THE EFFECTS OF EMBODIED PEDAGOGICAL AGENT INTEGRATED WITH STUDENTS' COMMONLY ASKED QUESTIONS IN THE LEARNING OF SCIENCE AMONG LOW ACHIEVERS

by

MALLIGA K. GOVINDASAMY

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KEBERKESANAN AGENT PEDAGOGI "BERLEMBAGA" DIADUNI DENGAN SOALAN-SOALAN LAZIM PELAJAR DALAM PEMBELAJARAN SAINS DIKALANGAN PELAJAR BERPRESTASI RENDAH

ABSTRAK

Kajian ini bertujuan untuk menguji keberkesanan agen pedagogi 'berlembaga' diaduni dengan soalan-soalan lazim pelajar dalam pembelajaran topik *Energy* dalam Sains Tahun Lima di kalangan pelajar Tahap Lima berprestasi rendah yang diklasifikasikan sebagai *field dependent* ataupun *field independent*. Dua mod pembelajaran berasaskan web, iaitu Agen Pedagogi "Berlembaga" digabung dengan Soalan-soalan Lazim Pelajar (EPA bersama SCAQ) dan Agen Pedagogi "Tidak Berlembaga" digabung dengan Soalan-soalan Lazim Pelajar (DPA bersama SCAQ) telah direkabentuk dan dibangunkan untuk menguji soalan-soalan kajian ini. Pembolehubah bersandar kajian terdiri daripada (i) peningkatan pembelajaran diukur melalui perbezaan diantara skor pra dan pascaujian, (ii) persepsi kepercayaan kendiri terhadap sains diukur melalui item kepercayaan kendiri dari *Motivational Strategies for Learning Questionnaire* (MSLQ), (iii) persepsi terhadap motivasi belajar diukur melalui *Instructional Materials Motivational Survey* (IMMS) dan (iv) penglibatan pembelajaran diukur melalui *Learning Engagement Scale* ($LE_{ng}S$) serta skor daripada aktiviti pembelajaran. Persepsi pelajar terhadap agen pedagogi berlembaga sebagai satu alat bantu belajar pula diukur melalui *Agent Facilitation of Learning Scale*. Gaya kognitif pelajar dikenalpasti dengan menggunakan *Group Embedded Figures Test* (GEFT). Kajian rekabentuk eksperimen kuasi dengan faktoran 2 X 2 telah digunakan untuk menguji kesan utama mod pembelajaran dan gaya kognitif pelajar serta kesan interaksi di antara mod pembelajaran dan gaya kognitif pelajar ke atas pembolehubah-pembolehubah bersandar. Sampel kajian terdiri daripada 156 pelajar-pelajar Tahap Lima berprestasi rendah dipilih secara terkawal dari dua buah sekolah bandar di daerah Johor Bahru. Subjek kajian mengikuti salah satu mod pembelajaran yang ditetapkan untuk tempoh masa selama satu minggu dan instrumen kajian telah ditadbirkan. Data yang dikumpul dianalisa dengan

menggunakan kaedah diskriptif dan inferens iaitu ANOVA, ANCOVA dan MANOVA untuk menjawab soalan kajian dan mengesahkan hipotesis kajian.

Hasil kajian terhadap kesan utama mod pembelajaran menunjukkan bahawa agen pedagogi "berlembaga" mempengaruhi secara signifikan peningkatan pembelajaran, persepi kepercayaan kendiri terhadap sains, persepsi terhadap motivasi belajar dan penglibatan pembelajaran diukur melalui $LE_{ng}S$. Untuk kesan utama gaya kognitif, pelajar *field independent* menunjukkan peningkatan dalam persepsi terhadap motivasi belajar dan penglibatan pembelajaran diukur melalui $LE_{ng}S$. Hasil kajian juga menggariskan kesignifikanan kesan interaksi diantara pelajar *field dependent* dan agen pedagogi "berlembaga" dalam peningkatan pembelajaran, persepi kepercayaan kendiri terhadap sains, persepsi terhadap motivasi belajar dan penglibatan pembelajaran diukur melalui $LE_{ng}S$. Satu dapatan nyata daripada kajian ini ialah, kesemua pelajar tanpa mengira gaya kognitif ataupun mod pembelajaran yang diikuti, telah mendapat maanfaat yang setara dalam ingatan semerta terhadap pelajaran (skor aktiviti pembelajaran berkorelasi dengan ingatan semerta pelajar terhadap pelajaran yang diikuti). Justeru, hasil kajian ini mengesahkan kesan instruksi agen pedagogi terutamanya terhadap pelajar berprestasi rendah secara umum dan pelajar *field dependent* secara khusus. Lantaran, perekabentuk teknologi agen pedagogi harus mempertimbangkan pembangunan antaramuka dengan mengambilkira prinsip-prinsip interaksi manusia-komputer (HCI) dan gaya kognitif pelajar.

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ABSTRACT

This study examined the effect of embodied pedagogical agent integrated with students' commonly asked questions in the learning of topic 'Energy' in Science Year Five among Year Five low achieving students classified either as field dependents or field independents. Two web-based treatment conditions namely, Embodied Pedagogical Agent with Students' Commonly Asked Questions (EPA with SCAQ) and Disembodied Pedagogical Agent with Students' Commonly Asked Questions (DPA with SCAQ) were designed and developed to examine the outcome measures in this study which include learning gain score measured through differences in the pre and post test score, perceived science self-efficacy beliefs measured via self-efficacy items from Motivational Strategies for Learning Questionnaire (MSLQ), perceived motivation to learn measured via Instructional Materials Motivational Survey (IMMS) and learning engagement measured through (i) Learning Engagement Scale ($LE_{ng}S$) and (ii) scores from learning engagement activities. Students' view on embodied pedagogical agent as a tool that aids learning was measured via Agent Facilitation of Learning Scale. Students' field dependency was determined using Group Embedded Figures Test (GEFT). A 2x2 factorial design study was employed to examine the main effects of the treatment conditions and students' cognitive styles and the interaction effect between treatment conditions and students' cognitive styles on the dependent variables. The sample of the study consisted of 156 Year Five low achieving students from purposively selected two urban primary schools in the district of Johor Bahru. The participants were treated with one of the treatment conditions for the duration of one week consisting of five periods of thirty minute sessions each and were administered with the research instruments. Descriptive and inferential statistical analyses using ANOVA, ANCOVA and MANOVA were carried out to test the research questions and to validate the corresponding null hypotheses.

Findings on the main effect of the treatment conditions indicated that the embodied pedagogical agent significantly affected students' learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement measured via $LE_{ng}S$. As for the main effects of students' cognitive styles, field independent students performed significantly better than field dependent students in the measures of perceived motivation to learn and learning engagement measured via $LE_{ng}S$. The findings also outlined significant interaction effect between field dependents and embodied pedagogical agent in the measures of learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement measured via $LE_{ng}S$. One key finding delineated by this study was that the students profited equally in the measures of immediate retention of the learned content (scores in the learning engagement activities correlates with immediate retention of the learned content) independent of differences in the treatment conditions and cognitive styles. Given the findings of this study confirming the instructional impact of embodied pedagogical agent on low achieving students in general and low achieving field dependents in particular, designers of pedagogical agent technology should consider building a user interface that allows learning with an understanding of human-computer interaction (HCI) principles and students' cognitive styles.

