

THE IMPACT OF ANIMATED AND STATIC PEDAGOGICAL AGENTS ON STUDENTS' LEARNING ACHIEVEMENT IN AN INTRODUCTORY PSYCHOLOGY COURSE

Erwin Tjew, Siew Pei Hwa*

Faculty of Creative Industries, Universiti Tunku Abdul Rahman

*Email: siewph@utar.edu.my

ABSTRACT

The use of a Pedagogical Agent (PA) to promote multimedia learning comes in various multimedia designs. Many PA designs from prior studies are found to exist without the combination of animation, human recorded voice, interactivity, and narration. In the current study, two interactive multimedia modules (IMMs) were developed, comprising two different types of PAs, namely animated PA (APA) with emotive responses and static PA (SPA) designs. Both IMMs conveyed the fundamental of psychology lessons to students. At the end of the intervention, a set of achievement tests was used to measure students' learning achievement in Introductory Psychology knowledge acquisition. This study is to compare students' learning achievement between APA and SPA groups in Introductory Psychology through a two-group post-test only experimental design. Thirty-two participants were recruited and equally allocated to APA and SPA groups to interact with the two different types of PA designs in the learning modules. The research findings corroborate the hypothesis that learning through the use of APA with animated characters and spoken text/recorded voice features is more effective than SPA with static characters and written text features in acquiring Introductory Psychology knowledge.

Keywords: animation, human recorded voice, learning achievement, multimedia learning, pedagogical agents, psychology

INTRODUCTION

Numerous studies ever since have brought multimedia learning technology to the invention of the Pedagogical Agent (PA), an Intelligence Tutoring System (ITS) in computer science, primarily used to simulate the interaction between learners and computerised characters [1]. PAs are virtual characters developed to assist teaching and learning [2]-[3]. The agents are commonly designed and projected as humanoid computer graphics. The intention is to instil the presence of a familiar educator's figure in providing knowledge. However, PAs are often presented with a lack of human-like attributes, such as adequate appearance, social features, or even artificial emotions, despite current graphical computer technology (e.g., Pi et al. [4]; van derMeij, van derMeij & Harmsen [5]). Additionally, designing a PA with higher human-like

attributes could result in indistinguishable learning responses compared with a PA with lower attributes, known as static PA [6]-[7].

In the past decades, hundreds of studies in PA e.g., Kim & Baylor [8], Romero-Hall [9], and Schroeder [10] were conducted to investigate its impact on teaching and learning, varied in their designs and features, effects and affects, and even learning subjects and outcomes. Although few studies have applied the interactive and two dynamic media design features e.g., Dincer & Doganay [11]; Johnson & Lester [6]; Ryu & Ke [12], a portrayal of all three features as mentioned (i.e., interactive, animation and audio) were scarce in past studies. Furthermore, various findings of learning outcomes from previous PA studies have given rise to the question of whether using PA in multimedia learning truly affects learning; if so, how and why.

Based on the summary of numerous prior studies, this study was hypothesised to fill the gap of the lack of interactive and dynamic multimedia features in prior PA designs by developing PAs that incorporate three essential elements i.e., interactive, animation and audio.

There were two objectives in this study: 1) to design and develop two different Interactive Multimedia Modules (IMMs) where each embedded with different types of PA designs, i.e., animated pedagogical agents (APA) with emotive features and Static Pedagogical Agents (SPA) with non-emotive features in delivering Introductory Psychology lessons; and 2) to conduct a comparative study to investigate the effectiveness of APA and SPA in the teaching and learning of Introductory Psychology on students' learning achievement.

The remainder of this paper is structured in four sections. The second section describes the animated and static pedagogical agents in the Introductory Psychology learning environment. The third section discusses the efficacy of different types of pedagogical agents for Introductory Psychology learning. The last section concludes the paper.

PEDAGOGICAL AGENTS IN THE INTRODUCTORY PSYCHOLOGY LEARNING ENVIRONMENT

The combination of animation, human voice, and interactivity features in PA design

Multimedia technology continuously progressed with varied additional features. As information technology progresses, multimedia design stepped into more interesting features to aid immersive computer learning. Recent advancements in multimedia interfaces, text-to-speech software, and agent-generation technologies have led to the advent of animated pedagogical agents in learning environments.

