice regarding the relationships between plants and the environment. In addition, Herman will also provide encouragement and assistance to students when they encounter problems. Feedback will be given after the students had designed the plants.

Dr. Phyz was used in the study of Mayer, Dow and Mayer (2003) to examine the modality effect, interactivity effect, self-explanation effect and presence effect on student learning. Researchers manipulate the way of communication and the agent’s on-screen image to see its impact on student’s learning. Study showed that students who learned with an agent presented on the screen did not generate significantly more answers on the problem-solving transfer test than students who learned with no agent presented on screen.

Nina and the Geek were used in one of the studies by Baylor (2005) related to engineering. Nina is designed as an attractive female engineer who is pretty and outgoing whereas Geek is also a female engineer, but who is not pretty, shy and quiet. The purpose of this study was to determine the impact of stereotypical vs. non-stereotypical images on students’ attitudes toward engineering.

Mike (Kim et al., 2006) is a male pedagogical agent in his 20s. Mike wore a casual T-shirt and spoke informally with computer-generated voice. Mike worked together with students and will stay on the screen when the students are performing the tasks. Mike is the only source of information for students to learn instructional planning.

Parrot Peedy is the pedagogical agent used in the study of Kizilkaya and Askar (2008). Parrot Peedy will appear on the screen to give directions and give motivational support to the students. The main function of this pedagogical agent in the tutorial is to guide and provide motivational support for the students.

2.4 The effect of pedagogical agents on the retention, transfer and motivation

The presence of pedagogical agents in multimedia learning environment is expected to improve students' achievement and motivation in learning. The studies involve pedagogical agent measuring learning by the two submeasures of recall (retention) and transfer (application). To assess student recall of information, they were asked to recall and record what they have read, seen and heard in the presentation of information conveyed by the pedagogical agent. A pedagogical agent is effective when students are able to recall many of the input they had provided earlier. To measure the transfer ability, the students were required to apply the knowledge they have learned to new situations and try to solve new problems. The more problems that can be solved by the students, the better the effect of pedagogical agents on the transfer skills. In the aspect of motivation, the students were required to answer questionnaire regarding the level of motivation after learning with the pedagogical agents.

Study of Moreno and colleagues (2000) showed that there was no significant effect of the pedagogical agent on retention. The mean of the items recalled by the pedagogical agent group is not significant compared with the mean of the items recalled by the group without pedagogical agent. However, the students in the pedagogical agent group solve more problems compared to the students in the no-pedagogical agent group. In fact, the grade given by a group with pedagogical agents to continue learning and their interest in the material is significantly higher than the no-pedagogical agent group. Students communicate better, become more interested, learn better and prefer computer lessons that contains social cues such as human voice and facial expressions compared with those without the social cues.

In addition, students who learn through communication with the pedagogical agent using personalized dialogue recall more and solve more problems than students in group who communicate through non-personalized monologue (Moreno et al., 2000). Students who learned by reading dialogue-style text rated the lesson more favorably compared to students who learned by reading monologue-style text. Students also prefer to communicate with computers through speech than on-screen text. The result of the study confirmed the social-cue prediction in which students are more interested in programs that communicate via speech. The situation is reversed in the study of Atkinson (2002) in which he concluded that pedagogical agents that provide an explanation in the form of monologue using non-verbal cue (signal and body gestures) to attract the attention of students are more effective at fostering learning. This conclusion is made by comparing the results obtained from the text-based learning environment with a pedagogical agent.

There are conflicts of ideas among researchers in studies involving pedagogical agent on whether it actually improve students' learning at all. For example, Baylor (2002), Craig et al. (2002) and Kirk (2008) concluded that the use of pedagogical agents do not contribute to improve student performance. In the study of Mayer et al. (2003), results from modality effect experiment (Experiment 1) showed that students generate more answers on the problem solving transfer test when they worked with speaking pedagogical agent. Students also performed better in transfer test if they can control the order and pace of the presentation in the interactivity effect experiment (Experiment 2a). However, the presence effect experiment (Experiment 4) found that students who learned with an agent on the screen does not get better results in solving problems compared to students who study without a pedagogical agent on the screen. However, the study of Moreno, Mayer, Spires, and Lester (2001) reported that samples from two studies (college students and seventh-grade students) who are in the pedagogical agent group does not necessarily acquire more information, but they do learn better than students who learn in a more conventional text-based environment. In addition, students are more motivated and more interested, and they achieve better transfer, when a computer-based lesson is presented in a social agency environment rather than in an on-screen text environment.