CHAPTER 1

INTRODUCTION

1.1 Introduction

Beginning from the recommendation of Razak Report in 1956 until the set up of the Smart Schools (one of the flagship in Vision 2020) in 1997, the School Science Curriculum has undergone many phases of changes to fulfill the aspirations of the nation. The implementation of Vision 2020 calls for Malaysians to make a shift towards a more technologically literate and thinking work force which is able to perform in a global work environment and use the tools available in the ICT Age. One of the challenges of Vision 2020 is to form a society of consumers of technology and contributors to the field of science and technology. To meet these challenges, student interest and confidence in science and technology must be bolstered. Educational reformation in science and technology was seen as pivotal to realize this vision. As such technology supported learning environment became fundamental for the teaching of science.

Since the implementation of Smart School Flagship in 1997, e-learning environments comprising of World Wide Web and interactive CDROMs, began to dominate the list of teaching resources in schools. Educators felt that integrating computer technology into teaching and learning practices of science and technology will prepare students to face the challenges presented in this era of information and communication technology. According to Poh (2003), effective science education is not about rote memorization of facts but is a process of inquiry which involves knowledge acquisition with process, product and attitude throughout a child's schooling years. Therefore, regardless of the medium used for instruction, there must be a climate for inquiry. This raises the demand for computer technology to support the inquiry process in students, providing them a better grasp on scientific knowledge.

Consensus on the instructional values of computer technology are overwhelming, however the focus has been centered upon the cognitive outcomes. Affect which concerns the social aspects of learning also must be tapped. Computer technology can make learning more compelling, personal and accessible and therefore will continue to be a growing force in students' lives. However, there is a need to question (i) to what extent textual materials transferred to an electronic environment improve learning?, (ii) what are the emerging trends in educational technology that respond to new understandings of how students learn? and (iii) how to structure the field of e-learning environment from the standpoint of generating questions and answering in the pursuit of inquiry process?

1.2 Background of the Study

Science is defined as an inquiring attitude, observation and reasoning about this world (Poh, 2003). Science is developed, not by memorizing facts or conclusions to get the answer but by the process of inquiry. Inquiry has been defined as seeking for information or knowledge through questioning (Anderson & Ladd, 1971). Skillful questioning can help students to recognize and fix gaps and inconsistencies in what they know of a domain. As such, questioning can stimulate thinking. Just as teacher questioning is integral to inquiry-based instruction, so is student questioning. In support of this, Starko (2005) presented that students' questions are very effective thinking and learning tools and are superior to teacher posed questions in the classroom. Furthermore, research findings reported that students who compose and answer their own questions are perceived as independent learners who play an active and initiating role in the learning process (Taboada & Guthrie, 2006). According to King (1992b), guided learner generated questioning strategy will prompt learners to elaborate on new material in an effort to facilitate their understanding of that material. Confirming the importance of guidance in inquiry, Lee (2004) stated that teachers should guide and lead students to pose questions pertaining to the intended learning material. While high achievers rely less on teachers' help in generating questions, low achievers' dependency

increases as they are unable to scaffold their own learning. As such, instructors play a pivotal role in guiding low achievers to generate questions in an effort to comprehend the learning material better.

Low achieving students' needs, as used in this study, have always topped the priority list in educational settings. Instructional practices ranging from remedial classes, peer coaching, game-based learning to interactive multimedia-based learning have been carried out as supplemental approaches in schools in Malaysia to tackle low achievers' specific instructional needs. Despite the continued concern and effort by schools and teachers to meet their needs, low achieving students continue to represent a sizable population in schools. According to Underwood (2009) low achievement is an individual's lack of achievement compared to a group norm or inability to achieve at a set benchmark. Along this line, a variety of criteria have been used to identify low achieving students. For example, Fuchs, Fuchs and Prentice (2004) identified low achievers as those students performing one to two years behind their same age peers. In Malaysian educational settings, students' academic achievement in examinations has been taken as a yardstick to classify a student as high or low achiever. The Johor State Education Department identified low achievers as those students who only manage to get either a grade "D" or "E" in their examination (*Bahagian Peperiksaan dan Penilaian, Jabatan Pelajaran Negeri Johor, 2007*). Generally, poor schema acquisition, poor teaching strategies and lack of attention and support from other social entities in schools are cited as some of the factors that contribute to students' lower academic performance. Students who are tracked as low achievers often described as having lower self-concept, lower self-motivation and self-regulation, less goal directed behaviors and negative attitudes toward school and teachers (McCoach & Siegle, 2001). These students are also described as being more anxious and less self-efficacious (Vanzile-Tamsen & Livingston, 1999). Their ineffectuality in educational settings often resulted in their limited classroom interaction and subsequently withdrawal from classroom participation (Brophy, 1996). Low achievers' inability to meet grade-level expectations has resulted in them

seeking for additional instructional attention. Research documented intensive one-to-one tutoring as highly effective intervention for low achievers (Bloom, 1984).

Providing personal tutoring experience for a broader audience is not plausible, however the emerging trends in educational technology have complemented this void to certain extent. Literature reported that e-learning environments can offer highly individualized instruction and allow students to learn at their own pace (Barrow, Markman & Rouse, 2007). E-learning either ported over the Internet in the form distance, open or web-based learning or in the form of CDROM (Clark & Mayer, 2003) consists of content (lesson) delivered via an instructional method (technique) using media elements such as texts, visuals, animation, audio and video. The distinct objective of e-learning courses is to help learners reach personal learning goals through personalized and individualized learning. According to Oh and Lim (2005), e-learning systems inherent with provisions for self-paced learning can provide significant assistance to low achieving students in which they have control over their pace of learning, information flow, selection of learning activities and time management. They further extended that the content delivery with interactive student activities can hold students' interest and attention, thus providing an engaging learning experience to low achieving students. However, e-learning environments lack the human side of personal interaction available in traditional tutoring session. According to Woolf (2010), in order to interact naturally and supportively with students, e-learning systems must provide an environment that recognizes affect and expresses socio-emotional competencies. As such, designers and researchers target on the pedagogical and socio-emotional capability of virtual human-like characters to fill the void in the presence of a human entity in instructor-less e-learning environments.

Virtual human-like characters in pedagogical roles, serving as conversational partners have provided new opportunities to foster human-computer social interaction and communication ubiquitous in traditional tutoring sessions in digital learning environment. Maldonado et al.