Animation is a type of pictorial introduction. It has turned into an evident innovation-based learning conditions component [13]. Along the way, the study of multimedia and instructional design moved forward to using animation and narrative content to aid learning [14]. In recent studies, the animation is still an essential aid in the multimedia learning environment. Chiou, Tien and Lee [2] used the combination of animation in

multimedia learning to improve learning achievement, retention, and satisfaction in Taiwan. Liu and Elms [15] noted that students increasingly demand engaging, customised multimedia content in the modern age of education. They utilised a series of animations by combining audio messages with tailored visual cues and graphics to explain complex concepts and engage student interest in the learning process to enhance their understanding. The study of Liu and Elms resulted in numerous novel and valuable insights in related to animations as a powerful pedagogical tool in higher education.

Mayer and Estrella [16] suggested that emotional design in multimedia learning is a beneficial factor. In contrast, Schroeder, Romine and Craig [17] implied that using human voices in PA increases learners-virtual human communication. Romero-Hall [18] acknowledged that human qualities such as movement and human voice reflect emotive behaviour in PA.

This study intended to investigate specific attributes in PAs, focusing on the visual design (appearance) and audio (voice) aspects of the PAs. Mayer and Moreno [19] claimed that visual and audio aids in multimedia learning are applied together to achieve optimal learning effectiveness. In this study, the emotive animated PAs (APA) are simulated by combining both human-like appearance and voice features, while non-emotive static PAs (SPA) are presented without these two features. This study attempted to explore the possible effects caused by applying emotive animated behaviour in PAs and at the same time to find possible differences caused by PAs with non-emotive static behaviour in the teaching and learning processes of an Introductory Psychology course.

Introductory Psychology as Learning Content

Norcross et al. [20] suggested that introducing the introductory and minor psychology programmes shapes the discipline of undergraduate students. Despite only a few prior studies in psychology, they were meant for non-educational purposes [21]-[22]. Provoost et al. [21] conducted a study with an embodied conversational agent to interact with psychiatric patients. Rizzo et al. [22] analysed psychological signals using a virtual human interviewing agent. This study focuses on the use of interactive multimedia and

animated PAs in multimedia learning particularly to introduce fundamental psychology lessons to non-psychology programme undergraduate students. Table 1 depicts the topics discussed by the PAs in both IMMs in the current attempt.

Two Different Types of PA Designs in the Interactive Multimedia Modules for Introductory Psychology Learning: Emotive Animated PAs versus Static PAs

Citing past research work, Wang et al. [23] noted that the recent advancement in computer technology, artificial intelligence, and virtual reality technology allows instructional designers to create vivid onscreen PAs in multimedia learning environments. Wang et al. described a PA as “an image of a character presented on a screen intended to help student learning”. Schroeder, Adesope and Gilbert [24] noted that pedagogical agents could be as simple as static characters which respond through visual stimuli, such as text on the screen, to as complex as life-like three-dimensional characters which can provide visual signalling through gestures and body language, as well as auditory cues through narration. Chen et al. [25] stated that APAs with characteristics such as facial expressions, gestures, human emotions, and an interactive user interface are attractive to students.

Tegos and Demetriadis [7] suggested that students had a higher level of explicitness and comprehensiveness in response to peer-designed conversational agents. Karen (female pedagogical agent in IMMs) and Joe (male pedagogical agent in IMMs) are purposefully designed to match the age and status of targeted

participants of this study, i.e., Year 2 university students. Both PAs in the IMMs represented their typical classmates’ (peers) characteristics. Karen plays the character of a high-achiever student who spends her time mostly studying. In contrast, Joe is depicted as otherwise. However, both Karen and Joe shared the same instructional roles in assisting and leading the learners to understand the Introductory Psychology lessons delivered in IMMs.

Animators and character designers are required to adhere to a close resemblance between human-like movement and the law of physics [26]. APA characters are constantly moving around (fully animated) during the same interaction while delivering the psychology lessons. Animated PAs present certain characteristics and emotions to improve students’ motivation.

Craig and Schroeder [27] asserted that PA-based IMM learning with a recorded human voice might be more effective than learning from a machine-synthesised voice. In the IMMAPA, Karen and Joe were equipped with different recorded human voices to play their own characters and deliver dialogues differently following the users’ responses. Additionally, this allows the audio/speech modality to play a role in interaction with the users. According to Ryu and Ke [12], providing audio enhancement such as the agent’s voice and dialogue increases the animated pedagogical agent’s human-like characteristic.

