EFFECTS OF PEDAGOGICAL AGENTS' INSTRUCTIONAL ROLES ON LEARNERS WITH DIFFERENT COGNITIVE STYLES IN TERMS OF ACHIEVEMENT AND MOTIVATION

by

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Thesis submitted in fulfilment of the requirements
for the degree of
Master of Arts (Educational Technology)

May 2010

ACKNOWLEDGEMENTS

I would like to take this golden opportunity to acknowledge and to express my sincere appreciation and gratitude to several people for continuously providing me with guidance and support along my postgraduate studies till the completion of this dissertation.

First of all, my deepest appreciation goes to my supervisor, Professor Hanafi Atan for his continuous and unwavering support, encouragement, inspiration, patience, perseverance, suggestions, comments and generous contribution of his valuable time in guiding me from the beginning of my research to the end. He has continuously inspired me by showing enthusiasm about educational research. His knowledge, expertise and rich experience in instructional technology as well as open and distance learning have greatly benefited me in my research.

My sincere thanks are also extended to Associate Professor Omar Majid, the Dean of School of Distance Education (SDE), and Associate Professor Dr. Zuraidah Abdul Rahman, the Deputy Dean of School of Distance Education (SDE), for their unwavering support and encouragement during my research studies. I am so grateful to the School of Distance Education for giving me a great deal of chances and opportunities for exposure to sharpen my skills and knowledge in the educational research.

I sincerely express my gratitude to Associate Professor Dr. Fong Soon Fook from the School of Educational Studies, USM for all his advice, guidance and

support. He is indeed a great mentor. I am very thankful to him for providing me with a great and helpful group of undergraduate students as the research sample. Besides, I am grateful for his assistance for assessing the validity of the instructional material and the items in the pre-test and post-test.

I wish to record my appreciation to Associate Professor Dr. Abdul Rahman Othman and Miss Teh Sin Yin from the School of Distance Education (SDE), USM, who are great experts in the field of statistics. Their solid knowledge and high ethics as statisticians impressed me and built my competency in using statistical tools. I am so thankful to them for guiding me in the statistical analyses of this research.

I also wish to express my appreciation to Associate Professor Dr. Toh Seong Chong from the Centre for Instructional Technology and Multimedia (CiTM), USM for his constructive comments and suggestions on the selections of the research instruments. I also extend my sincere thanks to Associate Professor Dr. Irfan Naufal Umar from the Centre for Instructional Technology and Multimedia (CiTM), USM for his comments and suggestions on the research design and statistical analyses of this research.

I would like to extend my special thanks to Dr. George Teoh Boon Sai from the School of Distance Education (SDE), USM for proof reading the final draft of this dissertation as well as my journal articles and proceedings. I am so grateful for his assistance in polishing up the quality of this dissertation, particularly in terms of English language.

My profound acknowledgement goes to the Institute of Graduate Studies (IPS) for awarding me a USM Fellowship to financially support me in my postgraduate study. I would also like to thank the Malaysian Ministry of Science, Technology and Innovation (MOSTI) for funding this research via the e-Science Fund, led by Professor Hanafi Atan.

I would also like to take this opportunity to express my sincere thanks to my friends and colleagues who faithfully gave me encouraging support and motivation throughout the duration of my study. They were willing to support me spiritually and physically whenever their help was needed. The data collection couldn't be conducted so smoothly without all of you as the facilitators and invigilators.

Last but not least, my affectionate appreciation goes to my family members for their love, understanding, patience, sacrifice, prayers, confidence and never-ending support. To my beloved parents and grandparents, may you be blessed with good health and happiness for all your love and prayers throughout my entire life. My postgraduate study would not have been possible without the selfless love, understanding, constant encouragement and spiritual support of my beloved wife, Kathy Belaja. Thank you very much for being understanding and for accepting the answer "Sorry dear, I am busy..."

Thanks to those who have directly or indirectly contributed to this research and the writing of this dissertation. Words are inadequate to express my gratitude and I love you all with all my heart.

Foo Kok Keong

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LIST OF ABBREVIATIONS

AIMC	Artificial Intelligence Management Center
ANCOVA	Analysis of Covariance
ANOVA	Analysis of Variance
EXA	Expert Agent
FD/FI	Field-Dependence/Field-Independence
FD	Field-Dependent
FD-EXA	Field-Dependent learners who used the Expert Agent
FD-MEA	Field-Dependent learners who used the Mentor Agent
FI	Field-Independent
FI-EXA	Field-Independent learners who used the Expert Agent
FI-MEA	Field-Independent learners who used the Mentor Agent
GEFT	Group Embedded Figures Test
ICT	Information and Communication Technology
IMI	Intrinsic Motivation Inventory
IQ	Intelligence Quotient
LMS	Learning Management System
MEA	Mentor Agent
SD	Standard Deviation
SPSS	Statistical Packages for Social Sciences
USM	Universiti Sains Malaysia

KESAN PERANAN INSTRUKSI AGEN PEDAGOGI

TERHADAP PELAJAR DARI PELBAGAI GAYA KOGNITIF

DARI SEGI PENCAPAIAN DAN MOTIVASI

ABSTRAK

Kajian ini bertujuan untuk mengenal pasti kesan peranan instruksi agen pedagogi dalam suasana pembelajaran multimedia berasaskan agen pedagogi terhadap pelajar dari pelbagai gaya kognitif dari segi pencapaian dan motivasi.