The presence of pedagogical agents in the learning environment may increase the student's motivation to perform a task better (Lester et al., 1997). Thus, animated pedagogical agents present two key advantages over earlier work: they increase the bandwidth of communication between students and computers, and they increase the computer's ability to engage and motivate students (Johnson et al., 2000). Students working with the pedagogical agent found problems less difficult than students working without the agent, despite the fact that the problems given to both groups of students were similar (Moundridou & Virvou, 2002). The research samples in Atkinson's (2002) study who worked with speaking pedagogical agents found that the examples shown are not difficult compared with their counterparts from the group without an agent. This shows the importance of motivation in the learning process. Students who studied with pedagogical agents were more motivated than those who studied on their own.

Previous studies showed that the use of pedagogical agents in multimedia can help improve students' motivation in learning. Improvement in learning achievement and performance is not guaranteed by the existence of pedagogical agents as they only help in creating a more conducive learning environment. Students themselves are responsible for their own learning.

3. Diversity of pedagogical agents

Researchers who carried out research on pedagogical agents in multimedia modules can vary the characteristics of pedagogical agents. For example, researchers can vary the ethnicity, gender, image, voice, role, style of communication and competency level of the agent to meet the needs of various students.

3.1 Ethnicity and gender

Researchers designed the image of pedagogical agents with different ethnicity (Caucasian or African-American) and gender (male or female). The results (Baylor, 2005; Baylor, Shen & Huang, 2003) showed that African-American learners were significantly more likely to choose an agent with the same ethnicity and also have significantly more positive attitude toward the chosen agent after learning from it. MANOVA also revealed the main effect of agent ethnicity on self-regulation. It was found that black agents lead to increased self-regulation compared to white agents, Wilks' Lambda = .96, $F(3, 205) = 2.90$, $p < .05$. In addition, ethnicity has an impact on student learning. Post hoc t-tests showed significant differences between black experts ($M = 2.61$, $SD = .75$) and the white experts ($M = 2.13$, $SD = .84$, $p < .01$), which indicates that Black agents are more effective in their role as an expert than white agents. Apart from that, students reported significantly more facilitation of learning (e.g., focus on relevant information, help in concentration) from the African-American Expert agents (Baylor, 2005) and Black Experts (Baylor & Kim, 2004). Baylor (2005) also reported that the African-American Motivator agents were rated as significantly more enjoyable, enthusiastic, motivational than the Caucasian Motivator agents ($d = .40$).

The study regarding the gender of pedagogical agent provides similar conclusion. The male agents are more popular than the female agents. Students perceived male pedagogical agents as more extraverted, agreeable, and satisfying than female agents (Baylor & Kim, 2004). For motivational-related outcomes, there was an overall positive effect for the male agents (in contrast to the female agents): students working with male agents reported higher self-regulation, greater self-efficacy, and rated the agents as significantly more useful, interesting and leading to more satisfaction (Baylor, 2005; Baylor & Kim, 2004).

The presence of pedagogical agents in multimedia module provides a more stimulating effect on girls. Female students who use the tutorial with a pedagogical agent performed better compared to the boys (Kizilkaya & Askar, 2008). Thus, instructional designers need to analyze the characteristics of the user before starting the design process.

3.2 Image

Pedagogical agent on a computer screen can be designed as a cartoon or realistic image. It was found that girls tend to choose a cartoon-like agent compared to the boys (Baylor, 2005; Baylor et al., 2003). In the study of Baylor and Kim (2004), students who worked with realistic agents performed marginally better than students who worked with cartoon-like agents. In addition, it was found that male students working with realistic agents learned more than those working with cartoon agents. As for female students, the effect of agent realism was not significant.

