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EFFECTS ON VALENCE, AROUSAL AND EMOTIONS IN LEARNING ACROSS DIFFERENT REALISM DESIGNS OF 2D VIRTUAL AGENTS



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ABSTRACT

This research was aimed to analyse students' emotions caused by the character's realism design in the dimension of valence and arousal and its' mediating effects on emotions in learning. 2D female virtual agents with four different realism appearances namely realistic, semi-realistic, stylized and cartoon-like were designed and developed. Quasi-experimental design was used to answer the research questions derived and the data obtained was analysed using ANOVA, post hoc and bootstrap mediation analysis. The experiment was carried out with 600 Electrical Engineering students from seven polytechnics in Malaysia. Students were divided into four different groups using multistage sampling methods, where each group consisted of 150 students who underwent four different realism designs of the virtual agents respectively. The ANOVA test show that there are significant differences on valence ($F(3, 596) = 15.48$, $p=0.00$, $\eta_p^2= 0.07$), arousal ($F(3, 596) = 15.79$, $p=0.00$, $\eta_p^2= 0.07$) and emotion in learning ($F(3, 596) = 2.89$, $p=0.35$, $\eta_p^2= 0.01$) caused by different realism designs of virtual agents. The results revealed that cartoon-like design scored the lowest mean score for both valence and arousal followed by stylized, realistic and semi-realistic design. It has been found that all the different realism designs of virtual agents fell at high affective state and consequently escaped from the uncanny valley effect. Interestingly, cartoon-like design scored the highest mean score for emotions in learning followed by semi-realistic, realistic and stylized designs. In summary, cartoon-like agent is the best agent among others in inducing positive emotions in learning. In addition, the mediation analysis showed that only arousal has mediating effects on the relation between different realism designs and emotions in learning ($\beta=-0.311$, $CI = -0.564$ to -0.114). Therefore, this study recommends cartoon-like agent as the best suitable design for 2D virtual agent followed by semi-realistic, realistic and stylized designs. Finally, the findings of this study can be a useful guideline for character designers in determining the ideal 2D virtual agent appearance to elicit maximum impact of it in promoting positive emotions in multimedia learning environment.





KESAN TERHADAP KESERONOKAN, RANGSANGAN DAN EMOSI DALAM PEMBELAJARAN DISEBABKAN REKA BENTUK EJEN MAYA 2D DENGAN TAHAP REALISTIK YANG BERBEZA

ABSTRAK

Kajian ini bertujuan untuk menganalisis emosi pelajar dari dimensi keseronokan dan rangsangan yang diakibatkan oleh reka bentuk tahap realistik ejen maya dan kesannya sebagai perantara terhadap emosi dalam pembelajaran. Ejen maya 2D wanita dengan empat penampilan tahap realistik berbeza, iaitu realistik, separa realistik, *stylized* dan rupa kartun telah direka bentuk dan dibangun. Reka bentuk eksperimen kuasi telah digunakan bagi menjawab persoalan-persoalan kajian yang dibina dan data yang diperolehi telah dianalisis dengan menggunakan ANOVA, post hoc dan analisis perantara bootstrap. Eksperimen ini dijalankan terhadap 600 orang pelajar Kejuruteraan Elektrik dari tujuh buah politeknik di Malaysia. Pelajar dibahagikan kepada empat kumpulan yang berlainan menggunakan kaedah persampelan pelbagai tahap, di mana setiap kumpulan terdiri daripada 150 pelajar yang menerokai empat reka bentuk ejen maya dengan tahap realistik yang berbeza. Ujian ANOVA menunjukkan terdapat perbezaan yang signifikan terhadap keseronokan ($F(3, 596) = 15.48, p=0.00, \eta_p^2=0.07$), rangsangan ($F(3, 596) = 15.79, p=0.00, \eta_p^2=0.07$) dan emosi dalam pembelajaran ($F(3, 596) = 2.89, p=0.35, \eta_p^2=0.01$) disebabkan oleh reka bentuk ejen maya dengan tahap realistik yang berbeza. Dapatan kajian menunjukkan ejen rupa kartun memperoleh skor min yang terendah bagi kedua-dua dimensi keseronokan dan rangsangan dan ianya diikuti oleh ejen *stylized*, ejen realistik dan ejen separa realistik. Juga didapati bahawa kesemua reka bentuk tahap realistik ejen maya berada dalam situasi afektif yang tinggi dan boleh dikatakan bebas daripada kesan *uncanny valley*. Menariknya, reka bentuk rupa kartun memperoleh skor min tertinggi bagi emosi dalam pembelajaran yang diikuti oleh separa realistik, realistik dan *stylized*. Kesimpulannya, reka bentuk rupa kartun adalah reka bentuk terbaik berbanding reka bentuk lain untuk merangsang emosi positif dalam pembelajaran. Seterusnya, analisis perantara menunjukkan bahawa hanya rangsangan mempunyai kesan perantara bagi hubungan antara reka bentuk tahap realistik ejen maya yang berbeza dan emosi dalam pembelajaran ($\beta = -0.311, CI = -0.564$ to -0.114). Oleh itu, kajian ini mencadangkan reka bentuk rupa kartun merupakan pendekatan terbaik bagi ejen maya 2D diikuti oleh reka bentuk separa realistik, realistik dan *stylized*. Dapatan kajian ini boleh menjadi panduan berguna bagi pereka bentuk karakter dalam menentukan penampilan agen maya 2D yang ideal, yang mana reka bentuk tersebut dapat berperanan menghasilkan impak maksimum dalam penjaan emosi positif bagi persekitaran pembelajaran berasaskan multimedia.