Dua mod agen pedagogi yang berlainan peranan instruksi, iaitu Agen Pakar (*Expert Agent*–EXA) dan Agen Mentor (*Mentor Agent*–MEA), telah direka bentuk dan dibangunkan secara sistematik untuk memenuhi tujuan kajian ini. EXA direka untuk memberi informasi secara langsung dan tepat apabila pelajar menanyakan sesuatu soalan. Manakala MEA direka untuk memberi bimbingan kepada pelajar untuk mencari maklumat, dan tidak memberi jawapan terus kepada soalan yang ditanya oleh pelajar. Dari semasa ke semasa, MEA akan memberi kata-kata motivasi dan galakan kepada pelajar untuk mengekalkan penglibatan mereka dalam tugasan pembelajaran.

Kajian "eksperimen-benar" ini menggunakan reka bentuk faktorial 2 x 2 dengan mengambil dua mod agen pedagogi yang berlainan peranan instruksi (EXA dan MEA) sebagai pemboleh ubah tidak bersandar, gaya kognitif *field-dependence/field-independence* (FD/FI) pelajar sebagai pemboleh ubah moderator. Skor pencapaian pelajar dan skor motivasi pelajar merupakan dua pemboleh ubah bersandar dalam kajian ini. Seramai 86 pelajar mahasiswa tahun empat dari Pusat

Pengajian Ilmu Pendidikan Universiti Sains Malaysia yang mengikuti kursus 'PGT436E: ICT dalam Pendidikan', menyertai kajian ini sebagai sampel kajian. Sebahagian pelajar diberikan agen EXA dan sebahagian lagi diberikan agen MEA secara rawak. Mereka diminta untuk berinteraksi dengan agen pedagogi yang ditetapkan dalam portal pembelajaran multimedia yang disediakan.

Statistik deskriptif dan inferens telah dilaksanakan untuk menganalisis data yang dikumpul. Dapatan analisis menunjukkan bahawa pelajar-pelajar yang menggunakan MEA menunjukkan prestasi yang lebih baik secara signifikan berbanding pelajar-pelajar yang menggunakan EXA dari segi pencapaian dan motivasi. Apabila gaya kognitif pelajar diambil kira, impak terbesar MEA diperhatikan secara nyata terhadap pelajar-pelajar FD, di mana pelajar-pelajar FD yang menggunakan MEA menunjukkan prestasi yang lebih baik secara signifikan berbanding pelajar-pelajar FD yang menggunakan EXA dari segi pencapaian dan motivasi. Antara pelajar-pelajar FI, mereka yang menggunakan MEA menunjukkan motivasi yang lebih tinggi secara signifikan berbanding mereka yang menggunakan EXA. Namun, tiada perbezaan signifikan diperhatikan dalam min skor pencapaian di antara pelajar-pelajar FI yang menggunakan MEA dan pelajar-pelajar FI yang menggunakan EXA. Dapatan-dapatan ini membuktikan bahawa peranan instruksi mentor adalah lebih baik berbanding peranan instruksi pakar dalam mereka bentuk agen pedagogi untuk suasana pembelajaran multimedia.

EFFECTS OF PEDAGOGICAL AGENTS' INSTRUCTIONAL ROLES ON LEARNERS WITH DIFFERENT COGNITIVE STYLES IN TERMS OF ACHIEVEMENT AND MOTIVATION

ABSTRACT

This study investigated the effects of pedagogical agents' instructional roles in an interactive agent-based multimedia learning environment on learners with different cognitive styles in terms of achievement and motivation.

Two modes of pedagogical agent with different instructional roles, namely, the Expert Agent (EXA) and the Mentor Agent (MEA), were systematically designed and developed to serve the purpose of this study. The EXA was designed to present direct and accurate information when questions were asked by the learners. Whereas the MEA was designed to provide sufficient guidance for learners to search for information, rather than giving the information directly when questions were asked by the learners. Occasionally, the MEA would provide words of motivation and encouragement to the learners to engage their involvement towards the learning task.

This true-experimental study employed a 2 x 2 factorial design by taking the two modes of pedagogical agent with different instructional roles (EXA and MEA) as the independent variable, and the learners' cognitive styles of field-dependence/field-independence (FD/FI) as the moderator variable. The dependent variables were the learners' achievement score and motivation score. A total of 86 fourth-year undergraduate students from the School of Educational Studies Universiti Sains Malaysia, who enrolled in the 'PGT436E: ICT in Education' course,

participated in this study as the research sample. The learners were randomly assigned to one of the pedagogical agents (EXA or MEA) and were requested to study the instructional materials provided in the agent-based multimedia learning portal by interacting with their assigned pedagogical agent.

Descriptive and inferential statistics were performed to analyse the collected data. The analyses revealed that learners who were facilitated by the MEA performed significantly better compared to those who were facilitated by the EXA in both achievement and motivation. When the learners' cognitive styles were taken into consideration, the greatest impact of the MEA was observed on the FD learners – whereby FD learners who used the MEA outperformed those FD learners who used the EXA significantly in both achievement and motivation. Among the FI learners, learners who used the MEA were significantly more motivated compared to those who used the EXA. But, no significance difference was identified in the mean of achievement score between the learners who used the MEA and the learners who used the EXA. These results implied that the mentor instructional role is preferable over the expert instructional role when designing pedagogical agents for multimedia learning environments.