3.3 Voice

Voice plays a vital role in communication and human relations, including the relation between the pedagogical agents and the students as described in The Media Equation (Reeves & Nass, 1996). Some researchers diversified pedagogical agent voice and examined the impact on students learning. For example, Atkinson (2002), Baylor and colleagues (2003) and Mayer and colleagues (2003) who used human voice and machine-generated voice as the voice of pedagogical agents in their studies. The same conclusion was obtained by the three studies; students preferred pedagogical agent who spoke with a human voice. Students commented that the pedagogical agent who spoke with a machine-generated voice is less dynamic, less attractive and less superior to the human-voiced agent (Mayer, Sobko & Mautone, 2003). The lack of human characteristics affects their concentration as they have to struggle to understand what the computer-generated voice was saying (Atkinson, 2002). On the other hand, students who studied with an agent who spoke with a human voice get better results in both retention and transfer tests (Mayer et al., 2003). The students rated the agent as engaging and human-like (Baylor, Ryu & Shen, 2003) and the learning material is easier than the machine-generated voiced agent (Mayer et al., 2003).

Mayer and colleagues (2003) also examined the effect of accent and non-accented voice on students' learning. Their study used an agent who spoke standard English and another agent who spoke with a Russian accent. Results showed that students from both groups achieved similar results in retention test, but students from the normal accent group achieved higher score on problem solving test. Students who listened to a non-accented voice rated the speaker more positively than the students who listened to an accented voice.

Research results are consistent with cognitive load theory which describes that cognitive load affects student learning. Students who studied with an agent who spoke with the machine-generated voice and foreign accent may have to exert considerable cognitive energy in listening to the voice and therefore face increased cognitive load. Due to the increasing cognitive load, the students are less able to receive relevant information and build connections among the information received which will lead to poorer results in retention and transfer test.

3.4 Role

Pedagogical agents in multimedia modules have a variety of roles such as an expert, learning companion or motivator. Results in Baylor and Kim's study (2004) showed that students who worked with the mentor or motivator

agents rated their self-regulation and self-efficacy significantly higher than students who worked with the expert agent. In terms of gender, students preferred male expert and male motivator because they were perceived as significantly more intelligent, knowledgeable, competent and expert-like than the female counterpart. (Baylor, 2005).

3.5 *Ways of communication and interaction*

Pedagogical agents can communicate with students by spoken words (narration) or by printed words (on-screen text). Students who learned with the voice of an agent rated the lesson more favorably, recalled more, and were better able to use what they have learned to solve problems than students who learned the same materials as on-screen text (Mayer et al., 2003; Moreno & Mayer, 2000; Moreno et al., 2000). In addition, students who learned by communicating with a pedagogic agent via a personalized dialogue recalled more and were better able to use what they have learned to solve problems than students who communicated via a non-personalized monologue (Moreno et al., 2000).

Pedagogical agents in the proactive condition will provide information or ideas to the students proactively without being requested by the student. When students entered a new learning unit or a new phase, the agent will give students all the information related to this new phase. On the other hand, in a responsive condition, the agent provided information or ideas only at the learner's request. Study of Kim and colleagues (2006) showed that students who studied in the proactive group ($M = 2.18$, $SD = 2.17$) scored significantly higher compared with the responsive group ($M = 1.61$, $SD = 2.3$). This result showed that proactive agent improves learning more than responsive agent. Hence, the researchers recommended the use of proactive agents in multimedia modules, particularly in helping novice learners by providing them relevant information.

3.6 *Competency*

There are different levels of competency among human beings, as well as pedagogical agents designed in the multimedia modules. High-competency agent always provides accurate information or ideas but, suggestions or ideas given by the low-competency agent are less accurate and sometimes wrong. Students who studied with high-competency agent ($M = 2.63$, $SD = 1.39$) scored significantly better than students who studied with low-competency agent ($M = 2.03$, $SD = 1.19$) (Kim et al., 2006). Although low-competency agent doesn't enhance learning but it has positive impact on learners' self-efficacy beliefs in the task. Students in low-competency agent group ($M = 3.00$, $SD = 1.18$) showed significantly higher self-efficacy compared with the high-competency agent group ($M = 2.47$, $SD = 0.98$). Students also showed a more positive attitude towards high-competency agent. Study that examined the effect of competency of the agent on students learning was also carried out by Xiao and colleagues in 2004. The results from the interview showed that responses from high-competency agent were useful, but response from low-competency agent was not helpful.

