Malaysian Journal of Educational Technology
Volume 10, Number 2, December 2010

Embodied Agent's Social Presence in Web-based Learning Environment: Effects on Field Dependent/Independent Low Achievers' Self-Efficacy Beliefs and Learning Engagement

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Abstract

Embodied pedagogical agent serving as conversational partners in e-learning environments has become one of the most advanced innovations in educational technology. Commonly deployed in implementing tutoring strategies, these agents through their social behaviours and motivational dialogue, are able promote the construction of knowledge profoundly. This study was designed to explore whether embodied pedagogical agent (EPA) with students' commonly asked questions (SCAQ) as pedagogical approach has influence on lower academic ability students' self-efficacy beliefs and learning engagement and whether students' cognitive styles interacted with the treatment conditions in the outcome measures. The participants consisting of 156 year five lower academic ability students who fit in the continuum of field dependent/independent learners learned the topic "Energy" in year five science over a period of one week either through the experimental condition of Embodied Pedagogical Agent with Students' Commonly Asked Question (EPA with SCAQ) or comparison condition of Voice Over with Students' Commonly Asked Questions (VO with SCAQ). The findings showed that students in the embodied agent condition performed significantly better than their counterparts in voice over condition in all measures of outcomes. Significant interaction effects were found between embodied agent condition and field dependent learners in the outcome measures. Overall this study extended knowledge to designers of pedagogical agent technology in building a user interface that allows learning with an understanding of human-computer interaction principles and students' cognitive styles.

Govindasamy, M.K., Muniandy, B. & Jamaluddin, R. (2010). Embodied Agent's Social Presence in Web-based Learning Environment: Effects on Field Dependent/Independent Low Achievers' Self-Efficacy Beliefs and Learning Engagement. *Malaysian Journal of Educational Technology, 10*(2), pp. 55-71.

Introduction

Instructional merits of computer technology documented by literature is overwhelming, however the focus has been centred upon the cognitive outcomes. Affect which concerns the social aspects of learning also must be tapped. Computer technology can make learning more personal, engaging and accessible however there is a need to question whether textual materials transferred to an electronic environment improve learning for all students. Students walk into the classroom with varied cognitive and affective profile and therefore technology supported learning environments that accommodate to students' specific needs are high in demand. Specifically, lower ability students may demonstrate higher need for emotional and psychological support. Their ineffectuality in educational settings often results in inhibition of classroom participation, especially from the standpoint of posing questions in pursuit of knowledge. They need a non-threatening and non-intimidating technology supported learning environment to pose questions and receive answers. Also, students' cognitive styles which determines success in e-learning environment, has to be tracked in order to yield better learning outcomes.

Review of Relevant Literature

Animated human-like virtual characters with pedagogical ability, known either as animated or embodied pedagogical agents can act as cognitive and communicative tools guiding students in experiencing the learning materials better (Moreno et al, 2001; Craig, et al, 2002). Pedagogical agents visually represented on the screen, manifesting non verbal social behaviours (eye movement, gestures, head nods and facial expression) and emotion as well as interacting in natural dialogue style conversation renders personas in e-learning environment. This persona effect as postulated by Lester et al (1997) gives emphasis to affect in instruction. The sense of companionship fostered through the affective variables leads to emotional connection between learners and virtual teachers. Agent related studies documented that intriguing life-like pedagogical agents with conversational style utterances providing information, explanation, feedback

as well as asking questions and drawing attention to certain parts of the virtual learning environment can improve students' learning, engagement and motivation (Johnson et al, 2000; Mishra & Hershey, 2004).

According to Valetsianos (2007), life-like pedagogical agents' significant motivational benefits and social affordances are able to elicit psychological responses from learners that other traditional tutoring programs cannot afford. In substantiation, Maldonado et al (2005) stated that interaction between the learner and human-like virtual characters can be conceptualized as one-to-one tutoring or coaching intervention. Echoing on pedagogical agent's tutor role, Lester et al (1997) asserted that pedagogical agents are able to create one-to-one instructional environment engagement that can increases enjoyment of learning, increase self- regulation and efficacy and motivate students to continue to learn about a topic of a subject. Hence, pedagogical agent adopting the role of a tutor has been described as the most effective role to connect with the users (Prendinger et al, 2005; Baylor & Kim, 2004) and therefore the positioning of a fully embodied pedagogical agent within e-learning environment has become one of the promising ways to supplement one-to-one tutoring for students with special needs, in particular less-efficacious low achieving students.

Low achievers, being the target population of this study, are generally confined to their inability to perform adequately on achievement measures (Brophy, 1996). 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 these students' lower academic performance. Generally, low achievers attribute their failure to external factors such as tasks being too hard, not getting enough help as well as being neglected by teachers due to their discrepancies (Vanauker-Ergle, 2003). Literature described low achievers as having lower self-concept, lower self-motivation and self-regulation, less goal directed behaviours and negative attitudes toward school and teachers (McCoach & Siegle, 2001), 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). In sum, when students are tracked as low achievers, they perform poorly in large part due to the lack of challenging learning experiences and motivational and emotional support. This demands for the provisions of motivational and emotional support ubiquitous in human teachers in a non-intimidating and non-threatening technology supported learning environment.