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

This chapter introduces the general structure, concept and framework of this study. Firstly, the research background is duly discussed in this chapter. Then, the statement of problem is presented, followed by the objectives, questions and hypotheses of this research. The significance of this study is highlighted to show the contributions of this study from theoretical and practical standpoints. Next, both the theoretical framework and research framework are described to present the overall structure of this research. Lastly, the limitations of this study as well as the definitions of variables and key terms are discussed at the end of this chapter.

1.2 BACKGROUND OF THE STUDY

Social communication and knowledge exchange could naturally occur between instructor and learner along with the instructional material in a typical face-to-face educational setting. However, when the instructional process is mediated by a computer, the probability for social exchange to occur between the learner and the computer-based learning environment is normally low or absent. As a solution to the problem, several researchers proposed the incorporation of virtual instructors in the form of animated life-like characters into computer-based learning environments to simulate human-to-human communication and to foster social relationship between learners and computers (Atkinson et al., 2005; Johnson & Rickel, 2000; Mayer et al., 2003; Moreno et al., 2001). The animated life-like characters are generally known as pedagogical agents.

1.2.1 Introduction to Pedagogical Agents

Pedagogical agents are onscreen life-like characters designed to facilitate and support humans' learning by interacting with learners in interactive multimedia learning environments (Craig et al., 2002; Johnson & Rickel, 2000). The pedagogical agents can take advantage of verbal (e.g. words, speeches) and nonverbal (e.g. gesture, gaze) forms of communication within the multimedia learning environments to enhance learners' cognitive engagement as well as motivation towards the instructional materials (Atkinson, 2002). Consequently, the agents could function as an effective cognitive tool as well as a communicative tool that can guide the learners to experience the instructional materials better.

Over the decade, a growing number of research and development projects have been conducted concerning human-computer interaction and agent technology to study the potentials of pedagogical agents to enhance teaching and learning strategies. The research studies offered supportive evidences that the next major step of computer interface evolution in academia will be a shift towards highly personalised interfaces, in which the human-computer communication and instructional interventions will be mediated by embodied pedagogical agents (Andre et al., 1998). Due to their ability to simulate verbal and nonverbal social cues which are typically present in human-to-human interactions, pedagogical agents are ideally suited to serve as virtual instructors to aid in the learners' knowledge constructions and skill acquisitions. Thus, the utilisation of pedagogical agents in multimedia learning environment offers great promise for enhancing the potential of human-computer communication and increasing the ability of computers to engage and support learners for effective learning processes.

1.2.2 The Factor of Agents' Instructional Roles

The core reason of having pedagogical agents in multimedia learning environments is to serve as virtual pedagogical instructors to facilitate and support the humans' knowledge construction processes. As such, it is imperative that when designing pedagogical agents, their roles within the learning environments must be studied carefully so that they serve the intended instructional purposes (Baylor, 2003; Baylor & Kim, 2003). If pedagogical agents are well-designed with appropriate persona and media features, they can effectively play the role as virtual pedagogical instructors and can be perceived by learners, as being able to undertake the intended instructional role effectively.

The instructional roles of pedagogical agents and their effects on learning have received immense interest from researchers (Baylor, 2000, 2003; Baylor & Kim, 2003, 2004, 2005; Kim 2004; Kim & Baylor, 2006; Konstantin et al., 2007). The researchers identified several effective agents' instructional roles that are essential in learning, such as the agents as experts, mentors and motivators. Empirical research studies have been extensively conducted to investigate the effectiveness of the agents' instructional roles for promoting learning and motivation outcomes within various pedagogical agent-based learning environments.

In discussing pedagogical agents as virtual instructors to promote learning and motivation outcomes, two instructional roles that fit into the qualities of an ideal instructor are those of the expert and the mentor. Experts are persons who are very skilful in or knowledgeable about particular areas. Generally, they exhibit mastery and possess extensive knowledge within a particular domain of knowledge.

Moreover, they are usually confident, stable in performance and not easily influenced emotionally by internal or external conditions. On the other hand, mentors are individuals who are experienced in specific areas and they serve well as trusted trainers or advisors. Usually, the mentors work collaboratively with learners to achieve goals. As the ideal instructors, the mentors do not simply provide information but rather provide guidance for the learners to bridge the gap between the current and desired skill levels (Driscoll, 2000). At the same time, mentors develop a social relationship and a strong rapport with the learners to motivate them to perform better.

1.2.3 The Factor of Individual Differences

In the analysis of learners, two broad types of psychological profiles or human characteristics should be taken into consideration, namely the individual differences and individual similarities (Smith & Ragan, 2005a). Widely studied factors of individual differences include intelligence quotient (IQ), cognitive styles, psychosocial traits, developmental stages and prior learning. Conversely, individual similarities are aspects that are characterised by relative similarities among people rather than differences (e.g. sensory capacities, information-processing capabilities, human cognition and developmental processes).

One important learner characteristic to be focused is the individual differences in terms of the cognitive style of learners, as it highly contributes to the outcomes of learning. Cognitive style of field-dependence/field-independence is a stable individual difference that represents the learners' manner of processing information on a continuum between the analytical and the global way of processing

(Witkin et al., 1977). The cognitive style (FD/FI) also refers to the individual's consistent and characteristic tendency of perceiving, remembering, organising, processing, thinking and solving problems. It is an important individual difference to be studied as it provides information about the factors which contribute to the human differences from a cognitive and information-processing standpoint.