Two PAs with different features were created in the IMMs to gauge learners’ interaction and make a comparison of their various responses. The IMMs with

Table 1 Introductory Psychology lessons delivered by PAs in both IMMs

1. Definition, and etymology of psychology
2. Branches (types) of psychology
3. Developmental psychology (term and definition)
4. Clinical psychology (term and definition)
5. Mental illness (definition)
6. Abnormal psychology
7. Nature and nurture in psychology
8. Hereditary and psychology
9. Psychologist vs psychiatrist
10. Psycho-analysis – hypnotherapy
11. Introversion and extraversion
12. Ambiversion
13. Anti-social behaviour
14. Darwin’s theory of evolution and hereditary

different types of PAs (i.e., APA and SPA) were designed and developed using Adobe Animate CC as,

1. IMM with Animated Pedagogical Agents (IMMAPA): In the IMMAPA, PAs are presented with body gestures, facial expressions, or even voice activation as an artificial emotive communication function of animated characters. The two agents in the IMMAPA, Karen and Joe, were designed to speak with human voices to convey verbal information. Additionally, the subtitle is provided to assist learners in receiving the lessons more accurately (Figure 1); and

2. IMM with Static Pedagogical Agents (IMMSPA): Agents in the IMMSPA, Karen and Joe, are static and deliver learning content without audio. Both agents in IMMSPA are merely static almost all the time. Learners receive information in text rather than in a conversation between the SPAs. A series of the flow of text adhering to the lessons are provided in the conversational panel (Figure 2).

Table 2 outlines the differences in PAs between the two learning modules, whereas Figure 1 and Figure 2 depict the differences in PA designs in the IMMAPA and IMMSPA.

Table 2 Comparison of embedded features between the APA and SPA designs

Feature	APAs	SPAs
Embodiment	Advanced/high embodiment: The agent's ability to use his/her body (e.g., engage in gaze, movement, gesture, etc.) in full animation.	Minimal/low embodiment: The agent is represented as static graphics, constantly facing users all the time without body movement.
Facial expressions	Constantly changing expressive facial movements, such as raising eyebrows and eyes that open wide during conversations.	Limited facial movements such as eye and eyebrow only during extreme interaction. Non-animated characters.
Body Gesture	High level of animated body movements, such as head and hand movements, body leaning forward and backwards, reading books	Nobody movement animation. Stay static in one default pose.
Medium of Presentation – Audio Feature	Spoken text via recorded audio, in which female voice for Karen and male voice for Joe. Voice-over acting such as various tones and speed following conversation situations.	No recorded audio was embedded in the module. Use written text (i.e. animated text) to present the instructional content. Soothing background music to aid learning.
Medium of Presentation – Textual Feature	Subtitle aid at the bottom screen of each scene to complement the presentation of instruction content in the recorded speaking voice.	Animated texts flow on top of the screen as the main feature in delivering instructional content.



Figure 1 The design of IMMAPA with two animated characters move around accordingly and equipped with recorded human voice, and text flow is also provided as the subtitle at the bottom of the panel



Figure 2 The design of IMMSPA with two static characters showing limited movements of facial expressions and body gestures. Information presented via textual flow on top of the panel

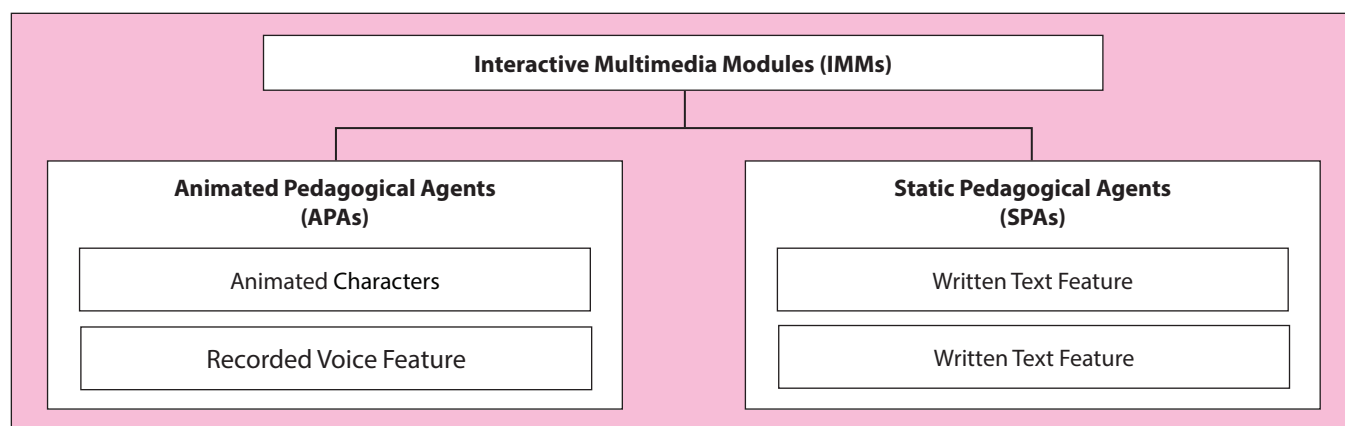


Figure 3 The development of two interactive multimedia modules (IMMs) with different types of pedagogical agents (PAs)