Questioning is an important facet of learning process. 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). Unfortunately, due to curricular pressures and tightly constrained class time, natural process of inquiry in large format classes is not much practiced. Classroom questioning is dominated by teachers with both questions and answers are provided by teachers and students often listen passively and repeat the given answers. This problem becomes more apparent in the case of low achievers. Brophy (1996), found that low achievers are more concerned about avoiding mistakes and embarrassment than about learning and this led to their inhibited classroom participation. Low achievers must be accorded active learning which gives them the opportunity to ask questions and generate their own form of information. However, 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). While high achievers rely less on teachers' help in generating questions, low achievers' dependency increases as they are unable to scaffold their own learning. Consistently, Lee (2004) suggested for teachers to guide and lead low achievers to pose questions pertaining to the intended learning material.

Howell (2003) presented that technology has provided interface for learners to ask questions and receive answers and thus have created a condition which is analogous to a ubiquitous private tutor being available for each student. Interface for asking questions in e-learning environment falls in the continuum of unguided/open to guided inquiry; however learner variable has to be considered when designing question asking interface that accommodates students' specific and unique needs. One important question raised pertinent to open inquiry 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 Howell (2003), low achievers inability to justify their learning objectives will result in them being lost or just drift through in open inquiry. Hence, low achievers need to be guided to form their own inquiry which is structured within the requirement of the curriculum. Howell further contended that FAQ list as one of the most appropriate interface 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. Therefore, the use of predetermined questions generated by students through the process of guided inquiry and by having pedagogical agent answer these questions was deemed more appropriate for low achievers and this approach was applied in this study.

Learners regardless of their aptitude levels and skills are subject to individual differences when coming into contact with learning situation. Their individuality is articulated in factors such as learning styles, prior knowledge and most importantly from the cognitive perspective, cognitive styles. Cognitive style refers to a stable pattern of how individuals perceive, interact, absorb, retain, organize and process information that will allow them to learn best (Riding & Rayner, 1998). Though there are many classifications of cognitive style, the most prominent dimension is the field dependence /independence continuum according to individuals' way of disembedding figures from distracting surroundings (Witkin & Goodenough, 1981). Literature present that field independent learners possess strong organizational skills that enable them to reorganize and reproduce information, recognize salient cues and restructure information as well as are non reliant on surroundings (Daniels, 1996). Conversely, field dependents are reliant on surrounding, prefer social interaction in learning situations and prefers highly structured and organized learning environment (Daniels, 1996). Specifically, in computer mediated learning, field dependence/ independence has been identified as having the most significant impact on ways learners organize and navigate information, prioritize content and develop meta-cognitive strategies (Oh & Lim, 2005). Consistently, researchers uphold that satisfying learners' cognitive styles from the perspective of filed dependency was a critical success factor for e-learning instruction (Hall, 2000; De Raad, 1996; Vermunt, 1998). Though considerable research have explored the impact of students' field dependency and academic achievement, yet studies on affective variables especially through pedagogical agent and cognitive styles among low achieving students in computer mediated environment still scarce.

This research conducted at macro level on the instructional benefits of pedagogical agent was intended to study the impact of embodied pedagogical agent as against to voice only condition in the learning of science among lower academic ability students who fall into the continuum of field dependence/independence. The following section discusses theories underpinning the present study.

Theoretical Framework for the proposed study

This study is grounded by theories under the social cognitive dimension. 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). According to Reeves and Nass (1996) people apply real life human social interaction rules to computer characters. Therefore, when interacting with an animated agent, learners expand more effort as if they are trying to understand a person who is having conversation with them. Thus the person-perception heuristics applied to animated pedagogical agent makes learning more relevant and meaningful. Consistently, the personalization principle of multimedia learning as postulated by Clark and Mayer (2003) proposes that the delivery of spoken text via conversational style dialogue by an onscreen coach or pedagogical agent yields better learning outcome because students perceive the interaction as real life teacher-student conversation.

Other theories under the social-cognitive dimension that lends support to this study are the social cognitive theory and social learning theory by Bandura (1997) and Vygotsky et al (1978) respectively. Vygotsky's (1978) Zone of Proximal Development (ZPD) postulates a 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. 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. 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 and help learners 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.

The construct of self-efficacy beliefs, a central component of social cognitive theory also lend support to this study. Self-efficacy belief as postulated by Bandura (1997) refers to an individual's belief about one's

capability to perform well in a given situation. Earlier, Bandura (1986) stated that self-efficacy beliefs are influenced by four major experiences, namely; enactive mastery experience, vicarious experience, social or verbal persuasion and physiological or emotional state. Of the four sources of influence for self-efficacy beliefs, social or verbal persuasion and physiological or emotional experiences lend support to the present study. According to Bandura (1986), student's physiological or emotional responses call for emotional support and motivational feedback from the learning environment. Bandura (1997) further suggested for strategies such as verbal persuasion, suggestions, appraisal of ability and assessment of activity as means to engender self-efficacy beliefs and reduce students' anxiety level. Specifically, when less self-efficacious student's physiological and emotional responses in the learning environment are addressed via another entity endowed with social intelligence, their self-efficacy beliefs are likely to be raised. Along this line, pedagogical agents' verbal persuasion and motivational feedback as well as emotional support 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. Consistently, research found that pedagogical agent equipped with encouraging dialogue, providing emotional and motivational support was able to alleviate students' anxiety and increase their self-efficacy beliefs (Baylor, Shen & Warren, 2004; Baylor & Kim, 2005). Furthermore, the concept of personal agency suggests that the exercise of control over one's learning environment raises academic self-efficacy beliefs (Bandura, 1997). Therefore, instructional design from the perspective of navigational control, choice of lesson or activities and pedagogical agents' interaction limited to being only responsive to students call will place the locus of control on students' hands thus increasing their self-efficacy beliefs.