(2005) stated that interaction between the learner and animated pedagogical agents can be conceptualized as one-to-one tutoring or coaching intervention. In substantiation, Valetsianos (2007) asserted that animated pedagogical agents' significant motivational benefits and social affordances are able to elicit psychological responses from learners that other traditional tutoring programs cannot afford. Echoing on pedagogical agent's tutor role, Lester et al. (1997) demonstrated that animated pedagogical agents are able to create one-to-one instructional environment engagement that can increase enjoyment of learning, increase self- regulation and efficacy and motivate students to continue to learn about a topic of a subject. Pedagogical agents adopting the role of a tutor has been described as the most effective role to connect with the users (Prendinger, Mori & Izhuka, 2005; Baylor & Kim, 2004) and the positioning of a fully embodied pedagogical agent within e-learning environment has been recognized as one of the promising ways to supplement one-to-one instruction in e-learning environment for students with special needs, in particular less-efficacious low achieving students (Kim & Baylor, 2007; Graesser, Chipman, Haynes & Olney, 2005; Baylor & Ryu, 2003; Moreno, Mayer, Spires & Lester, 2001).

Animated pedagogical agents, also known as embodied pedagogical agents, who appear on screen as embodied entities, taking the form of humans, anthropomorphized objects or animals are able to augment human cognition, interaction and social relations in e-learning environment. With the manifestation of social cues (eye movement, gestures, head nods and facial expression) and personalized speech, animated pedagogical agents are able to provide social presence that help students feel emotionally connected to the agent thereby leading to a more enjoyable and engaging learning experience. With a variety of discourse elaborations ranging from providing information, explanation, feedback as well as ask questions and draw attention to certain parts of the virtual learning environment, animated pedagogical agents have the potential to significantly impact cognitive and motivational outcomes in students (Atkinson, 2002; Baylor, 2002b; Moreno, et al., 2001; Johnson, Rickel & Lester, 2000; Lester et al., 1997).

Due to the increased attention on science standards, research involving computer technology for the development and identification of effective science instruction to low achievers has become of greater importance. In addition, due to learners' individual differences, designing instructional environment that successfully integrate educational technology that accommodates their various needs has been a challenging endeavor. Students walk into the classroom with different learner variables such as learning styles, prior knowledge, learning experiences and most importantly from an educational perspective, individual cognitive styles. Previous studies undertaken on computer simulated learning environment in Malaysian educational context, identified students' cognitive styles as having the strongest psychological impact on learning (Irfan, 2000; Fong & Ng, 2000). E-learning environment which demands students to be independent inquirer, reorganizing and restructuring information that are often presented loosely, necessitates consideration to students' cognitive styles; either as field dependents or independents for better learning experience.

Therefore, taking into consideration the potential inherent in student generated questions and motivational and affective characteristics of a fully embodied pedagogical agent, the present study investigated the effect of embodied pedagogical agent integrated with students' commonly asked questions in the learning of science among low achieving students with different cognitive styles on learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement.

1.3 Problem Statement

Technology innovations in instruction under the smart school establishment have centered upon the technological capacity to deliver information faster, in greater quantities and from greater distances (Smart Schools Task Force, 1997). However this does not imply that the full potentials of technology are optimized. The complex nature of human learning demands for better understanding on how best to deliver instruction through technology and this notion has to be acknowledged. Besides the inappropriate use of the technology, Cuban

(1986) asserted that very little regard has been given to how technology actually produces affective and cognitive outcomes and this has resulted in technology in instruction failing to deliver what it is anticipated of. According to Gulz (2004), learning is dual faceted, i.e., cognitive and affective. While the facet of cognitive refers to concepts such as meta-cognition and cognitive monitoring, affective usually refers to aspects such as motivation, satisfaction, affective needs (e.g. joy, passion, fulfillment, comfort, gratitude) and self-efficacy beliefs. Postle (1993) postulated that affective competence provides a base or substrate out of which healthy cognitive functioning can occur. Therefore, the affective component is equally important as the semantic component (Bickmore, 2004) and failure to recognize the affective process in virtual environment imposes serious limitation to learning (Virginio, Massimo & Marco, 2004).

Students who experience positive affect during learning exert more mental effort. This is evident from research reporting a reliable correlation between learner's affective state and memory capacity (Johnson et al., 2000). Research reported that verbal persuasion and physiological and affective states of instructor contributes greatly to self-efficacy of learner (Palmer, 2006). In line with this, Kim (2004) pointed out that interventions using educational technology might be able to successfully reach their goals when they include cognitive and affective processes ubiquitous in human interaction. In traditional classroom settings, teachers infer learners affect and motivation through naturally occurring social cues including personalized speech, feedback, body language, facial expression and behavior. However, in virtual learning environment, the opportunity for these social cues is often times nonexistent (Mayer, Sobko & Mautone, 2003) and as a result these environments lacked the affective and motivational characteristics present in human instructors. In light of this void as well as to support students' psychological needs, the social competence of classroom instructor must be leveraged in e-learning environment. This calls for computer-based learning materials to be designed with awareness to the affective communication channel of a human instructor.

In addition to leveraging on classroom instructors' affective variables, personalized learning is also seen as an important element in e-learning environment. Web-based educational sites such as Smart School learning portals as well as other educational portals from local and foreign media are fast gaining popularity among Malaysian students, however, these e-learning environments deliver instruction in "one size fits all" propositions without consideration to individual differences present in student, resulting in learner dissatisfaction (Mahmood & Ferneley, 2006). Learning is impacted by different types of learner variables. Thus personalizing the e-learning environment is seen necessary to reach out to a large number of diverse learners with different learner variables. Personalization, which refers to the tailoring of pedagogy, curriculum and learning support to meet learners' needs and aspirations is receiving increasing attention over the recent years (e.g. Ginns & Fraser, 2010; Kim & Chan, 2008; Aroyo et al, 2006). Personalization in e-learning environment comes in two categories, i.e., (i) learner control which empowers learner with navigational control in the environment and (ii) adaptive control in which the content of the lesson is adjusted by the instructional program based on the students' progress. However, as this study does not employ the adaptive control metaphor, the personalization of e-learning environment is discussed from the perspective of learner control metaphor.

Personalized learning employs an active learning strategy which empowers the learner to be in control of the context, pace and scope of their learning experience (Conlan, Bardy & Wade, 2004). Personalization allows students to be in control of their learning progress (move between section or learning segments), reflect on their progress at each stage or level (unit of lesson) through assessment, take risks with their approach to problem solving in a supportive and non-threatening environment and receive targeted feedback at each stage of the process. In addition to learner control, the delivery of instruction by a virtual character via personalized conversational dialogue mode using words like "I", "we" and "you" promotes a psychological engagement between learners and the learning environment (Mayer, Fennel, Farmer & Campbell, 2004). Another important feature to be thought of in

the personalization spectrum is learner variables that significantly impact students' learning outcome in e-learning environment. Consistently, researchers uphold that satisfying learners' cognitive styles was a critical success factor for e-learning instruction (e.g. Hall, 2000; Irfan, 2000). All these pave way for a learner-centered framework that encourages students to take an active role in their learning. As such, it is necessary to provide a personalized learning experience that accommodates to low achievers' academic ability and cognitive styles thus empowering them to take responsibility with their learning that leads to learner satisfaction.