Kim and colleagues (2006) suggested the use of highly competent agents for learning module in which objectives are focus on the acquisition of knowledge and skills. On the other hand, if the module emphasizes the self-efficacy belief, the use of less competent agents is more appropriate. Agents that are less competent are able to train and build confidence of novice learners and encourage them to continue their work.

4. Discussion and suggestion

As described, the pedagogical agent can exist in various ethnicity, gender, image, voice, role, way of communication and competency level. From previous studies, it can be concluded that the most effective pedagogical agents on students learning and most preferred by the students are male agents, Black agents and African-American agents. In the context of Malaysia, local researchers can design pedagogical agents in Malay, Chinese or Indian to meet the needs of multi-racial students. Studies (Baylor et al., 2003; Baylor, 2005) showed that respondents tend to choose an agent of the same ethnicity as them. Hence, local researchers can compare the results between respondents in Malaysia with the results in Baylor's study regarding the relationship between students' ethnicity and the choice of pedagogical agents.

In terms of image, the girls tend to choose agent in the form of cartoons, while boys preferred realistic agents. Agents must use human voice and speak in standard language to reduce the students' cognitive load. This will enable students to understand the information delivered by the agents easily. The needs analysis and survey regarding the students' background are important in helping instructional designers design their pedagogical agent's image. If there is a majority of female students in the learners' population, then the designer can use a cartoon image in the multimedia modules. The most important aspect to consider is the voice of the pedagogical agent which must use human voice and speaks standard language.

The role of pedagogical agents as experts, learning companions or motivators has their effects on student learning. Instructional designers should take these elements into consideration when designing the pedagogical agents. Creating agents should be based on the objectives or goals of the instructional modules as well as the students' background. If the module is focusing on the acquisition of knowledge and skills in subjects such as chemistry, the expert agent who is highly professional and competent should be used to provide accurate information for students, especially novice learners. On the other hand, if the module aims to build confidence and

motivation among the learners, then the instructional designer should design a medium or low-competent learning companion or motivator.

In terms of communication and interaction, the agent should be designed to interact verbally with the students rather than using on-screen text. In addition, the personalized dialogue has proven to help students in learning compared to monologue. Proactive agents are found to help the students in providing information as soon as the students enter a new phase. Again, instructional designers need to analyze the background of the users who will use the module. Proactive agent can be used if the users are novice learners while responsive agents are designed for advanced users.

5. Conclusion

Pedagogical agents in multimedia module are able to solve problems or deficiencies in the existing multimedia modules. Diversity of pedagogical agent in terms of physical, role, communication and competency level can meet the demands and needs of a diverse range of users. Most importantly, instructional designers need to analyze the background and needs of its users in order to produce a multimedia module with pedagogical agents that meets the needs of variety of learners.