Methodology

Research Design and Research Questions

The purpose of this study was two folded, i.e., (i) design and develop a web-based learning environment that incorporates embodied pedagogical agent or voice over as pedagogical tool and students commonly asked questions as pedagogical approach, namely (EPA with SCAQ and VO with SCAQ) and (ii) to examine the effect of the embodied pedagogical agent with students' commonly asked questions on science self-efficacy beliefs and learning engagement among low achieving field dependent and field independent students. A 2x2 factorial design study (as shown in Table 1) was employed in this study.

Table 1 Factorial design of the study

Independent Variable	Moderator Variable: Cognitive Style		Dependent Variable		
EPA with SCAQ	Field dependent	Field independent	O_1 O_3	X_1 X_1	O_2 O_4
VO with SCAQ	Field dependent	Field independent	O_1 O_3	X_2 X_2	O_2 O_4

O_1 pre-test
O_2 post test
O_3 SE before intervention
O_4 SE after intervention

Based on the design above, the following two research questions were posed:

1. Is there a significant difference in perceived science self efficacy beliefs and learning engagement between students in the EPA with SCAQ condition as compared to VO with SCAQ condition?
2. Is there a significant difference in perceived science self efficacy beliefs and learning engagement between field dependent and field independent students in the EPA with SCAQ condition as compared to VO with SCAQ condition?

Sample

The sample consisted of 156 year five low academic ability students from two urban primary schools. Students from two intact classes from each school participated in the study in which the intervention was carried out during the regular science lesson over a period of one week. A total of 77 students from School A interacted in the EPA with SCAQ condition whereas 79 students from school B interacted in the VO with SCAQ condition. Topic "Energy" in year five science with lessons on use of energy, forms of energy, transformation of energy and renewable and non-renewable energy were set as the instructional content.

Instrumentation

Students' field dependence/independence was determined using Group Embedded Figures Test (GEFT) developed by Witkin, et al (1977). The GEFT score is based on students' ability to locate 18 simple figures embedded in complex figures. Criterion established by Case and Scardamalia (as cited by Behzad & Ahmad, 2006), was used to classify the students as field dependent or independent. Student with a score less than 1/4 standard deviation (SD) below the mean are considered field-dependent (FD<mean -1/4 SD), and those with scores more than 1/4 standard deviation above the mean are classified as field independent (FI>mean +1/4 SD).

Students' science self efficacy beliefs were measured using eight self-efficacy items adopted from Motivational Strategies for Learning Questionnaire (MSLQ) by Pintrich, et al. (1991). The item's stem were rephrased to suit the current study. The instrument had a response format designed in Likert Scale using a five interval scale of "Strongly Agree "(5), "Agree" (4), "Not Sure" (3), "Disagree"(2) and "Strongly Disagree" (1) with each statement. A test-retest reliability study on the instrument showed a value of 0.89 and therefore deemed appropriate for use.

Students' learning engagement was measured via a Likert-type learning engagement scale, developed by the researcher. The construct in the scale consists of behavioural (what a student does during task involvement) and emotional (what a student feels during task involvement) constructs. There were 10 items for emotional construct and 8 items for behavioural construct. Students' responses were recorded using a five interval scale of "Strongly Agree" (5), "Agree" (4), "Not Sure" (3), "Disagree"(2) and "Strongly Disagree" (1) with each statement. The content of this instrument was validated by a panel of experts who are knowledgeable in the domain of educational psychology. Internal consistency of the instrument was computed using Cronbach's Alpha. The reported internal consistency coefficient for each of the construct and total questionnaires were 0.92 (emotional), 0.87 (behavioural) and 0.89 (total) respectively. A test-retest reliability study with an interval of two weeks showed a value of 0.94 for coefficient of stability.

The design of the research framework for this study is illustrated in Figure 1.

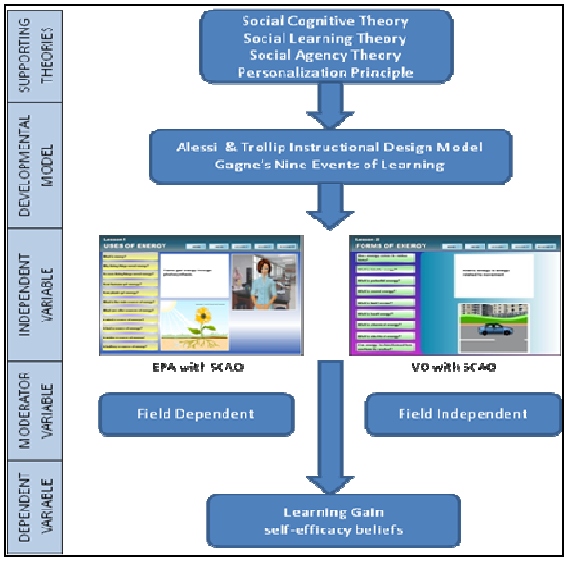

Figure 1 Graphical representation of research framework for the study

The Design and Development of the Web-based Environment

The web-based environment was designed according to guidelines provided by Alessi and Trollip's (2001) instructional design model while the instructional content adhered to Gagne's nine events of learning (1985). The instructional material comprised of verbal address by virtual instructor/voice over, narrated audio clips, sound effects, texts, and visual images. In addition to the delivery of the content, the learning

environment also included immediate retention learning activities for each lesson as well as an overall assessment on the content.