The primary function of a classroom teacher is to help students to learn. An important aspect of the learning process is asking questions about material one does not understand. Learning to ask good questions is essential for students learning science. King (1994) emphasized that comprehension and learning improves after students are trained on how to ask particular types of questions. Unfortunately, due to curricular pressures and tightly constrained class time, natural process of inquiry is not practiced much in large classes. Students rarely ask questions related to learning content because they are not trained to generate questions that could scaffold their understanding of the content knowledge. This problem becomes more apparent in the case of low achievers. Low achievers inhibited classroom participation, specifically question asking was discovered during my supervision of pre-service teachers' practicum session in schools. Discussion with teachers and school principals revealed that low achievers rarely asked questions pertaining the learning content due to various reasons such as do not know what to ask, embarrassment and afraid of infuriating the teachers. Even if they pose questions, those were vague questions or questions that were not related to the lesson (for example; asking permission to go to restroom). Consistently, research found that low achievers are always not able to ask for the right help because it is difficult for them to explain what they do not understand (Keijzer & Terwel, 2004). Furthermore, Karabenick and Newman (2006) reported that low achievers asked the fewest questions in classroom due to the increasing awareness of the costs of help seeking on self esteem. They were more concerned about avoiding mistakes and embarrassment than about learning (Brophy, 1996)

and these lead to depressed rate of classroom participation and disengagement. Thus the most disturbing implication is that students who are most in need of help seem to be least likely to request it. Low achievers must be accorded active learning which gives them the opportunity to ask questions and generate their own form of information. This raises the demand for technology supported learning environment to provide a non-threatening and non-intimidating environment that encourages low achievers to ask questions and perform repetitious tasks for enhanced learning.

One important issue raised pertinent to questioning is whether low achievers have the ability to make open inquiry in computer mediated learning environment that leads to the accomplishment of learning goals. According to King (1994), open inquiry is not the appropriate way of doing inquiry for achieving goals of the curriculum; instead guided inquiry has to be implemented at primary schools that leads children to construct knowledge on their own and helps to follow the hierarchic structure of knowledge. Also, Toh (2003) alerted that the constructivist value of the e-learning content may lead to learning impediments if it is left to the student without proper instructional guidance. In support of this, Howell (2003) suggested that low achievers inability to justify their learning objectives will result in them being lost or just drift through in open inquiry. Also in computer mediated environment, open inquiry via natural language questions through keyboard input may not be appropriate for low achieving students because they may not know what to ask and may make typo errors (Howell, 2003). Howell further contended that FAQ list is one of the most appropriate interfaces for asking questions as the list covers most of the questions that learners would probably ask. In order to have a good list of questions that covers a specific content or domain, she suggested for gathering the kind of questions that users really want to ask and have them answered asynchronously by an expert. Hence, guided student generated questions that are structured and organized in a way to help achieve the learning goals and placed as question asking interface in digital environment will benefit low achieving students in particular.

The major impetus for the present study had been to replicate one-to-one tutoring approaches that have been recognized as a successful remedial instruction for low achievers in a pedagogical agent mediated learning environment. Also as low achievers are known to be inhibited in classroom questioning as well as in need of motivational and emotional support from learning environment, the present study proposes for the use of embodied pedagogical agent integrated with the pedagogical approach of learning by asking questions for an interactive, personalized and emotionally responsive environment that is adaptive to lower academic ability students' unique need for individuality, pacing and structure.

1.4 Purpose of the Study

The purpose of the present study was to examine the effect of embodied pedagogical agent integrated with students' commonly asked questions in the learning of topic 'Energy' in Year Five Science among Year Five low achieving students with different cognitive styles. The independent variable was the mode of instruction with two treatment conditions, namely (i) Embodied Pedagogical Agent integrated with Students' Commonly Asked Questions (EPA with SCAQ) and (ii) Disembodied Pedagogical Agent integrated with Students' Commonly Asked Questions (DPA with SCAQ). The dependent variables researched were (a) learning gain score, (b) perceived science self-efficacy beliefs, (c) perceived motivation to learn and (d) learning engagement. Learning engagement was measured via two instruments, i.e., Learning Engagement Scale ($LE_{ng}S$) developed by the researcher of this study (measured affective and behavioral engagement) and scores from learning engagement activities (which in essence assessed students' retention of the learned content). In addition, students' view on embodied pedagogical agent as a tool that aids learning was investigated. Students' cognitive styles, either as field dependent or field independent were used as moderating variables in this study.

The present study was divided into two parts as below:

i) The first part was to design and develop a web-based learning environment that delivers the lesson through two treatment conditions. The design and development of the treatment conditions are described in detail in chapter 4.

ii) The second part was to study the effect of the two treatment conditions (independent variables) among low achieving students' with different cognitive styles (moderator variables) on their learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement (dependent variables).

The independent variable, which was the mode of instruction, encompasses the integration of two factors namely (i) pedagogical agent (either the embodied or disembodied agent) and (ii) students' commonly asked questions. While literature as discussed earlier has supported embodied pedagogical agent environment as an effective supplemental approach for one-to-one tutoring for students with special needs, my reading and search in local context shows that embodied agent phenomena has not found its way into Malaysian schools yet (Discussion in Chapter 2 shows that embodied pedagogical agent facilitated learning environments are mostly researched at higher learning institutions in Malaysia). Furthermore, evidence on the effect of student generated questioning technique in e-learning environment among low achieving students in local context is also not established. Therefore, the use of questions generated by students through the process of guided inquiry and by having embodied pedagogical agent answer these questions asynchronously was deemed more appropriate for low achievers who demonstrate reticence in question asking and this approach was applied in the present study. The need for the study, proposed intervention and measured outcomes are illustrated in graphical form in Figure 1.1.