1.3 PROBLEM STATEMENT

Kim and Baylor (2006) stated that different permutations of pedagogical agents' design might be advantageous but only if the characteristics of the targeted learners were considered in the design of the agents. This is because apart from the systematic design of the course content, graphics and highly realistic pedagogical agent, learning outcomes of an instruction are greatly dependent on the characteristics of the targeted learners.

Previous research studies (Baylor, 2000, 2003; Baylor & Kim, 2003, 2004, 2005; Kim 2004; Kim & Baylor, 2006; Konstantin et al., 2007) that were conducted focused on the effects of pedagogical agents and its roles towards various learning outcomes. However, there is still a lack of systematic research to specifically investigate the values and features of the pedagogical agents for supporting learning-related outcomes towards learners with different psychological profiles (particularly the learners' cognitive styles).

Considering the importance of the instructional roles of pedagogical agents for learning and their relation to learners' cognitive styles (FD/FI), investigations should be conducted to explore the effects of these two factors towards learning

outcomes. Therefore, this study attempted to examine and identify the most suitable agents' instructional role which could significantly enhance the achievement and motivation of learners with different cognitive styles (FD/FI).

1.4 RESEARCH OBJECTIVES

One important aspect of designing interactive pedagogical agents for multimedia instructions is to carefully design their roles within the learning environment to serve the intended educational purposes (Baylor & Kim, 2003). Therefore, the main purpose of this study was to identify the most appropriate instructional role for pedagogical agents to optimise and to enhance the learning outcomes of learners with different cognitive styles (FD/FI).

In order to achieve the abovementioned research objectives:

(1) Firstly, two modes of pedagogical agent with different instructional roles, namely, the Expert Agent (EXA) and the Mentor Agent (MEA) were designed, developed and operationalised. Subsequently, the developed pedagogical agents were embedded into the learning material to produce two versions of agent-based web courseware (EXA version and MEA version) which utilised the Learning Management System (LMS) as the delivery platform.

(2) Secondly, a true-experimental study was conducted to examine the effects of the different agents' instructional roles on learners with different cognitive styles (FD/FI) in terms of achievement and motivation.

1.5 RESEARCH QUESTIONS

In undertaking this study, the following research questions were put forward:-

Research Question 1 (Q1):

Taking the learners as a whole, would the learners who used the MEA perform significantly better compared to the learners who used the EXA in terms of achievement?

Research Question 2 (Q2):

Among the field-independent (FI) learners, would the FI learners who used the MEA (FI-MEA) perform significantly better compared to the FI learners who used the EXA (FI-EXA) in terms of achievement?

Research Question 3 (Q3):

Among the field-dependent (FD) learners, would the FD learners who used the MEA (FD-MEA) perform significantly better compared to the FD learners who used the EXA (FD-EXA) in terms of achievement?

Research Question 4 (Q4):

Taking the learners as a whole, would the learners who used the MEA perform significantly better compared to the learners who used the EXA in terms of motivation?

Research Question 5 (Q5):

Among the field-independent (FI) learners, would the FI learners who used the MEA (FI-MEA) perform significantly better compared to the FI learners who used the EXA (FI-EXA) in terms of motivation?

Research Question 6 (Q6):

Among the field-dependent (FD) learners, would the FD learners who used the MEA (FD-MEA) perform significantly better compared to the FD learners who used the EXA (FD-EXA) in terms of motivation?

1.6 RESEARCH HYPOTHESES

The level of significance (*p*-value) used in this study was set to 0.05. The hypotheses of this study that corresponded to the research questions were as follows:-

Hypothesis 1 (H1):

The learners who used the MEA will perform significantly better compared to the learners who used the EXA in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\,(MEA)} > \mu_{A\,(EXA)}$$

Hypothesis 2 (H2):

The FI learners who used the MEA (FI-MEA) will perform significantly better compared to the FI learners who used the EXA (FI-EXA) in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\,(FI\text{-}MEA)} > \mu_{A\,(FI\text{-}EXA)}$$

Hypothesis 3 (H3):

The FD learners who used the MEA (FD-MEA) will perform significantly better compared to the FD learners who used the EXA (FD-EXA) in the mean of achievement scores, μ_A, that is:-

$$\mu_{A\,(FD\text{-}MEA)} > \mu_{A\,(FD\text{-}EXA)}$$

Hypothesis 4 (H4):

The learners who used the MEA will perform significantly better compared to the learners who used the EXA in the mean of motivation scores, μ_M, that is:-

$$\mu_{M\,(MEA)} > \mu_{M\,(EXA)}$$

Hypothesis 5 (H5):

The FI learners who used the MEA (FI-MEA) will perform significantly better compared to the FI learners who used the EXA (FI-EXA) in the mean of motivation scores, μ_M, that is:-

$$\mu_{M\,(FI\text{-}MEA)} > \mu_{M\,(FI\text{-}EXA)}$$

Hypothesis 6 (H6):

The FD learners who used the MEA (FD-MEA) will perform significantly better compared to the FD learners who used the EXA (FD-EXA) in the mean of motivation scores, μ_M, that is:-

$$\mu_{M\,(FD\text{-}MEA)} > \mu_{M\,(FD\text{-}EXA)}$$

1.7 SIGNIFICANCE OF THE STUDY

The major goal of this study was to investigate the effectiveness of pedagogical agents with different instructional roles in a multimedia learning environment towards learners with different cognitive styles. With the findings of this study, we would be able to understand how to design effective pedagogical agents better to facilitate learning and enhance learners' motivation. Eventually, this study would provide implications (in both theoretical and practical perspectives) to the community who are interested in designing and developing pedagogical agents – especially, the community involved in educational technology.