The list of "*students' commonly asked questions*" was gathered from students with similar profile as the subject of the study from another urban school in the same district (pilot study school) that befitted the schools selected for the actual study. With the help of the science teachers from the respective schools (pilot and actual study school), the gathered questions were rephrased and restructured before being embedded in the web environment. The designed web environment was evaluated by the science teachers using multimedia evaluation form and their recommendation and suggestions were affected in order to increase the robustness of the web environment.

All text materials, visuals and animated graphics were produced using Flash. Agent files were created using Codebaby Production Studio 2.6. Agent behaviours were created using behaviour assets provided by the Codebaby Production Studio 2.6 and recorded voices were integrated for lip synchronization. Agent files which were rendered as .avi files were compressed to .swf files for web casting. The screen layout for EPA with SCAQ and VO with SCAQ are shown in Figures 2 and 3 respectively.

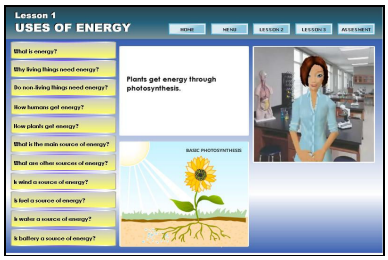

Figure 2 Interface for EPA with SCAQ

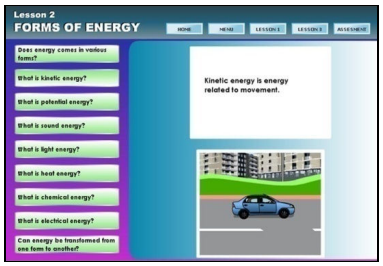

Figure 3 Interface for VO with SCAQ

Characteristics of Pedagogical Agent Designed for the Study

Desirable characteristics of a pedagogical agent, documented from empirical findings guided the creation of the virtual character employed as embodied pedagogical agent in this study. Literature supports for a life-like character in virtual environment to facilitate learning. As such, a person-like female instructor who adopted a tutor metaphor was designed to deliver the content and convey additional messages in this environment. The pedagogical agent was modelled with animated behaviours such as facial expression and deictic gestures. The agent employed gaze and gesture, head nods, body language as well as emotional expressions to draw student's attention to the learning environment. The agent spoke in conversational style using a recorded human voice with nuances and intonation variations. The verbal scripts prepared for the agent narration was done in accordance to affective and politeness theory. The agent utilized a variety of discourse functions such as, explain, ask question, clarify, critique, give feedback and show appreciation. As low achievers are in demand for detailed instructional messages (Kalyuga et al , 2003), the agent delivered the lesson in detail coupled with examples. During the assessment section, the agent provided clear and immediate motivational and encouraging feedback. However the feedback and responses provided by the agent were neither dynamic nor adaptive but rather pre-scripted. This was because the researcher intended to provide similar learning experiences in which the feedback and responses received from the agent were identical for all students. Baylor and Kim (2005) found from their study that controlling the agent-learner dialogue with pre-scripted dialogues out weighed the possible loss of ecological validity (not using truly conversational agents) and therefore the agent employed in this study was pre-scripted. The agent was designed to be responsive, that is played the role of supportive assistant responding to learners call but otherwise remain silent and unobtrusive. Hence by exercising the concept of "personal agency", the learner was afforded control on their learning. Research also suggests that low achievers who lacked meta-cognitive awareness need information to be provided proactively by an agent (Kim & Baylor, 2006b). Hence when the students are not responsive, i.e., fail to interact with the environment (click any button) for more than ten seconds, the agent prompted the students to react in order to proceed with the lesson and thus were proactive in it's role.

Intervention

The study, implemented with the assistance of the science teachers from the participating schools, took place during the regular session of science classes in the computer lab of each participating schools. Participants were seated at an individual computer workstation and provided with headphones to avoid distractions from one another. Teachers gave the students a brief introduction to the learning task and guided them on how to use the interfaces. Following this, the students log on to the specified instructional condition and were left to interact with the unit. The whole instruction consisting of three lessons were carried out through five sessions of 30 minutes each. The participants were required to complete all three lessons within a time frame of 150 minutes, with no time limit set for each lesson. Once students completed all three units, i.e. after the fifth session, they were instructed to attempt the multiple-choice assessment as practice exercise. All instruments used were administered to students by the science teachers. One week prior to the intervention, students were administered with the GEFT and the self-efficacy scale. One week after the intervention, the students responded to self efficacy and learning engagement scale.

Results

Classification of students as field dependent or field independent

Based on the calculated mean score from GEFT and using criterion established by Case and Scardamalia, the students were classified as field dependent or field independent. The number of students in each category of treatment condition and cognitive styles is represented in Table 2.

Table 2 Number of FD and FI students in each treatment condition

Moderator Variable	EPA with SCAQ (N=77)	VO with SCAQ (N=79)
Field Dependent	41 (53.25%)	40 (50.63%)
Field Independent	36 (46.75%)	39 (49.37%)

*N denotes number of students * student percentage in parentheses

EPA with SCAQ condition comprised of 41 (53.25%) field-dependent students and 36 (46.75%) field independent students. For the VO with SCAQ condition, 40 (50.63%) students were identified as field dependent and 39 (49.37%) students as field independent.

Comparison between EPA with SCAQ and VO with SCAQ in the measures of learning engagement

Students' learning engagement was measured via researcher developed learning engagement scale. Table 3 presents descriptive statistics for learning engagement across groups.