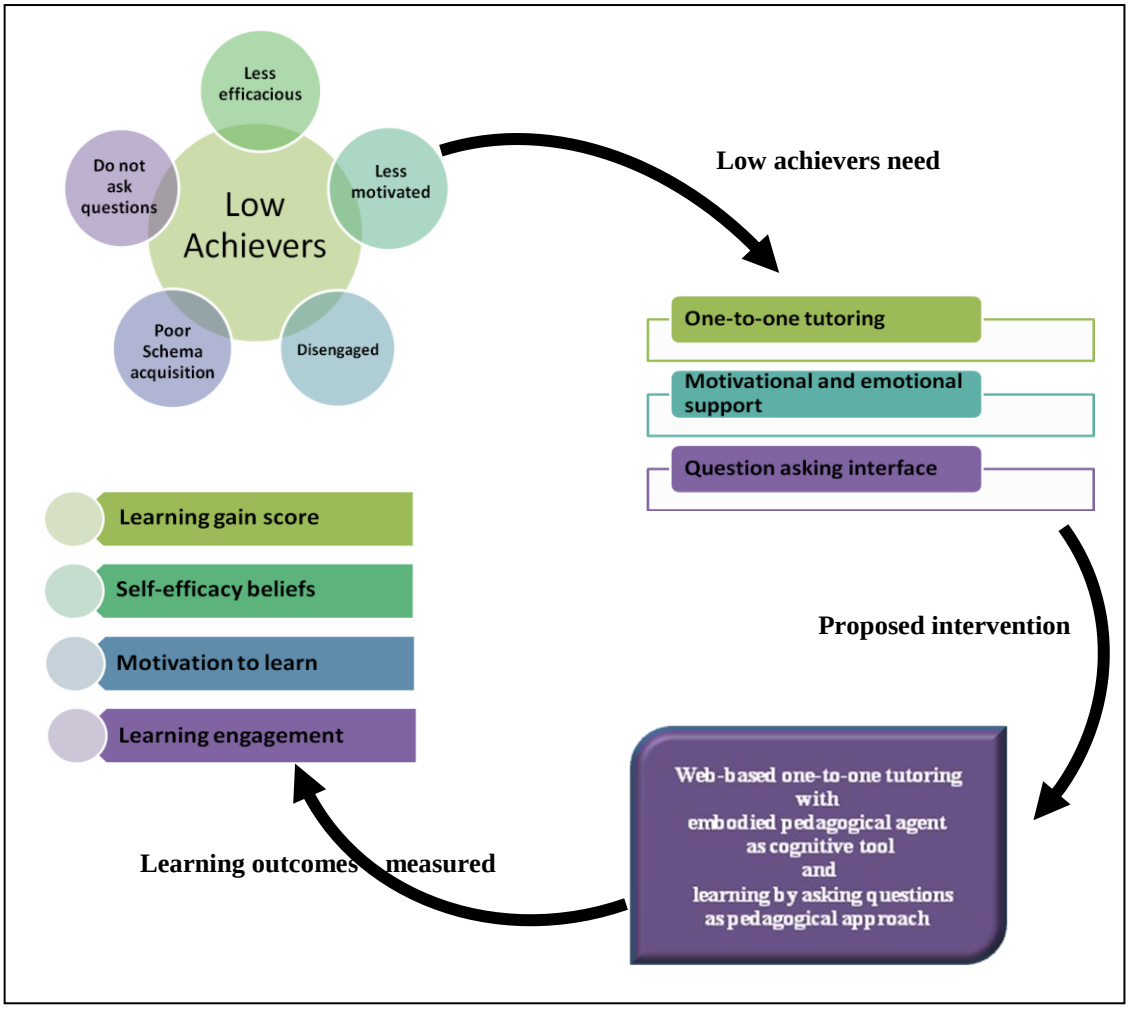

Figure 1.1: Graphical representation of the research purpose, proposed intervention and measured outcomes

1.5 Research Objectives

The objectives of the present study were as follows:

a) To design and develop a web-based learning environment with two treatment conditions namely, EPA with SCAQ and DPA with SCAQ for the learning of topic *"Energy"* from the theme *Force and Energy* in Year Five Science. The overview of the design of the study is shown in Table 1.1. The graphical representation of the study design is illustrated in Figure 1.2.

b) To investigate the effects of the EPA with SCAQ treatment condition compared to the DPA with SCAQ treatment condition on low achieving students' learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement.

c) To investigate the effects of the web-based learning environment on field dependent and field independent low achieving students' learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement.

d) To investigate the interaction effect of the treatment conditions and students' cognitive styles on low achievers' learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement.

e) To investigate field dependent and field independent low achieving students' view on embodied pedagogical agent as a tool that facilitates learning.

Table 1.1: Overview of the study design

Features	**Treatment Condition EPA with SCAQ**	**Treatment Condition DPA with SCAQ**
Pedagogical Agent	Embodied pedagogical agent (Human-like character)	Disembodied pedagogical agent (Voice over)
Pedagogical Approach	Students' commonly asked questions	Students' commonly asked questions
Outcome measures	• Learning gain score • Perceived science self-efficacy beliefs • Perceived motivation to learn • Learning engagement • Agent facilitation of learning	• Learning gain score • Perceived science self-efficacy beliefs • Perceived motivation to learn • Learning engagement

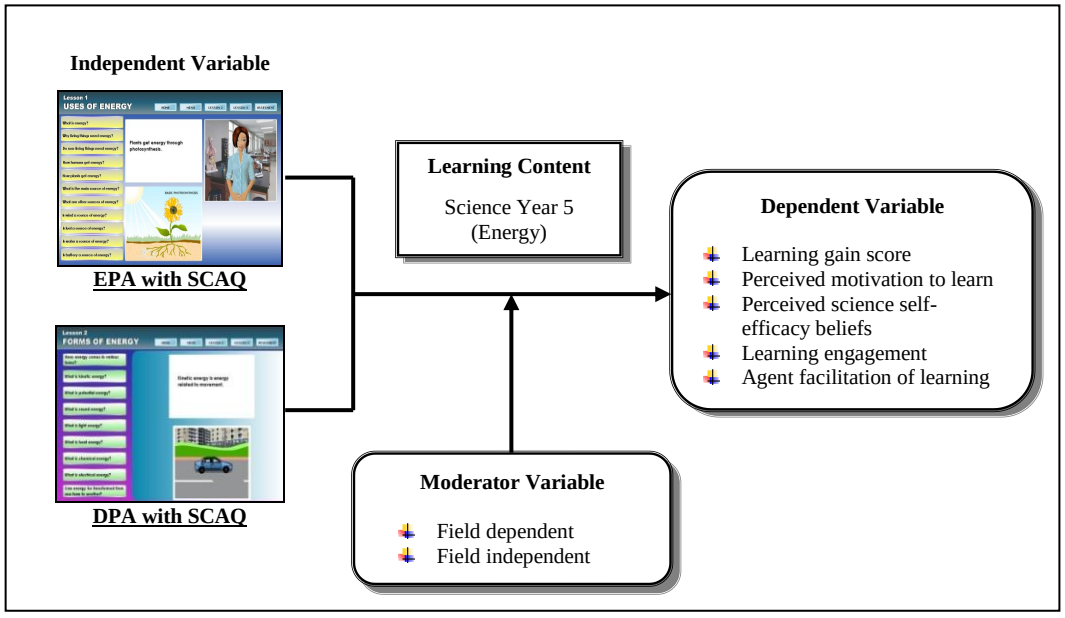

Figure 1.2: Graphical representation of the study design

1.6 Research Questions

The present study was designed to address specifically two sets of questions as below:

(A) What is the effect of embodied pedagogical agent versus disembodied pedagogical agent with students' commonly asked questions on field dependent and field independent low achieving students' learning gain score, perceived science self-efficacy beliefs, perceived motivation to learn and learning engagement? The subsidiary questions are as follows:

1. (a) Is there a significant difference in learning gain score between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition?
   (b) Is there a significant difference in learning gain score between field dependent and field independent students in both treatment conditions?
   (c) Is there a significant interaction effect between treatment conditions and students' cognitive styles on learning gain score?