From the theoretical viewpoint, this study sought to provide empirical evidence that would support and justify the effectiveness of assigning appropriate instructional roles to pedagogical agents in boosting learners' achievement and intrinsic motivation. Besides, this study attempted to refine the personalisation principle for multimedia instructional design proposed by Mayer and his colleagues (Clark & Mayer, 2008a; Mayer, 2005; Mayer et al., 2004). It is believed that the effects of the embedment of personalised pedagogical agents into multimedia learning environments would be further enhanced with the incorporation of appropriate instructional roles to the agents.

From the practical perspective, the result of this study would provide alternative guidelines for multimedia instructional designers in designing and developing pedagogical agents with appropriate instructional roles that would support the knowledge-construction of learners with different cognitive styles.

1.8 THEORETICAL FRAMEWORK

The theoretical foundation of this study was formed by the following theories and models:-

- Cognitive Theory of Multimedia Learning (Mayer, 2001a)
- Social Agency Theory (Atkinson et al., 2005; Mayer et al., 2003; Moreno et al., 2001)
- ARCS Model of Motivational Design (Keller, 1987)
- Model of Cognitive Apprenticeship (Collin et al., 1989)
- Gagné's Events of Instruction (Gagné, 1985; Gagné et al., 1992)

The Cognitive Theory of Multimedia Learning (Mayer, 2001a) and the Social Agency Theory (Atkinson et al., 2005; Mayer et al., 2003; Moreno et al., 2001) offered strong theoretical support for the embedment of pedagogical agents into multimedia learning environments to enhance cognitive processing and knowledge construction. Besides, the ARCS Model of Motivational Design (Keller, 1987) and the Model of Cognitive Apprenticeship (Collin et al., 1989) offered theoretical support and guidelines concerning the assignment of instructional roles in terms of expertise, guidance and motivation to the pedagogical agents.

The Gagné's Events of Instruction (Gagné, 1985; Gagné et al., 1992) served as the guideline model and the backbone for the development of the pedagogical agent-based web courseware. The events of instruction were based on the Information Processing Model (Gagné, 1985) which illustrated the way human process information from the surroundings. Figure 1.1 illustrates the conceptual framework of this study.

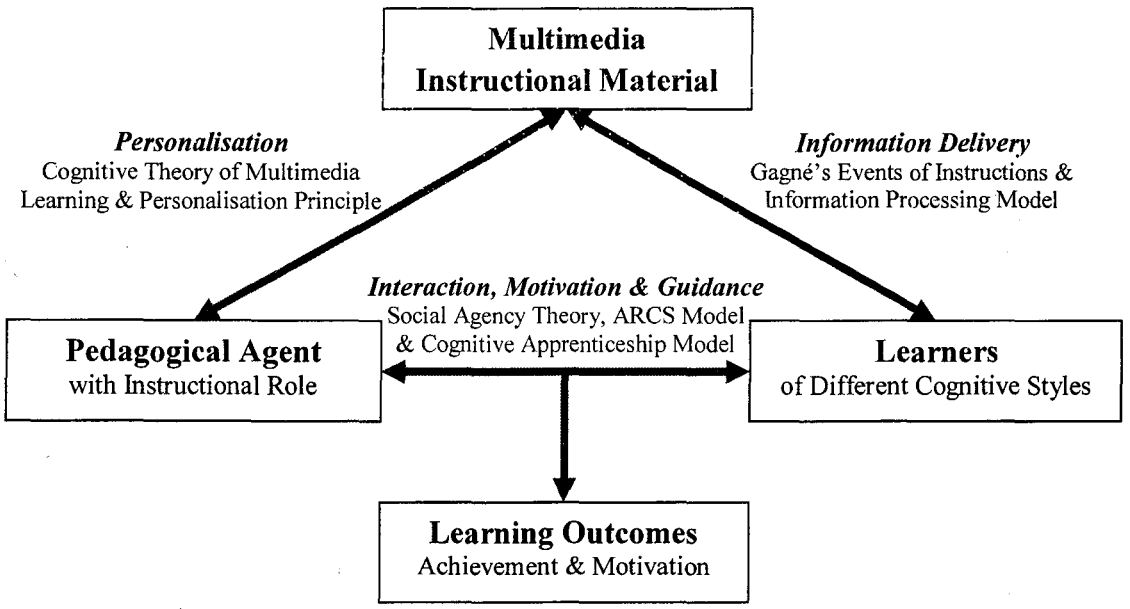

Figure 1.1: The Conceptual Framework

1.8.1 Cognitive Theory of Multimedia Learning

The Cognitive Theory of Multimedia Learning (Mayer, 2001a) explained that the human mind works to acquire and construct new knowledge from multimedia instructions by transforming information received by the eyes and ears in visual-pictorial channel and auditory-verbal channel respectively. This theory also explained the cognitive processes that would occur in humans' minds when they learn through multimedia instructions. In the design of multimedia instructions, two important aspects of design have to be taken into consideration, which are (a) to design the multimedia instructional materials in ways that reduce cognitive load to produce more capacity available for active cognitive processing during instruction, and (b) to increase learners' interest and motivation towards the instruction so that they would use the available capacity to engage in active cognitive processing. Therefore, several design principles were proposed as guidelines to develop an

effective multimedia environment for learning. One important principle which supported the utilisation of onscreen coaches or the pedagogical agents to promote personalised learning was the personalisation principle.