Table 3 Descriptive statistics for learning engagement across groups

Mode of Instruction	Cognitive Styles	N	Mean	Std. Deviation	Std. Error Mean
EPA with SCAQ	Field Dependent	41	4.275	.152	.024
	Field Independent	36	4.287	.162	.027
	Total	77	4.281	.156	.018
DPA with SCAQ	Field Dependent	40	4.140	.143	.023
	Field Independent	39	4.238	.161	.026
	Total	79	4.189	.159	.018

*N denotes number of students

Levene's test was run to ascertain the groups' homogeneity with regard to learning engagement. The result showed support for the homogeneity of variance assumption F (3, 152) = .155, p = .927, thus fulfilling the equal variance assumption for ANOVA. Univariate analysis for learning engagement is shown in Table 4.

Table 4 Univariate analysis for learning engagement

Source	df	Mean Square	F	Sig.
Treatment Condition	1	.329	13.819	.000*
(TC)	1	.117	4.905	
Cognitive Style (CS)	1	.071	2.996	.028*
TC x CS	152	.024		.085
Error				

* denotes significance at p < 0.05 level

Results showed significant difference in learning engagement between students in the two treatment conditions, F(1,152) =13.819, p=.000. Students who interacted in EPA with SCAQ treatment condition were significantly more engaged to the lesson (mean= 4.281) compared to their counterparts in DPA with SCAQ treatment condition (mean=4.189). Cohen's effect size estimate for this data was 0.59, which corresponds to a moderate effect. With regard to interaction effects, the data showed no significant interaction between treatment conditions and students' cognitive styles on learning engagement, F(1,152)= 4.163, p =.085. However, as the descriptive statistics showed varying mean value for learning engagement scale, cell means were examined to determine any trends in the data. Results of the pairwise comparisons carried out using separate t-tests are shown in Table 5.

Table 5 Pairwise comparisons for learning engagement

I (Treatment/ Cognitive Style)	J (Treatment / Cognitive Style)	Mean Difference	Std Error	Sig	95% Confidence Level Lower	Upper
EPA with SCAQ/FD	EPA with SCAQ/FI	-.0120	.0358	.739	-.0832	.0593
		.1348	.0328	.000*	.6960	.1998
	DPA with					
EPA with SCAQ/FD	SCAQ/FD	.0491	.0373	.192	-.2520	.1235
	DPA with					
EPA with SCAQ/FI	SCAQ/FI					

* denotes significance at p < 0.05 level

The t-test results showed no significant difference in learning engagement between field dependent and field independent students in EPA with SCAQ treatment condition, p=.732 >.05. Similarly there was no significant difference in learning engagement between filed independents in the two treatment conditions, p=.192>.05. However, the pairwise comparisons result revealed a significant difference between field dependent students in the two treatment conditions, p=.000 < .05. This implies that field dependent students in EPA with SCAQ treatment condition demonstrated higher learning engagement (mean=4.275) than field dependent students in VO with SCAQ treatment condition (mean = 4.140). Cohen's *d* statistics for these data yielded an effect size estimate of 0.91 which corresponds to a large effect and considered practically significant.

Comparison between EPA with SCAQ and VO with SCAQ with regard to perceived science self-efficacy beliefs

Students' perceived science self-efficacy beliefs were measured before and after intervention. Levene's homogeneity test yielded a sig vale of .117 indicating the error variances in the self-efficacy beliefs before treatment across the groups were homogeneous. Table 6 below shows the descriptive statistics for gain in perceived science self-efficacy beliefs (SE after treatment minus SE before treatment) across groups as measured by self-efficacy items from MSLQ.

Table 6 Descriptive statistics for gain in perceived science self-efficacy beliefs across groups

Mode of Instruction	Cognitive Styles	N	Mean	Std Deviation
EPA with SCAQ	Field Dependent	41	1.735	.079
	Field	36	1.723	.079
	Independent	77	1.730	.079
	Total			
VO with SCAQ		40	1.652	.076
	Field Dependent	39	1.690	.070
	Field	79	1.671	.075
	Independent			
	Total			

*N denotes number of students

In order to ascertain whether the groups had similar perception on their science self-efficacy beliefs prior to the treatment, ANOVA was conducted and the analysis yielded a significant value of .769 indicating that the groups appeared to be homogeneous with regard to their perceived science self-efficacy beliefs prior to receiving the treatment and thus any differences in the self-efficacy mean score after intervention would be the result of the treatment received. The results of the univariate analysis for gain in self-efficacy are shown in Table 7.

Table 7 Univarite Analysis for gain in perceived science self-efficacy beliefs

Source	df	Mean Square	F	Sig.
Treatment Condition (TC)	1	.132	22.633	.000*
Cognitive Style (CS)	1	.007	1.227	.270
TC x CS	1	.025	4.299	.040*
Error	152	.006		

*denotes significance at $p < 0.05$

The results indicated significant difference in gained self-efficacy beliefs between students in the two treatment conditions, $F(1,152) = 22.633$, $p = .000$. Students who interacted in the EPA with SCAQ treatment condition perceived their science self-efficacy beliefs significantly higher (mean=1.730) than students who worked in VO with SCAQ treatment condition (mean=1.671). The Cohen's *d* statistics for these data yielded an effect size estimate of 0.76, which corresponds to a moderate effect. The data also revealed a significant interaction effect between treatment conditions and students' cognitive styles on perceived science self-efficacy beliefs, $F (1,152) = 4.299$, $p = .040$. In order to analyze which groups were responsible for the interaction effect, separate t-tests were run to make pair-wise comparison. The results of the analysis are shown in Table 8.