Apart from the differences in PA designs between the two modules, IMMAPA and IMMSPA have several similar features and functions. Both present the Introductory Psychology lessons with the same instructional content, same background setting, same storyline, and same dialogues of PAs (but presented using different media elements, i.e., spoken text via human recorded voice in IMMAPA versus written text in IMMSPA as shown in Figure 3), and same interactive elements from start to the end of the learning engagement.

The development of IMMAPA and IMMSPA must be carried out and finalised before the commencement of this study. Both modules serve as the main research instruments in the study, mainly to transfer the fundamental of psychology knowledge and investigate how the IMMs with different PAs could enhance the learned-information retention in students.

THE EFFICACY OF DIFFERENT TYPES OF PEDAGOGICAL AGENTS FOR INTRODUCTORY PSYCHOLOGY LEARNING

Many studies have proved the benefits of learning with PAs. In this study, the author attempted to examine the value of different types of PAs by comparing the learning achievement of using APA with SPA in an Introductory Psychology classroom.

Research Instruments

The research instruments in this study included: 1) two IMMs with different types of PAs (i.e., IMMAPA and

IMMSPA) for the teaching and learning of Introductory Psychology, as have been discussed in the previous section; and 2) A set of achievement tests for the evaluation of the impact of different types of PAs (i.e., animated versus static) on students' learning achievement in an Introductory Psychology course.

Learning achievement in this study was measured using a set of achievement tests, which were developed and modified from several past Introductory Psychology quizzes designed by experienced psychology lecturers (i.e., lecturers with teaching experience in psychology for more than 5 years). Kinyua and Okunya [28] noted that teacher-made tests are generally valid and reliable. The first section of the test consisted of 10 multiple-choice questions, and the second section consisted of 10 true-or-false questions. These questions were built based on the selected Introductory Psychology topics included in the two IMMs with different types of PAs.

Research Participants

All the research participants were Year 2 undergraduate students from a Malaysian university. A comparative study was conducted to assess the effects of different PAs (i.e., APA and SPA) on students' learning achievement in an Introductory Psychology course. The participants were recruited via purposive sampling from a class in a Communication Programme who had not taken any psychology courses previously and were randomly allocated into two groups, i.e., 16 students participated in the APA group, while the other 16 students in the SPA group.

Scholars commonly suggest that carrying out experimental studies with at least 30 participants in one group is necessary [29]-[31]; otherwise, there will be inadequate power and the assumptions required of specific statistical tests used in the study will not be met. However, Basavarajaiah and Narasimha [32] noted that "The more heterogeneous a population is, the larger the sample size required to obtain a given level of precision. The less variable (more homogeneous) a population is, the smaller the sample size is". This means that if the population that is to be sampled is homogeneous (i.e., the relevant characteristics are evenly distributed), a smaller sample can be relied on if the population is less highly variable. In this study, due to the small sample size, all participants were selected from a single class to keep the homogeneity of variance. All participants from both the APA and SPA groups were selected on a similar trait basis. The requirements of the samples are Year 2 university students who were undertaking a Communication Programme and have never taken an Introductory Psychology course. Since these requirements are easily met, it is possible to show that sample characteristics such as age and learning experience are fairly homogeneous in any sample of students. Hence, a small number of participants are assumed to be adequate.

To this end, participants were assigned into two groups with different types of PAs,

1. APA Group: Participants in the APA group learned Introductory Psychology with the guidance of two emotive animated characters, which are equipped with both animation and recorded audio features, and
2. SPA Group: Participants in the SPA group learned Introductory Psychology with the aid of two static characters where animation and recorded audio features were absent.

Research Procedure

In this study, a two-group post-test only experimental design was conducted to evaluate the impact of IMM with different PAs (i.e., APAs and SPAs) in teaching and learning Introductory Psychology. According to Trochim [33], a pre-test is not required for this design and is used to compare the outcome difference of two groups, the control group and the treatment group, where subjects

are randomly assigned and given a test only after the experiment to eliminate testing effects. The use of the post-test only experimental design has been used in several past studies pertaining to multimedia learning with the pedagogical agent [34]-[36].