1.8.2 Social Agency Theory

The Social Agency Theory (Atkinson et al., 2005; Mayer et al., 2003; Moreno et al., 2001) highlighted the efficiency of fostering simulated human-to-human communications and the utilisation of pedagogical agents in multimedia learning environments. This theory elucidated the conditions for human-computer interactions to take place within a computer-based learning environment. According to this theory, multimedia instructions with social cues provided by pedagogical agents would activate learners' sense of social presence and response in the learning environment, as if they were conversing with the computer. The feeling of social presence causes the learners to engage in deeper cognitive processing by attempting to make sense of the instructional messages, thus increasing the quality of learning outcome from the instruction.

1.8.3 ARCS Model of Motivational Design

The ARCS Model of Motivational Design (Keller, 1987) indicated four design considerations or elements which are essential for creating motivating instruction: (1) Attention, (2) Relevance, (3) Confidence, and (4) Satisfaction. The pedagogical agents were believed to be able to demonstrate their fullest potential to facilitate learning if the agents were designed in the way to prime the learners' attention, show the relevance of the material, enhance learners' confidence and provide extrinsic motivation for learning satisfaction. This theory offered a useful

guideline for designing pedagogical agents with the element of motivation (e.g. providing learning guidance, giving words of encouragement, praise and motivation).

1.8.4 Model of Cognitive Apprenticeship

The Model of Cognitive Apprenticeship (Collin et al., 1989) is the extension of the guided discovery method which was formulated to serve the need of having an established relationship among several main components of a teaching and learning process (teacher, student, learning environment and learning activities). This model consists of six main components: (1) Modelling, (2) Coaching, (3) Scaffolding, (4) Articulation, (5) Reflection, and (6) Exploration. This current study of designing the expert and mentor agents employed this model as a backbone to conceptualise the idea and put it into practice.

1.8.5 Gagné's Events of Instruction

The Gagné's Events of Instruction (Gagné, 1985; Gagné et al., 1992) outlined nine events of instruction based on the Information Processing Model (Gagné, 1985), which should be included in an instructional system. These are (1) gaining attention, (2) informing learners of the objectives, (3) stimulating recall of prior knowledge, (4) presenting the stimulus material, (5) providing learning guidance, (6) eliciting performance and practice, (7) providing feedback, (8) assessing performance, and (9) enhancing retention and transfer. This study employed this model of instructional design as a guideline to design a systematic flow of instruction for the pedagogical agent-based web courseware.

1.9 RESEARCH FRAMEWORK

Figure 1.2 depicts the research framework of this study. The framework postulated the independent variable and moderator variable that would show significant variance on the two dependent variables. The independent variable was the two modes of pedagogical agent with different instructional roles (EXA and MEA). The two dependent variables were the achievement scores and motivation scores. The learners' cognitive styles of field-dependence/field-independence (FD/FI) served as the moderator variable in this study.

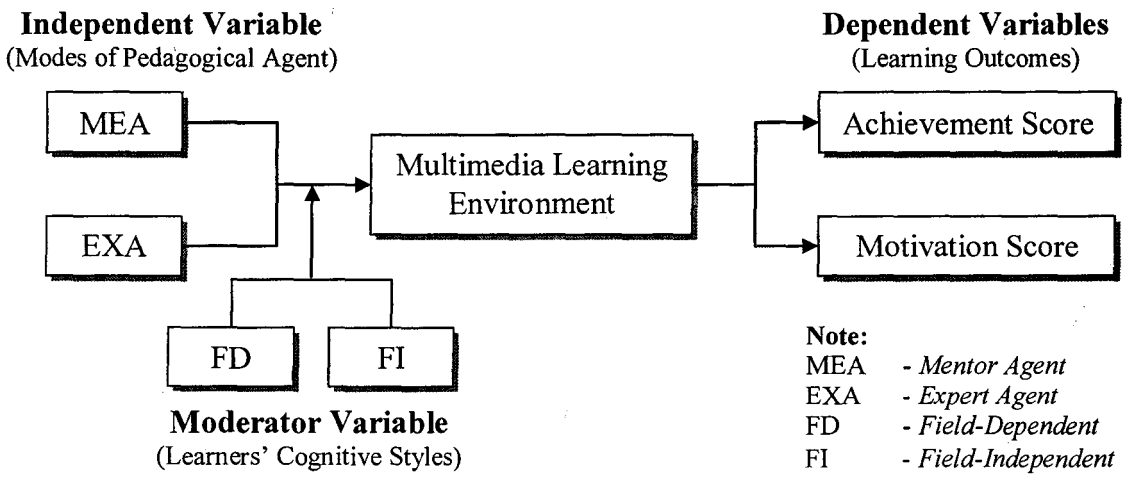

Figure 1.2: The Research Framework

1.10 LIMITATION OF THE STUDY

There were several limitations in this study. Firstly, the selected instructional roles of the agent were limited to the expert role and the mentor role only. This was because the elements of expertise and motivation were the key aspects that were considered in the design of the pedagogical agents for this study – where these elements could be effectively demonstrated by the experts and mentors. Hence, more studies could be conducted by experimenting on other instructional roles such as the roles of motivator, facilitator, counsellor and peer.