6. Reference

- Atkinson, R. K. (2002). Optimizing Learning From Examples Using Animated Pedagogical Agents. *Journal of Educational Psychology*, 94(2), 416-427.
- Baylor, A. L. & Kim, Y. (2004). Pedagogical Agent Design: The Impact of Agent Realism, Gender, Ethnicity and Instructional Role. *Presented at International Conference on Intelligent Tutoring Systems*. Maceio, Brazil, 2004.
- Baylor, A. L. (2002). Expanding Preservice Teacher's Metacognitive Awareness of Instructional Planning through Pedagogical Agents. *ETR&D*, 50(2), 5-22.
- Baylor, A. L. (2005). The Impact of Pedagogical Agent Image on Affective Outcomes. *Proceedings of Workshop on Affective Interactions: Computers in the Affective Loop, International Conference on Intelligent User Interfaces*, San Diego, CA, 2005.
- Baylor, A. L., Ryu, J., & Shen, E. (2003). The Effects of Pedagogical Agent Voice and Animation on Learning, Motivation, and Perceived Persona. *Paper presented at the Annual World conference of Educational Multimedia, Hypermedia, & Telecommunication*, Honolulu, Hawaii, 2003.
- Baylor, A. L., Shen, E., & Huang, X. (2003). Which Pedagogical Agent do Learners Choose? The Effects of Gender and Ethnicity. *Paper presented at the E-Learn (World Conference on E-Learning in Corporate, Government, Healthcare, & Higher Education)*, Phoenix, Arizona, 2003.
- Biswas, G., Leelawong, K., Belyne, K., Viswanath, K., Vye, N., Schwartz, D. & Davis, J. (2004). *Incorporating Self Regulated Learning Techniques into Learning by Teaching Environments*. Retrieved July 16, 2009, from <http://www.cogsci.northwestern.edu/cogsci2004/papers/paper365.pdf>.
- Chou, C. Y., Chan, T. W. & Lin, C. J. (2003). Redefining the learning companion: the past, present and future of educational agents. *Computers & Education*, 40, 255-269.
- Clarebout, G. & Elen, J. (2007). *In Search of Pedagogical Agents' Modality and Dialogue Effects in Open Learning Environments*. Retrieved July 23, 2009, from http://www.ascilite.org.au/ajet/e-jist/docs/vol10_no1/papers/full_papers/clarebout_elen.pdf.
- Clarebout, G., Elen, J., Johnson, W. L. & Shaw, E. (2002). Animated Pedagogical Agents: An Opportunity to be Grasped? *Journal of Educational Multimedia and Hypermedia*, 11(3), 267-286.
- Craig, S. D., Gholson, B. & Driscoll, D. M. (2002). Animated Pedagogical Agents in Multimedia Educational Environments: Effects of Agent Properties, Picture Features and Redundancy. *Journal of Educational Psychology*, 94(2), 428-434.
- Hayes-Roth, B., Maldonado, H., & Moraes, M. (2002). *Designing for diversity: Multi cultural characters for a multi-cultural world*. Retrieved July 15, 2009, from <http://www.stanford.edu/~kiky/Design4Diversity.pdf>.
- Hill, J. R. & Hannafin, M. J. (2001). Teaching and Learning in Digital Environments: The Resurgence of Resource-Based Learning. *ETR&D*, 49(3), 37-52.
- Johnson, W. L., Rickel, J. W. & Lester, J. C. (2000). Animated pedagogical agents: face-to-face interaction in interactive learning environments. *International Journal of Artificial Intelligence in Education*, 11, 47-78.
- Kim, Y., Baylor, A. L. & PALS Group. (2006). Pedagogical Agents as Learning Companions: The Role of Agent Competency and Type of Interaction. *ETR&D*, 54(3), 223-243.
- Kim, Y., Flann, N., Wei, Q. & Ko, Y. (n.d.). *MathGirls: Motivating girls to learn math through pedagogical agents*. Retrieved July 23, 2009, from <http://digital.cs.usu.edu/~flann/MathGirls.pdf>.
- Kirk, K. (2008). *Performance, Perception and Choice of Animated Pedagogical Agent*. (Doctoral dissertation, University of Nevada, Las Vegas, 2008).
- Kizilkaya, G. & Askar, P. (2008). The effect of an embedded pedagogical agent on the students' science achievement. *Interactive Technology and Smart Education*, 5(4), 208-216.