As described in the previous section, the APA group received an IMM where the content was delivered by two animated characters, whereas the SPA group received the same learning content but structured in a learning environment guided by two static characters to provide a comparison. Both IMM were specifically developed for this study. This study used post-test only for both APA and SPA groups. No pre-test was given to either APA or SPA group to eliminate the testing effects [37]-[38]. By having no measurements taken before the intervention (pre-test), the outcomes would not be affected by the results of a pre-test. For instance, a participant taking the test the second time may be more prepared for the questions asked [39]. The post-test scores of the APA and SPA groups were then compared to determine the efficacy of different types of PAs on students' learning achievement.

Before the intervention started, 16 computers in the computer lab were installed with APA-based IMM (IMMAPA). The other 16 computers were installed with SPA-based IMM (IMMSPA) without the participants' knowledge. All 32 participants are allowed to take any seats in the lab. Both groups believed that they received the same intervention. At the beginning of the study, a 30-min introductory session on using the IMM was conducted. Then, participants were given a 2-hour session to familiarise themselves with the IMM and learn the selected Introductory Psychology topics covered in the IMM. Once the APA and SPA groups completed working through the selected topics, a post-test was conducted. Both groups were tested using the achievement test to collect data and information to measure their learning achievement in Introductory Psychology learning. The participants took about 20 minutes to complete the test.

Data Analysis and Research Findings

Total scores obtained through the test were calculated by summing up the score for each correct answer to measure participants' achievement in the knowledge acquisition of Introductory Psychology after the

intervention (i.e., learning Introductory Psychology using IMM with different types of PAs). The IMM group with a higher score was assumed to successfully retain the instructional content more effectively in this study. The evaluation of the effects of IMM with two different PAs on students' learning achievement in Introductory Psychology was measured through hypothesis testing. The data were then analysed using SPSS (Statistical Package for Social Science). Independent-samples t-test was used to test the following null hypothesis,

H_0 : There is no significant difference between the learning of Introductory Psychology using IMMSPA and IMMSPA on students' learning achievement.

An independent-samples t-test was used to determine whether there was a statistically significant difference between the means in two unrelated samples [40].

Even though this study involved a small sample size (i.e., $N = 16$ for each group), the parametric test (independent t-test) was used instead of performing a non-parametric test since the sample characteristics such as age and learning experience are fairly homogeneous in any sample of students. According to Usman [40], non-parametric tests are usually less powerful. Moreover, de Winter [41] asserted that some studies had suggested that applying the t-test to small samples is feasible. The independent samples t-test was conducted to determine whether there was a significant difference between the mean scores of students' achievements under two different conditions (i.e., learning Introductory Psychology using IMMSPA and IMMSPA) among respondents. The results are shown in Table 3.

Through the results, as shown in Table 3, the p-value was 0.003 ($p < 0.01$), indicating that the data provides

Table 3 Comparison of APA and SPA groups on post-test

Group	N	M	SD	t-value	p
APA (Learning through the use of IMMSPA)	16	18.06	1.61	3.19	0.003**
SPA (Learning through the use of IMMSPA)	16	916.13	1.82		