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LIST OF ABBREVIATIONS

AEQ	Achievement Emotions Questionnaire
MLE	Multimedia Learning Environment
PSSUQ	Post-Study System Usability Questionnaire
Q-MLE	Quiz based Multimedia Learning Environment
SAM	Self-Assessment Manikin
SAM	Successive Approximation Model
SF-L-AEQ	Short-Form Learning-related Achievement Emotions Questionnaire





LIST OF APPENDICES

- A** Validation form of the character design
- B** Validation form of the quiz questions
- C** Expert's view on the language of dialogues
- D** Expert's view on the language of the quiz questions
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- F** Instruments
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- H** Letters





CHAPTER 1

INTRODUCTION



1.1 Introduction

Virtual agents are animated life-like characters generally used in virtual learning environments to facilitate learning tasks (Bian et al., 2016; Choi & Clark, 2006; Craig, Gholson & Driscoll, 2002; Gulz, 2005; Hong, Chen & Lan, 2014; Johnson, Rickel & Lester, 2000; Moreno, 2005; Tien & Kamisah, 2010). Based on the functionality and behaviours, virtual agent is also known as pedagogical agent (Baylor, 2002, 1999; Baylor & Kim, 2004; Johnson & Lester, 2016; Liew, Mat Zin & Sahari, 2017), virtual character (Ferstl, Kokkinara & McDonnell, 2016; Gulz, 2004; Heyselaar, Hagoort & Segaert, 2017; Veletsianos & Russell, 2014), avatar (Chen et al., 2012); talking-head (Dey, Maddock & Nicolson, 2010; Mohd Najib, Ahmad Zamzuri & Annuar, 2015), virtual peer (Moreno, Reislein & Ozogul, 2010; Ryokai, Vaucelle & Cassell, 2003), or





embodied conversational agent (Bickmore & Cassell, 2005; Nunamaker, Derrick, Elkins, Burgoon & Patton, 2011). This clearly indicates how virtual agent have been widely used in various learning platforms and conditions.

With virtual agent, students can hold meaningful interactions throughout the learning process for more effective cognition (Katerina, 2011; Veletsianos, 2010; Yang & Zapata-Rivera, 2010). Virtual agent often offers students with additional life-like communication that could increase the interaction capability of the instructional media and consequently improves its capability to engage and motivate learners (Chen et al., 2012; Gulz & Haake, 2006a; Hong et al., 2014). Studies suggested that virtual agent plays many different roles in the multimedia learning environment, such as demonstrating, scaffolding, coaching, modelling, testing, and so on (Clarebout, Elen, Johnson & Shaw, 2002; Schroeder & Adesope, 2012). In addition, social interaction still exists among students though human peers are absent (Kim & Wei, 2011; Mohammadhasani, Fardanesh, Hatami, Mozayani & Fabio, 2018). Since, social relationship between the virtual agent and learner is important, thus bigger prominence should be granted in the design phase of the virtual agent's appearance (Persson, Laaksolahti & Lonnqvist, 2002; Rosenberg-Kima, Baylor, Plant & Doerr, 2008; Shiban et al., 2015).

Positive emotions arise in the multimedia-based learning environment able to affect learners' experience, therefore facilitate cognitive processes and learning (Um, Plass, Hayward & Homer, 2012). Hence, the effectiveness of virtual agent in term of promoting positive emotion is very much related to character realism influence (Mohd Najib, 2015; Moore, 2012). Based on previous studies in animation and games





industries, it clearly indicated that the realism factors had impact on the success of the animation and games (Butler & Joschko, 2009; Freedman, 2012; MacDorman & Chattopadhyay, 2016; MacDorman & Entezari, 2015; Schwind, Wolf, Henze & Korn, 2015). Hence, a question arises if the same effects will befall on the virtual agent, specifically for education purposes. Therefore, it is essential to conduct studies that address this phenomenon in instructional settings.