- Land, S. M. (2000). Cognitive Requirements for Learning with Open-Ended Learning Environments. *ETR&D*, 48(3), 61-78.
- Lester, J. C., Converse, S. A., Kahler, S. E., Barlow, S. T., Stone, B. A. & Bhogal, R. S. (1997). *The Persona Effect: Affective Impact of Animated Pedagogical Agents*. Retrieved July 16, 2009, from <http://research.csc.ncsu.edu/intellimedia/papers/dap-chi-97.pdf>.
- Maldonado, H. & Hayes-Roth, B. (2004). *Toward Cross-Cultural Believability in Character Design*. Retrieved July 15, 2009, from <http://hci.stanford.edu/publications/2004/CrossCultBelievability0304/CrossCultBelievability0304.pdf>.
- Maldonado, H., Roselyn Lee, J. E., Brave, S., Nass, C., Nakajima, H., Yamada, R., Iwamura, K., Morishima, Y. (2005). We Learn Better Together: Enhancing eLearning with Emotional Characters. In T. Koschmann, D. Suthers, & T. W. Chan (Eds.). *Computer Supported Collaborative Learning: The Next 10 Years!* (pp. 408-417). Mahwah, NJ: Lawrence Erlbaum Associates.
- Mayer, R. E., Dow, G. T. & Mayer, S. (2003). Multimedia Learning in an Interactive Self-Explaining Environment: What Works in the Design of Agent-Based Microworlds? *Journal of Educational Psychology*, 95(4), 806-813.
- Mayer, R. E., Sobko, K. & Mautone, P. D. (2003). Social Cues in Multimedia Learning: Role of Speaker's Voice. *Journal of Educational Psychology*, 95(2), 419-425.
- Mohd Feham Md. Ghalib. (2006). *Design, Development & Evaluation of a Web Courseware with a Pedagogical Agent*. (Doctoral dissertation, Universiti Sains Malaysia, 2006).
- Moreno, R. & Mayer R. E. (2000). *Pedagogical agents in constructivist multimedia environments: The role of image and language in the instructional communication*. Retrieved July 15, 2009, from <http://www.unm.edu/~moreno/PDFS/Roundtable.pdf>.
- Moreno, R. & Mayer, R. E. (2005). Role of Guidance, Reflection, and Interactivity in an Agent-Based Multimedia Game. *Journal of Educational Psychology*, 97(1), 117-128.
- Moreno, R., Mayer, R. E. & Lester, J. C. (2000). *Life-Like Pedagogical Agents in Constructivist Multimedia Environments: Cognitive Consequences of their Interaction*. Retrieved July 16, 2009, from <http://www.unm.edu/~moreno/PDFS/ED-MEDIA-DAP.pdf>.
- Moreno, R., Mayer, R. E., Spires, H. A. & Lester, J. C. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? *Cognition & Instruction*, 19, 177-213.
- Moundridou, M. & Virvou, M. (2002). Evaluating the Persona Effect of an Interface Agent in an Intelligent Tutoring System. *Journal of Computer Assisted Learning*, 18(2), retrieved August 26, 2009, from <http://thalis.cs.unipi.gr/~maria/JCAL.pdf>.
- Park, S. H. & Jung Lim. (2007). Promoting Positive Emotion in Multimedia Learning Using Visual Illustrations. *Journal of Educational Multimedia and Hypermedia*, 16(2), 141-162.
- Passerini, K. (2007). Performance and Behavioral Outcomes in Technology-Supported Learning: The Role of Interactive Multimedia. *Journal of Educational Multimedia and Hypermedia*, 16(2), 183-211.
- Predinger, H., Saeyor, S. & Ishizuka, M. (n.d.). *Animated Agents for Language Conversation Training*. Retrieved July 15, 2009, from <http://www.miv.t.u-tokyo.ac.jp/papers/helmut-edmedia01.pdf>.
- Reeves, B. & Nass, C. (1996). *The media equation : How people treat computers, television, and new media like real people and places*. Cambridge: Cambridge University Press.
- Slater, D. (2000). *Interactive Animated Pedagogical Agents Mixing the Best of Human and Computer-Based Tutors*. (Master dissertation, Stanford University, 2000).
- Veletsianos, G., Yerasimou, T. & Doering, A. (n.d.). *The role of intelligent agents on learner performance*. Retrieved July 23, 2009, from <http://www.alicebot.org/articles/Learner.pdf>.
- Williamson, V. M. & Abraham, M. R. (1995). The Effects of Computer Animation on the Particulate Mental Models of College Chemistry Students. *Journal of Research in Science Teaching*, 32(5), 521-534.
- Xiao, J., Stasko, J., & Catrambone, R. (2004). An empirical study of the effect of agent competence on user performance and perception. *Paper presented at the Autonomous Agents and Multiagent Systems (AAMAS 2004)*, New York City. Retrieved November 24, 2009, from <http://www.cc.gatech.edu/~john.stasko/papers/aamas04.pdf>.