Data presented in Table 8 revealed no significant difference in perceived science self-efficacy beliefs between field dependent and field independent students in EPA with SCAQ treatment condition, $p=.516 > .05$. Similarly there was no significant difference in perceived science self-efficacy beliefs between filed independents in the two treatment conditions, $p=.061>.05$. However, the pairwise comparisons result revealed a significant difference between field dependent students in the two treatment conditions, $p=.000 < .05$.

This implies that field dependent students in EPA with SCAQ treatment condition perceived their science self-efficacy beliefs higher (mean=1.735) compared to field dependent students in VO with SCAQ treatment condition (mean = 1.652). Cohen's *d* statistics for these data yielded an effect size estimate of 1.07, which corresponds to a large effect and considered practically significant.

Table 8 Pairwise comparisons for gain in perceived science self-efficacy beliefs

I (Treatment/ Cognitive Style)	J (Treatment / Cognitive Style)	Mean Difference	Std Error	Sig	95% Confidence Level	
					Lower	**Upper**
EPA with SCAQ/FD	EPA with SCAQ/FI	.0118	.0181	.516	-.0243	.0479
		.0835	.0173	.000*	.0491	.1179
	VO with SCAQ/FD	.0328	.0172	.061	-.0015	.0672
EPA with SCAQ/FD	VO with SCAQ/FI					
EPA with SCAQ/FI						

* denotes significance at p < 0.05 level

Discussion

On students' classification as field dependents/independents

Based on the score obtained from GEFT, the sample selected for the purpose of this study, consisting of low achieving students as defined by their academic performance, fell into a continuum of different cognitive styles. In total, eighty one students were identified as field dependents and seventy five students as field independents. Literature supports the view of field dependence as an aspect of intelligence (Sternberg & Grigorenko , 1997) and levels of field dependency having the greatest relative importance in distinguishing between high and low achieving students (Downs, 1989). That is to say, low achieving students demonstrate characteristics parallel to field dependency and high achieving students demonstrate characteristics that befitted field independency. However, contrary to this, based on the GEFT instrument, the low achieving students in this study demonstrated varying ability to dissemble a figure from a more complex visual field and as such fell into either the field dependent or field independent cognitive style sub groups. Consistently, Badrunisha and colleagues' (2009) claim that cognitive style has less to do with how intelligent or competent the students are and therefore it is a tendency trait displayed by all students in response to learning environment. In sum, students of all groups fall into a continuum of different cognitive styles. This study raises awareness to whether the general characteristics of lower academic ability students are superior to their cognitive styles or the cognitive styles surpassed the general characteristics of lower academic ability students. The discussion on the findings that follows may enlighten us on this issue.

The effect of the treatment conditions on student's perceived science self-efficacy beliefs and learning engagement

The above question addressed by the current study concerned whether the type of treatment condition affected students' performance in the measures of dependent variable. The findings revealed that students in the embodied pedagogical agent condition outperformed students in voice over condition in measures of perceived science self-efficacy beliefs and learning engagement. The current study moderately supported what is asserted in literature namely, the visual representation of the virtual character positively affecting students' cognitive and psychological outcomes.

With regard to increased self-efficacy beliefs, the findings were consistent with other researches that supported the instructional value of animated agent presence to increase self-efficacy beliefs among students (Kim, et al, 2007; Baylor & Kim, 2005). Several explanations can be put forth for the higher perception on science self-efficacy beliefs among students in the embodied agent environment. Consistent with Bandura's (1997) assertion that emotional support and motivational feedback in the form of verbal

persuasion can help to remove the impact of negative mood, reduce anxiety and thus positively affect low ability students' self-efficacy beliefs, the embodied pedagogical agent manifesting affect and emotive behaviours was able to eliminate some of the low achieving students' emotional inadequacy and help to increase their belief in their capability to achieve the desired learning outcome. The agent were polite when giving verbal elaborations on the learning content, provided encouraging and motivating responses when students did not perform well in the learning activity, persuaded them to approach the lesson and the activities confidently and expressed affective behaviours as and when necessary thus creating a more user-friendly as well as non-intimidating learning environment. This not only lowered students' anxiety level but created an energizing feeling and positive mood for better learning thus boosting their beliefs in self-efficacy. Consistently, a recent study by Woolf et al., (2010) also reported the correlation between affective agent and students improved affective outcomes. Their study found that low-achieving students reported reduced frustration and anxiety after interacting with affective pedagogical agents.

With regard to learning engagement, the findings from this study lend support to earlier findings on the correlation between pedagogical agent's presence and increased learning engagement (Atkinson, 2002; Moundridou & Virvou, 2002; Johnson et al, 2000). The presence of embodied agent led to the undivided attention to the learning environment and sense of ease with the learning environment. Students reported that the lesson was less difficult, felt relaxed, less anxious and comfortable when interacting with the embodied agent.
Consistently, research presents that pedagogical agent's can reduce the learner's perception of the difficulty level of the learned material (Andre et al., 1998). Also, Johnson et al (2000) reported that student-agent interaction results in students perceiving their learning more positively and consequently opt to spend more time in the learning environment. The embodied agent's motivational and affective feedback helped students to develop positive attitudes towards the lesson and perceive the environment as more engaging and entertaining. This was in line with earlier findings by Eck (2006) who reported that agent's advisement and feedback have the ability to increase students' learning engagement.