2. (a) Is there a significant difference in perceived science self-efficacy beliefs between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition?
   (b) Is there a significant difference in perceived science self-efficacy beliefs between field dependent and field independent students in both treatment conditions?
   (c) Is there a significant interaction effect between treatment conditions and students' cognitive style on perceived science self-efficacy beliefs?

3. (a) Is there a significant difference in perceived motivation to learn between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition?

(b) Is there a significant difference in perceived motivation to learn between field dependent and field independent students in both treatment conditions?

(c) Is there a significant interaction effect between treatment conditions and students' cognitive styles on perceived motivation to learn?

4. (a) Is there a significant difference in learning engagement between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition as measured by (i) Learning Engagement Scale and (ii) scores from learning engagement activities?

(b) Is there a significant difference in learning engagement between field dependent and field independent students in both treatment conditions as measured by (i) Learning Engagement Scale and (ii) scores from learning engagement activities?

(c) Is there a significant interaction effect between treatment conditions and students' cognitive styles on learning engagement as measured by (i) Learning Engagement Sale and (ii) scores from learning engagement activities?

(B) What is the view of low achieving students' with different cognitive styles on pedagogical agent as a tool that facilitates learning?

1. Is there a significant difference between field dependent and field independent students in the EPA with SCAQ treatment condition in their view on embodied pedagogical agent as a tool that aids learning?

1.7 Research Hypotheses

The hypotheses for this study were formulated as null hypotheses. Several reasons constitute to this formulation. First, the null hypotheses provided me with the starting point for statistical test. It allowed me to test the significance level α, at 0.05 and therefore conclude

on either to affirm or negate the null hypotheses statement. Second, the sample of the study was drawn from the same population. There is a high chance that the groups will not differ in terms of performance in the outcome measures. As such I wanted to presume that there is no significant difference until proven otherwise. Also, while evidences drawn from literature discussed earlier suggest the positive impact of embodied pedagogical agent on students' cognitive and psychological outcomes, its' instructional merits among low achieving students in Malaysian context has not been established. Hence, it was premature to make directional hypotheses with a strong stance that one of the treatment conditions as employed in this study will be superior to the other. Thus the hypotheses statements were phrased non-directionally leading to the formulation of null hypotheses. The null hypotheses that correspond to the above research questions are as follows.

H_oA1_a: There is no significant difference in learning gain score between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition.

H_oA1_b: There is no significant difference in learning gain score between field dependent and field independent students in both treatment conditions.

H_oA1_c: There is no significant interaction effect between treatment conditions and students' cognitive styles on learning gain score.

H_oA2_a: There is no significant difference in perceived science self-efficacy beliefs between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition.

H_oA2_b: There is no significant difference in perceived science self-efficacy beliefs between field dependent and field independent students in both treatment conditions.

H_oA2_c: There is no significant interaction effect between treatment conditions and students' cognitive styles on perceived science self-efficacy beliefs.

H_oA3_a: There is no significant difference in perceived motivation to learn between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition.

H_oA3_b: There is no significant difference in perceived motivation to learn between field dependent and field independent students in both treatment conditions.

H_oA3_c: There is no significant interaction effect between treatment conditions and students' cognitive styles on perceived motivation to learn.

H_oA4_a: There is no significant difference in learning engagement between students in the EPA with SCAQ condition and students in the DPA with SCAQ condition as measured by (i) Learning Engagement Scale and (ii) scores from learning engagement activities.

H_oA4_b: There is no significant difference in learning engagement between field dependent and field independent students in both treatment conditions as measured by (i) Learning Engagement Scale and (ii) scores from learning engagement activities.

H_oA4_c: There is no significant interaction effect between treatment conditions and students' cognitive styles on learning engagement as measured by (i) Learning Engagement Scale and (ii) scores from learning engagement activities.

H_oB_1: There is no significant difference between field dependent and field independent students in the EPA with SCAQ treatment condition in their view on embodied pedagogical agent as a tool that aids learning.

1.8 Theoretical Framework

The present study was designed based on four theories namely Cognitive Theory of Multimedia Learning (Mayer, 1997, 2001), Cognitive Load Theory (Sweller, 1988, 1994), Social Agency Theory (Mayer, Sobko & Mautone, 2003; Moreno, et al., 2001) and Social Cognitive Theory (Vygotsky, 1978; Bandura, 1986). The culmination of these four theories

formed the theoretical framework for this study. The instructional material was designed and developed based on Alessi and Trolip's (2001) Instructional Design Model. The instructional content adhered to Gagne's (1985) Nine Events of Learning.

Cognitive theory of multimedia learning and cognitive load theory provide a solid theoretical foundation in designing guidelines for constructing e-learning content in a way that enhances learning. Propositions under the cognitive theory of multimedia learning (Mayer, 1997; 2001) generated several principles to yield better learning outcome in multimedia learning environment. These principles postulate that students learn better from words and graphics than words alone (multimedia principle), instruction should exploit the visual and verbal channel of learning (modality principle) so that learner's working memory capacity is not overloaded (redundancy principle), information should be presented as a coherent summary (coherence principle) so that learners can effortlessly select, organize and make connections between corresponding representation (contiguity principle) and verbal provisions of information using conversational style and personalized learning agent (personalization principle) creates an engaging and meaningful learning experience for the students.

Cognitive load theory (Sweller, 1988; 1994) proposes that due to limitations in human's information processing systems, working memory should not be stressed by unnecessary or seductive details within the learning environment and that instructional content and activities should be designed to allow for efficient schema acquisition. Therefore, reducing total cognitive load imposed by a body of to-be-learned information increases the portion of working memory which is available to attend to the learning process. Cognitive load theory was applied in several learning context and led to the demonstration of several effects such as (i) modality effect which suggest that when presenting information, textual content should be presented aurally in order to minimize the overload of processing both textual and pictorial information via visual channel (ii) redundancy effect which suggest that working memory load can be reduced by removing unnecessary processing of repetitive information

(presenting a single source of information either visual or textual that can provide full intelligibility, yields superior performance), (iii) split attention effect which suggest that working memory capacity can be increased by physically integrating textual and visual sources and (iv) element interactivity effect which suggest that high level of element interactivity (complex instructional content) will impose overload on working memory and that elements must be processed in an isolated fashion in the working memory to reduce intrinsic cognitive load.