Secondly, the learners' differences examined in this study were limited to the cognitive styles of field-dependence/field-independence (FD/FI). Other cognitive styles such as impulsive/repulsive, visual/haptic and levelling/sharpening could also be considered for investigation. Besides, more research could also be conducted to examine the effects of the agents' instructional roles on other individual differences such as intelligence levels, psychosocial traits, ethnicity, gender and developmental stages.

Thirdly, the study was conducted utilising undergraduate students as the participants. This could be a limitation as the experimental effects of the agents' instructional roles would differ for participants with a different range of ages. In addition, this research is confined to the students from the School of Educational Studies, Universiti Sains Malaysia (USM). Thus, the results and outcomes of this study may apply to the abovementioned institution exclusively due to the characteristics and the environment of the study.

Fourthly, the instructional material of the agent-based web courseware was designed specifically for the learning of concepts and principles, which could also be a limitation as different instructional roles would serve well for different instructional strategies and intended outcomes. Therefore, the result of this study could not be generalised to all types of subjects, contents (e.g. facts, concepts, processes, procedures, principles), learning strategies or learned capabilities (e.g. intellectual skill, cognitive strategy, verbal information, motor skill and attitude).

Lastly, the duration allocated for the learning activity (interaction between the learners and the pedagogical agents) was limited to 45 minutes. This could also be a limitation because the outcomes of the study may differ if the duration for interaction was extended to a longer period of time (e.g. one week, one month or one academic year). Extended research could be conducted by extending the duration of the learning activity with the pedagogical agents.

1.11 DEFINITIONS OF VARIABLES AND KEY TERMS

The following variables and terms used were either adopted from other studies or were operationally defined by the researcher based on the context of this study.

Pedagogical Agents

Pedagogical agents are onscreen life-like characters designed to facilitate and support humans' learning by interacting with learners in interactive multimedia learning environments (Craig et al., 2002; Johnson & Rickel, 2000). This study utilised animated pedagogical agents in the form of talking heads as virtual instructors.

Instruction

Instruction is defined as the facilitation of learning (Alessi & Trollip, 2001). Instruction has been portrayed as an approach whereby knowledge is given to people by an instructor.

Multimedia Learning Environment

Multimedia can be defined as the presentation of material using both words and pictures (Mayer, 2001b) or using more than one medium of expression or communication (Soanes & Stevenson, 2004). In this study, multimedia learning environment refers to a learning environment which optimised the use of both visual-pictorial channel and auditory-verbal channel for instructions.

Web-Based Learning Portal

Web-based learning portal is nn online learning portal that consists of learning objects (e.g. agent-based web courseware, quizzes) and tools (e.g. forum board, wiki, chat room) for online instruction. In this study, the web-based learning portal utilised the *Moodle* Learning Management System (LMS) as the main delivery platform for instruction.

Agent-Based Web Courseware

Web courseware is an online learning program or material designed for educational purposes. In this study, agent-based web courseware refers to a web-based learning courseware with pedagogical agent embedded as virtual instructor.

Agents' Instructional Roles

Instructional roles are functions or roles played by instructor or teacher in specific educational setting (e.g. expert, mentor, motivator, peer, facilitator, coach). In this study, agents' instructional roles is defined as the functions or roles played by pedagogical agents to facilitate learning (expert and mentor).

Expert Agent (EXA)

In this study, Expert Agent (EXA) is a pedagogical agent assigned with the instructional role of an expert. The EXA demonstrates mastery and possess extensive knowledge within a particular domain of knowledge. The EXA was designed to present direct and accurate information when questions were asked by the learners.

Mentor Agent (MEA)

In this study, Mentor Agent (MEA) is a pedagogical agent assigned with the instructional role of a mentor. The MEA consists of both expertise and motivation elements. In this study, the MEA was designed to provide sufficient guidance for learners to search for information, rather than giving the information directly when questions were asked by the learners. Occasionally, the MEA will provide words of motivation and encouragement to the learners to engage their involvement towards the learning task.

Cognitive Style

Cognitive style generally refers to the manner in which people receive and process information. Ragan and his colleagues (Ragan et al., 1979; Smith & Ragan, 2005b) identified ten dimensions of cognitive style which demonstrated potential usefulness to the design of technical training – which were the field-dependence/field-independence, impulsive/reflective, visual/haptic, levelling/sharpening, constricted/flexible control, breath of categorisation, scanning, tolerance for unrealistic experiences, cognitive complexity/simplicity and conceptualising styles.

This study focused on the cognitive style of field-dependence/field-independence (FD/FI), which is a stable individual difference that represents the learners' manner of processing information on a continuum between the analytical and the global way of processing (Witkin et al., 1977).

Field-Dependent (FD) Learners

Field-dependent (FD) learners refer to learners who scored below the calculated mean score of Group Embedded Figures Test (GEFT) (Witkin et al., 1971). FD learners tend to be extrinsically motivated and enjoy cooperative learning. In the case of interpersonal skills, the FD learners were observed to be more autonomous compared to the FI learners.