Though the comparison condition also provided identical discourse elaborations via voice over, yet the lack of social intelligence in presentation especially the non-verbal communicative behaviours makes this condition less credible and social. Consistently, research presents that the visual presence of the agent enhances the learners' perception that 'someone' is socially present and collaborating in the same place (Heeter as cited by Baylor, 2009). Hence, the agent's visual presence and emotive behaviours expressed provided extra attention and emotional support thus helped to fill important psychological needs for low academic ability students.

The interaction effect between treatment conditions and students' cognitive styles on perceived science self-efficacy beliefs and learning engagement
With regard to interaction effect between treatment conditions and students' cognitive styles, the findings indicated that field dependent students in embodied agent condition perceived their science self-efficacy beliefs higher and were more engaged to the lesson compared to field dependent students in voice over condition. This showed that the learning support provided by the embodied agent significantly affected field dependent students' performance in learning settings. Consistently, research indicated that field dependents require direction and support from an authority figure in web-based environments (Yalcinalp & Askar, 2006) and when there is provision for this, field dependents are more likely to perform better.

Literature supports that field dependent students pay more attention to social cues and they favour situations that bring them in contact with others, specifically in learning context they prefer teaching methods that encourages student-teacher interaction (Yalcinalp & Askar, 2006). Similarly, low achieving students believe that they are unable to achieve the desired learning outcomes independently and seek the resources and help of more knowledgeable adult to guide them. In sum, low achieving field dependents are students who are less likely to favour self-regulatory in learning situations and are reliant on social dependency. Research claims that, students are who prone to social dependency and not willing to make independent efforts, are happier in learning situation with strong teacher regulated instruction because they feel more secure and fully utilize the external support and guidance (Salonen et al., 1998). In line with this , Witkin et al (1977) stated that field dependent students perform most efficiently when there is structured reinforcement from the teacher. Similarly Bandura (1997) claimed that learners seek the

expertise of a knowledgeable someone to assist them in learning and when this happens, they belief they are capable of performing up to the mark. Therefore, the embodied agent adopting the role of a tutor, interacting with the students, providing verbal elaborations on the content and guiding them through the task created a learning environment that was most favoured by the field dependents. Consistent with social agency theory and the construct of self-efficacy beliefs, students exerted more effort to understand the material and experienced a reduced anxiety level. This led to the demonstration of better learning engagement and higher self-efficacy beliefs. On the other hand, field dependent learners' needs to socialize and interact with people would be a shortcoming in the voice over condition where the presence of social entity was void. This may make them feel that there is not enough interaction or feedback from the learning environment. Though the instructional elaborations, feedback, and responses in both treatment conditions were identical, yet the absence of an authoritative figure in the voice over condition makes field dependents' preference for social orientation and support neglected.

Another possibility for the better performance of field dependents in embodied agent environment in aforementioned outcome measures could be related to the field dependents tendency to attend to the most vivid or dominant cues in the information field (Daniels, 1996). The field dependents may have regarded the visually present embodied pedagogical agent, manifesting social cues, drawing attention to important facts through hand gestures as the most salient cue. Consistently, research presents that field dependents rely more on visual cues and visually active instruction primarily assists field dependent learners (Fitzgerald and Semrau, 1998). Hence, the visually dominant social cues from the embodied agent helped to guide and draw the students' attention to the lesson and led them to concentrate more on what is being said by the agent. These increased their learning engagement and they believed in their ability to successfully achieve the designated learning outcome. On the other hand, just listening to the discourse elaborations transmitted through voice created less attraction to the field dependents as they may have regarded this as non salient cue and concentrated more on other visual modalities (text and animated graphics) that were present on the screen. As the embodied agent condition was more likely to meet field dependents' learning preferences, obviously it led them to be more engaged to the lesson and perceive their self-efficacy higher compared to their field dependent counterparts in voice over condition.

With regard to field independents and treatment conditions, the findings indicated that field independent students from both conditions achieved equally in all measures of outcome. Few possible explanations can be put forth for the insignificant correlation between field independents and treatment conditions with regard to the outcome measures. Firstly, though low achieving academically yet the field independent students in this study showed some degree of independency of the surrounding field when retrieving information from the lesson. This could be detected by their ability to dissembed a figure from a more complex visual field as tested by the GEFT instrument. Consistently, research presents that field independents are not easily influenced by visual cues (Witkin & Goodenough, 1981). In addition, research indicated correlation between field independence and auditory cues, in which field independents could more rapidly locate simple tune within a complex melody (White as cited by Altun & Cakan, 2006). Hence the verbal elaborations in voice only condition did not impede their learning as they were able to capture and extract important facts from the voice. This led to the students learning engagement not affected by the nature of the treatment received.

Secondly, though linear in design sequence, the web-based learning environment provided learner control, another learner variable that affected learning, allowing students to roam through the lessons, activities and assessment according to their needs and interest thus personalizing the learning. This was consistent with Bandura's personal agency concept which claims that when students are able to control their learning, their self-efficacy increases. Similarly, research claims that field independents prefer autonomy in learning environment (Altun & Cakan, 2006). Another explanation for the equal performance of field independent students in experimental and control groups could be due to their preference for inquiry based learning. According to Jonassen and Grabowski (1993) one of the characteristics displayed by field independent students are preference for inquiry and discovery learning methods as well as avenue to ask questions. Costa et al (2000) claimed that low achieving students though raise questions in their mind but do not ask aloud in the classroom due to personal variables such as lower self concept, low self esteem and less motivation. However in non-threatening learning environment they do take the opportunity to pose questions in pursuit of knowledge. As both the conditions employed students commonly asked questions as pedagogical approach, the field independent students found the environment challenging and interesting

as they were able to ask questions and discover or find answers on their own. Therefore, both treatment conditions met the requirement of low achieving field independent students and this led to their equal performance in the outcome measures of this study. Generally, these findings reflect Witkin's assertion that field independent learner can work as well under any set of circumstances (Witkin et al, 1977).