Theories under the social cognitive dimensions, defines teaching and learning as highly social activities. Social interaction among participants in the learning context is seen as the primary source of cognitive and social development. Two theories, namely social agency theory and social cognitive theory provided a deeper understanding of how students acquire knowledge by interacting with a knowledgeable someone. Social agency theory emphasizes the need to emulate human-to-human connections in computer-based learning environments. Essentially, social agency theory posits that meaningful learning occurs by combining verbal and visual modalities of instruction with human-like virtual characters (Mayer et al., 2003; Moreno, et al., 2001). Priming on the social interaction schema derived from media-equation hypotheses (Reeves & Nass, 1996), social agency theory claims that, when interacting with an agent, learners interpret their interaction with the computer consistent with human-to-human communication and thus exert more effort to deeply understand and process the instructional content. Perceiving the computer as a social partner encourages the learner to engage in a sense making process that increases the probability of positive transfer (Mayer, et al., 2003). As such, embodied pedagogical agent residing in e-learning environment, interacting with learners while chiefly delivering the lessons, can make learning more relevant and meaningful for students with varying aptitude levels.

Social cognitive theory postulates that students are able to develop their intellectual ability when involved in learning activities in which they interact with others rather than working in

isolation. Vygotsky (1978) propose the zone of proximal development (ZPD) which clarify that learners experience the potentially viable connection which bridges the gap between what a student know on his own and what a student may come to know with the assistance of a more knowledgeable adult. Personal endeavors help learners attain a certain level of knowledge, however pedagogical assistance provided by an adult in the learning environment enable them to learn more. Along this line, a pedagogical agent designed with higher intellectual ability assuming the role of tutor has the ability to advance learners in the zone of proximal development. Similarly, the concept of proxy agency as recommended by Bandura (2001) posits that people seek the resources or expertise of others to accomplish what they desire. By interacting with an on screen pedagogical agent designed with relevant competency, either as knowledgeable adult or peer partner with similar attributes, learners are able to attain the desired learning goals. Consistently, Kim (2005a) claimed that pedagogical agents functioning as competent social models can transmit knowledge and skills to learners thus becoming social entities influencing students' learning in computing environments.

In addition, Bandura's (1997) concept of personal agency emphasizes the need for learners to take control of their learning and consequently increase self-efficacy beliefs in the task. In order to engender self-efficacy beliefs and reduce students' anxiety level, Bandura (1997) suggested for strategies such as verbal persuasion, suggestions, appraisal of ability, and assessment of activity. Along this line, pedagogical agents' verbal persuasion and motivational feedback which come in the form of suggestions, feedback, hints, encouragement and appraisal of ability allows learners to develop positive feelings about their ability to accomplish tasks within a particular domain. In addition, emotional support provided by the pedagogical agent through the manifestation of positive affect significantly improves students' perception of the learning environment. Consistently, findings from research have shown that pedagogical agent equipped with encouraging dialogue (Baylor & Kim, 2005) and emotional and motivational support (Baylor, Shen & Warren, 2005) were

able to alleviate students' anxiety that led to a moderate trend for enhancing self-efficacy beliefs and this was specifically relevant to the positive effects of pedagogical agent for low achieving students. Figure 1.3 gives graphical representation of the theoretical framework underpinning the present study.

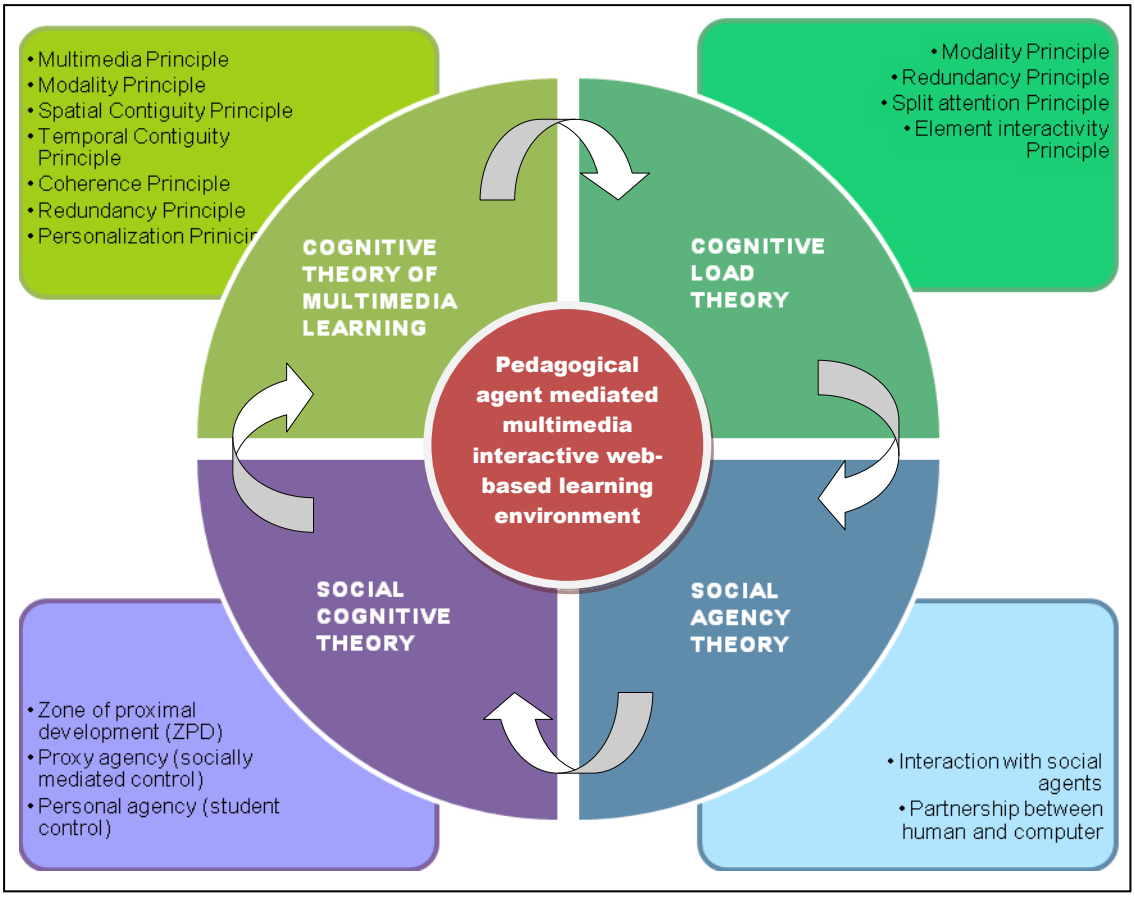

Figure 1.3: Graphical representation of the theoretical framework for the present study

1.9 Research Framework

Based on the theoretical framework, instructional design model, treatment conditions (independent variables), moderator variables and learning outcomes (dependent variables), the research framework is illustrated in Figure 1.4.