Field-Independent (FI) Learners

Field-independent (FI) learners refer to learners who scored above the calculated mean score of GEFT (Witkin et al., 1971). FI learners tend to be intrinsically motivated and enjoy individualised learning. In terms of cognitive restructuring, FI learners were more autonomous in relation to the development of cognitive restructuring skills compared to the FD learners.

Achievement Score

Achievement score is the score obtained from performance tests (pre-test and post-test) by calculating the difference between the post-test score and the pre-test score (post-test minus pre-test). The achievement score determines the learner's achievement or improvement after learning in the agent-based web courseware.

Motivation Score

Motivation score is the score obtained from the learner's response in the Intrinsic Motivation Inventory (IMI) (Ryan, 1982). The motivation score demonstrates the learner's level of intrinsic motivation towards the instructions.

Group Embedded Figures Test (GEFT)

GEFT is a recognised and reliable tool developed by Witkin et al. (1971) to access individuals' level of field-dependency. It consists of 21 items that require the individuals to find simple geometric shapes embedded in complex figures within a specific time limit.

Intrinsic Motivation Inventory (IMI)

IMI is a multidimensional instrument designed by Ryan (1982) which consists of seven subscales to assess individuals' intrinsic motivation and subjective experience related to a specific activity or learning task.

Performance Tests (Pre-Test and Post-Test)

The performance tests (pre-test and post-test) were developed by the researcher which aimed to measure the learners' achievement on the instructional materials before (pre-test) and after (post-test) the learning activities in the agent-based web courseware. Each test consists of 14 multiple choice questions and 3 open-ended structural questions. Both pre-test and post-test items were similar in content but the sequence of the items was randomised.

1.12 SUMMARY

This chapter generally introduced the main ideas and concepts of this study. Initially, this chapter reviewed the background of this study which focused on the utilisation of pedagogical agent technology in learning and the possibilities of assigning instructional roles to them. Next, the objectives, questions, hypotheses and significance of this study were clearly stated.

This chapter also discussed the theoretical framework of this study, which was formed by the Cognitive Theory of Multimedia Learning (Mayer, 2001a), the Social Agency Theory (Atkinson et al., 2005; Mayer et al., 2003; Moreno et al., 2001), the ARCS Model of Motivational Design (Keller, 1987) and the Model of Cognitive Apprenticeship (Collin et al., 1989). A research framework to examine the effects of the different agents' instructional roles on learners with different cognitive styles in terms of achievement and motivation was depicted in this chapter. In addition, several limitations of this research were discussed and the important operational terms used in this study were clearly defined at the end of this chapter.

The following chapter will review and discuss several important literatures, theories, models and past research studies which were relevant in this study.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter elucidates a review of the literature related to this study. Firstly, a review on several past research studies concerning pedagogical agents is presented in this chapter to consolidate the effectiveness of utilising pedagogical agents in enhancing learning and motivation in computer-based learning environments. Further reviews on several empirical studies concerning the effects of agents' instructional roles are also highlighted in this chapter.

In addition, the Cognitive Theory of Multimedia Learning (Mayer, 2001a), the Social Agency Theory (Atkinson et al., 2005; Mayer et al., 2003; Moreno et al., 2001), the ARCS Model of Motivational Design (Keller, 1987) and the Cognitive Apprenticeship Model (Collin et al., 1989) are duly discussed in this chapter as they form the theoretical framework of this study. Besides, the Gagné Events of Instruction (Gagné, 1985; Gagné et al., 1992) are also discussed as it served as the guideline model and the backbone for the development of the pedagogical agent-based web courseware. A review of literature on learners' differences particularly the cognitive styles of field-dependence/field-independence (FD/FI) is also presented in this chapter.

2.2 PEDAGOGICAL AGENTS

Pedagogical agents are onscreen life-like characters designed to facilitate and support humans' learning by interacting with learners in interactive multimedia

learning environments (Craig et al., 2002; Johnson et al., 2000). The pedagogical agents can take advantage of verbal (e.g. words, speeches) and nonverbal (e.g. gesture, gaze) forms of communication within the multimedia learning environments to promote learners' cognitive engagement as well as motivation towards the instructional materials (Atkinson, 2002).

The pedagogical agents can be represented visually as cartoon-like characters, as talking-head video or as virtual reality avatars (Clark & Mayer, 2008a). In terms of voice, the agents can also be represented verbally through machine-simulated voice or human recorded voice. Pedagogical agents with anthropomorphised interface have the ability to interact with learners more naturally and socially, which makes pedagogical agent-based learning distinct from traditional computer-based learning.

2.2.1 Pedagogical Agents in Multimedia Learning

Over the years, large numbers of pedagogical agents have been developed to facilitate learning. They have also been examined in controlled studies to identify their effectiveness in promoting meaningful learning.

Examples of popular pedagogical agents that have been developed and studied include *Herman-the-Bug* in the Design-A-Plant Instructional Game (Moreno & Mayer, 2000a; Moreno et al., 2001), *Steve* who shows students the steps to operate and maintain gas turbine engines aboard naval ships (Rickel & Johnson, 2000), *Cosmo* who guides students through the architecture and operation of the Internet (Lester et al., 2000) and *Peddy* who teaches students how to solve proportionality