The equal performance in the outcome measures of this study between field dependent and field independent students in the embodied agent environment could be a result of the treatment condition itself compensating for the needs of students from both end of cognitive styles continuum. The presence of the pedagogical agent on the screen compensated field dependent students' need for social bond in learning environment. As for the field independents, their non reliance tendency as well as the ability to work under any circumstances could have boosted their learning. Also, the lesson was well structured and highly organized. Witkin et al (1977) confirmed that field dependent and field independent learners may perform equally well when learning materials are highly organized. At the same time, King (1992) presented that low achievers learn better when instruction is structured and more guidance are given. Hence the well organized and structured learning environment met the low achievers' learning preferences in general.

Implications

Discussion on the findings of this study provides important implications for the design of embodied pedagogical agent simulated learning environment for low achieving students with different cognitive styles. The dynamic social behaviours manifested by the embodied agent are traits favoured by weak students in general (Kim & Baylor, 2007). These intriguing features provided an engaging learning experience for them. Though Clark and Choi (2006) reported controversially on the instructional value of animated pedagogical agent, however their study did confirm a significant learning benefit of animated pedagogical agents for learners with lowest level of prior knowledge. Hence, it is not surprising that the students in the embodied agent condition performed significantly better than students in voice over condition in the dependent variables. If designed well with introduction, tasks, resources, guidance and feedback, embodied pedagogical agents in web based learning can provide low achieving students with motivational, engaging and realistic learning experience.

Another implication for instruction that can be drawn from the aforementioned findings is the favourable correlation between field dependents and embodied agent facilitation. The social interaction aspect, a tendency favoured by field dependents, when employed in e-learning environment via a social model is likely to affect field dependents' academic performance. The findings of this study prove a more solid theoretical understanding of the cognitive issues from the standpoint of students' academic ability, cognitive styles and embodied agent simulated learning environment. In traditional learning environment, instruction is tailored or rather adapted to suit students' individual differences such as cognitive styles, learning styles and prior knowledge (Kalyuga et al., 2003). Therefore educational technologist and instructional designers should consider designing pedagogical agent facilitated learning environment that accommodates to students individual differences, especially their cognitive styles.

Limitations

An obvious limitation in this study would be the interaction time of the actual study. The intervention in this study was limited to one week which consists of five periods of interaction. Also the target population of this study was year five low achieving students drawn from two non-vernacular urban schools. External generalizing for low achieving students in vernacular schools and from other localities (rural or suburban) is therefore limited to this population. Hence, replication studies with different sample (different type of schools and other localities) who could interact with and learn from the agents for a longer period of time are needed before an ability to generalize the findings beyond the current population is possible.

Recommendation

The results of this study offer several opportunities for future research. The present study examined the effect of embodied pedagogical agent facilitation on low achieving students with different cognitive styles in a well structured and organized linear web-based multimedia learning environment. The agent primarily delivered instructions and examples to the students thus adopted instructivist modelling theory. Future study on the employment of pedagogical agent in a non-linear hypermedia environment adopting constructivist modelling, providing necessary background information through coaching will further

contribute to our understanding on the relationship between learners' cognitive styles, academic ability and embodied agents' guidance and support in hypermedia environment. In addition, the present study specifically involved only science domain. As field dependent students are known to lack the spatial ability for science learning, the possibility for the students to demonstrate inability to science discipline even before intervention is very likely. Therefore, a more comprehensive study including other domain or disciplines like psychology, or sociology that are favoured by field dependents (Riddle as cited by Yalcinalp & Askar, 2006) will give a more solid evidence on the effect of agent facilitation on their performance in academic settings.

Another avenue for future research is how knowledge is constructed through the use of pedagogical agent in open inquiry environment. Researchers have suggested that pedagogical agents are most helpful when placed in open-ended learning environments that foster comprehension and reflection (Johnson et al, 2000). As field dependents lack ability to perform open inquiry, does the guidance from the agent help them build knowledge in open inquiry model. Future studies can probe into this.

Conclusion

This study extended knowledge to designers of pedagogical agent technology in building a user interface that allows information retrieval with an understanding of human-computer interaction principles and students' cognitive style. The social interaction between pedagogical agents and learners in virtual environment is consistent with real life student-teacher student interaction in one-to-one tutoring thus suggesting new opportunities for lower academic ability students in computer mediated learning. The findings from this study provide evidence that properly designed embodied pedagogical agent simulated learning environment can help meet the challenges of educating these students. Thus providing underachievers with interactive exploratory learning with pedagogical agents will prepare these students to fully exploit the potential of information and communication technology and help train them to function effectively in technology rich world.

Although the employment of animated pedagogical agents serving as proxies in virtual learning environment appears promising however caution has to be exercised when designing pedagogical agent simulated learning environment. Considering the cause-effect factor that controls any technology related intervention, , designers and practitioners of agent environment should seriously consider designing more sophisticated social model who does not merely be an ornamental or irrelevant element to the lesson but rather a supportive entity that help student feel emotionally connected and make sense of the material thus offering greater benefits to learning.

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