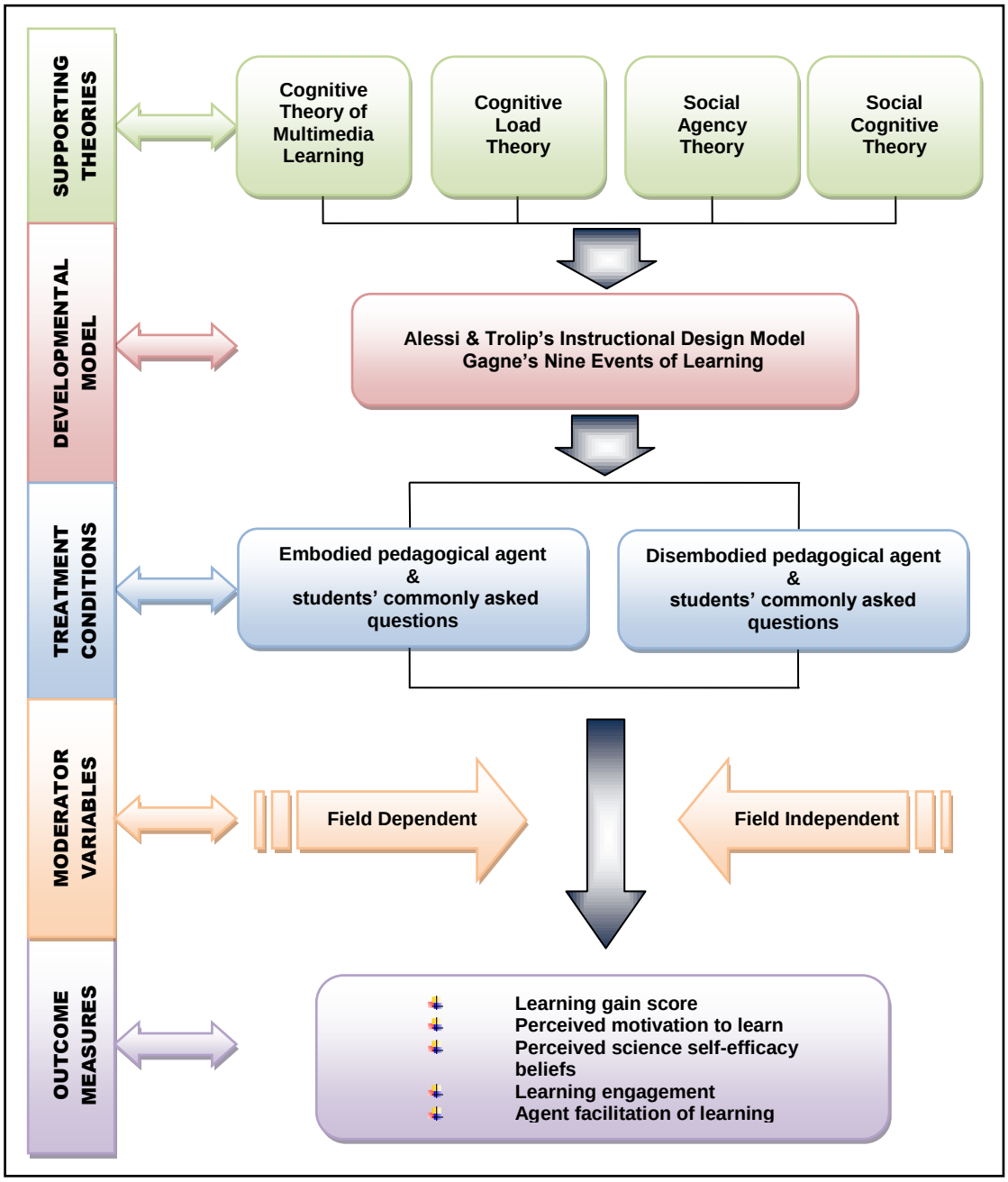

Figure 1.4: Graphical representation of the research framework for the present study

1.10 Significance of the Study

The findings from the present study have important implications for the design of technology supported learning environment. Literature supports that the affective and motivational characteristics of animated pedagogical agents as having a strong positive impact on students' perceptions of their learning experiences. As such, designers of interactive virtual learning environments can consider including embodied pedagogical agent as tutors or

facilitators to provide an engaging learning experience for low achievers who are in demand of emotional and motivational support in learning environments. In addition, learners' cognitive styles significantly impact learning outcomes in e-learning environment and this call for designers to give consideration to this student variable during instructional design process. The significance of the study is discussed in detail as below.

Providing one-to-one tutoring in traditional classroom for weak students is not possible due the huge cost and pedagogical assistant involved. Literature supports the use of virtual talking characters in pedagogical roles as one way of supplementing one-to-one instruction in digital environment. As such, the findings of this study will contribute to the field of pedagogical agent by addressing issues surrounding the impact of virtual teacher on low achieving students; (a) Does the embodied agent's motivational dialogue provides emotional support for the low achievers? (b) Does the agent-student interaction keep low achievers engaged to the environment? and (c) Does the physical presence and social intelligence manifested by the embodied pedagogical agent make low achievers exert more mental effort in processing learning material? Also, low achievers' inhibited classroom participation, especially limitation in posing questions can be overcome by sophisticated assistive devices. As such, the findings of this study will help to provide guidelines on how to structure the field of one-to-one instruction from the standpoint of inquiry learning (posing questions and receiving feedback or answers) in a pedagogical agent mediated e-learning environment.

Research on the impact of learner variables, specifically cognitive styles in e-learning environment for primary level students is still scarce in Malaysia. Therefore, this study was not only designed to explore the benefits of embodied pedagogical agents on lower academic ability students but also to examine how their different cognitive styles, specifically field dependence/independence interact in a embodied agent mediated web-based learning environment. Hence, the findings from this study will provide grounding for a fruitful

direction for pedagogical characters in relation to students' cognitive styles in e-learning environment.

The use of web-based learning environment to assist low achievers in their learning can help to eliminate the digital divide between low and high achievers. At present, Smart School learning system proposes the use of more traditional learning resources for low achievers, while high achievers get to use an array of sophisticated resources including computer and internet. Under these circumstances, low achievers rarely become involved in tasks that allow them to delve deeply into a topic or examine a problem via computer. Generally, low achieving students are allowed to use computers for simple tasks, such as repetitive drills. Therefore, moving away from the regular drill and practice tutorial programs for underachievers to interactive exploratory learning with embodied pedagogical agents will give these students an opportunity to become familiar with sophisticated technology as well as prepare them to fully exploit the potential of information and communication technology. As such, exposure to sophisticated technologies as early as in primary schools will bolster their interest and confidence in science and technology and thus will help train them to function effectively in technology rich world.

1.11 Limitations of the Study

An obvious limitation in the present study would be the interaction time of the actual study. The intervention in this study was limited to one week which consisted of five periods of interaction. Also the target population of this study was Year Five low achieving students. The sample selected was drawn from two non-vernacular urban schools. External generalization for low achieving students in vernacular schools and from other localities (rural or suburban) is therefore limited to this population.

Secondly, teachers are typically not tech savvy. They may not show interest in creating the pedagogical agent mediated learning environment which is obviously time consuming and