** Significant at 0.01 level (2-tailed)

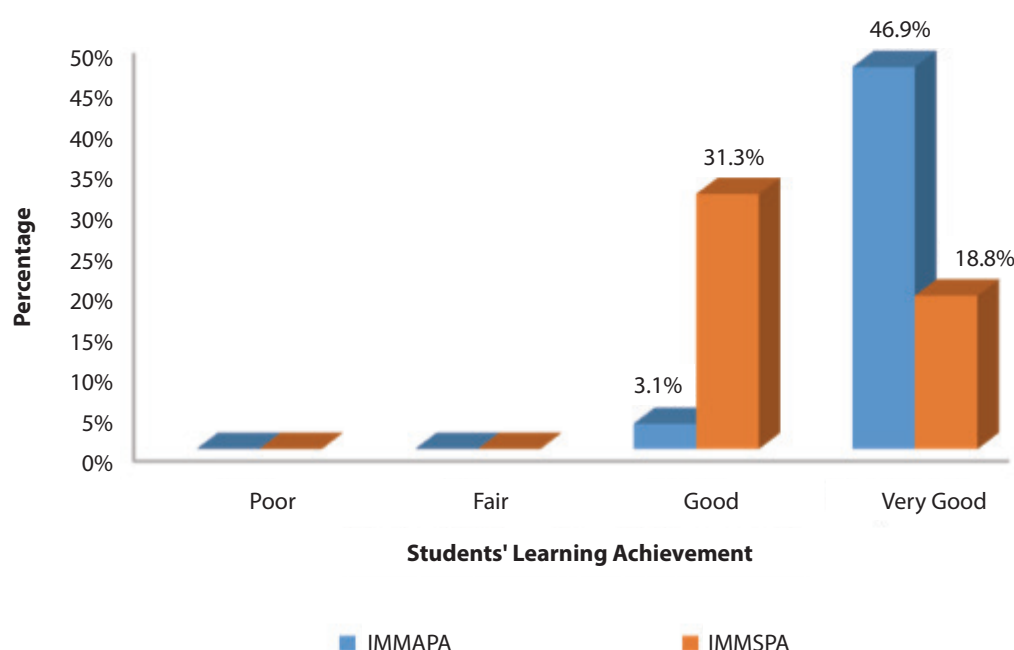


Figure 4 Students' learning achievement on achievement test to measure their knowledge in Introductory Psychology

enough evidence to reject H_0 at a 0.01 significance level ($t=3.19$, $p=0.003$). The results explain a significant difference between the achievements of the APA and SPA groups in the post-test. The results also corroborate the assumption that “there is a significant difference between the learning of Introductory Psychology using IMMAPA and IMMSPA on students’ learning achievement,” with a significant difference in mean scores between the two ($M_{IMMAPA}=18.06$, $SD_{IMMAPA}=1.61$; $M_{IMMSPA}=16.13$, $SD_{IMMSPA}=1.82$) as shown in Table 3.

The results obtained from the testing of H_0 using the independent samples t-test indicated a significant difference in mean scores between the two groups, namely learning of Introductory Psychology using IMMAPA ($M_{IMMAPA}=18.06$, $SD_{IMMAPA}=1.61$) and IMMSPA ($M_{IMMSPA}=16.13$, $SD_{IMMSPA}=1.82$) as shown in Table 3.

The difference between the learning achievements of both the APA and SPA groups in the post-test is clearly shown in Figure 4. Figure 4 reveals that none of the respondents in either group fell into the “Poor” and “Fair” categories, i.e., scored less than 11 points in the total score of the achievement test. The research findings proved that the IMMs with PAs had a positive impact on students’ learning achievement, in which both IMMAPA and IMMSPA groups scored well, i.e., 11 points and above in the total score of the achievement test. Figure 3 also shows that students who learned using IMMAPA performed better than students who learned using IMMSPA, where the percentage of students in the IMMAPA group that contributed to the value “Very Good” (scored 16-20 points in total) in the achievement test was higher (46.9 per cent) than the students in the IMMSPA group (18.8 per cent). However, 31.3 per cent of students in the IMMSPA group’s rating fell in the value “Good” (scored 11-15 points in total), whereas the students in the IMMAPA group were only 3.1 per cent.

The results also imply that different PAs in the IMMs had a significant effect on students’ performance in Introductory Psychology learning. The research findings from the current attempt coincide with the past studies such as Kervellec et al. [42], Li et al. [43], Park [44], Wang et al. [45], and Yung and Paas [36]. These studies share a common finding that animated pedagogical agents in multimedia learning resulted

in more effective learning and positively effected on students’ learning achievement.

CONCLUSION

The aforementioned results suggest that students who learned using IMMAPA, which is equipped with human-like qualities of PAs such as body gestures, facial expression, and the human voice have a positive impact on students’ learning achievement in Introductory Psychology, as compared to students who learned using IMMSPA with PAs equipped with a static visual and written text representation. The research findings indicate that the combination of interactivity, animation, and recorded human voice embedded in APAs aided the simulation of human-like communication in a multimedia learning environment. Stef et al. [46] suggested that emotions are the trigger factor of the expressions for communicating with other beings and indicating the traits. Craig and Schroeder [27] implied that the effect of the human voice was greater when combined with virtual humans. However, this is small-scale research where further studies are needed to generalise the findings of this study. The 20 years of PA technology have been studied and researchers are looking for better learning outcomes by enhancing the designs and functions. However, there is still much to figure out in making PA an actual intelligent learning system [6]. Results in this study could provide insight to future similar studies, but it is only one of many types of research that need to figure out what factors to be considered in potentially enhancing human-like communication in the use of the pedagogical agent in teaching and learning processes.

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