1.2 Research background

Animated characters usually relate to movies, cartoons or special effects. However, there were numerous positive results indicated that animation have major contribution in education field as well (Balasubramanyam, 2012; Kogilathah, Ahmad Zamzuri & Tan, 2013; McMenemy & Ferguson, 2009). These days, animations are consolidated as a feature of computer based multimedia learning aid to facilitate human learning through technologies such as virtual agent (Baylor, 2002; Johnson et al., 2000; Kearsley, 1993; Tien & Kamisah, 2010). A virtual agent is a potential approach of instructional material in assisting learning (Massaro, Liu, Chen & Perfetti, 2006; Mohammadhasani et al., 2018; Mohd Najib, 2015). It is based on the capability of the virtual character in delivering learning content visually and verbally in students' memory structure compared to verbal only methods which only benefits in terms of verbal channel (Massaro et al., 2006; Mohd Najib, 2015). Therefore, virtual agents are animated life-like characters (Bian et al., 2016; Choi & Clark, 2006; Craig et al., 2002; Gulz, 2005; Hong et al., 2014; Johnson et al., 2000; Moreno, 2005; Tien & Kamisah,



2010) presented on a computer screen in multimedia learning environments to guide users in learning (Heidig & Clarebout, 2011; Mohammadhasani et al., 2018).

People are happened to be attracted by the visual of face of others in communication processes. When individuals interact, they typically take a glance at each other, seeing the elements of others in vivid detail as shown in Figure 1.1 (Gulz & Haake, 2006a; McCloud, 1993). Every one likewise maintains a steady awareness with his or her own face, however this mental picture is of an iconic environment (Gulz & Haake, 2006a; McCloud, 1993). Therefore, when users are exposed to an agent, identification and social affinity between user and agent occurs naturally and effortlessly. Consequently, it can increase the impact of an agent on users (Gulz & Haake, 2006a). Past studies showed that an animated agent can be more effective compared to without an agent (Baylor & Plant, 2008) or compared to text-only (Atkinson, 2002; Moreno, Mayer, Spires & Lester, 2001; Walker, Sproull & Subramani, 1994).

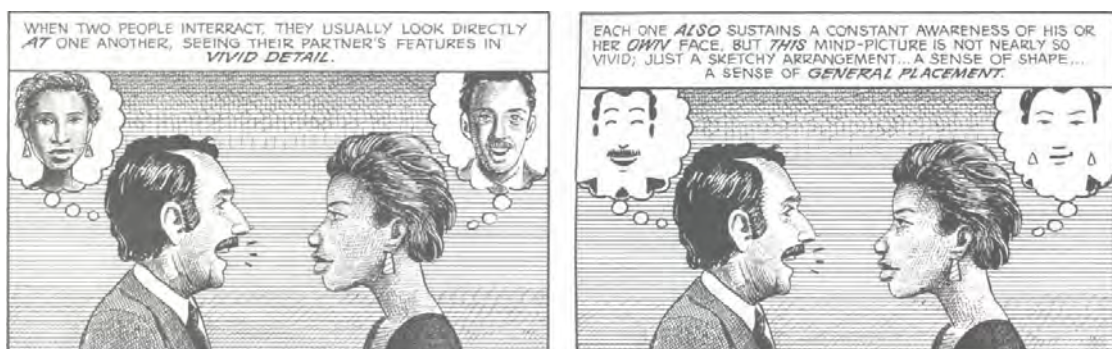


Figure 1.1. People who interact see each other faces in vivid detail, but in their mind they only have a schematic or iconic representation of their own faces. Source: McCloud (1993)



In the aspect of designs of virtual agent, the level of realism of the virtual agent is among the most vital attribute that should be addressed (Ahmad Zamzuri & Mohd Najib, 2016; Baylor & Kim, 2004; Fan et al., 2014; Kokkinara & McDonnell, 2015; Mohd Najib & Ahmad Zamzuri, 2014; Schindler, Zell, Botsch & Kissler, 2017; Schneider, Wang & Yang, 2007). It is to ensure that the virtual agent is capable of obtaining maximum impact in learning (Baylor, 2011; Johnson et al., 2000; Liew, Su-Mae & Jayothisa, 2013; Mohd Najib & Ahmad Zamzuri, 2014). Welch, Blackmon, Liu, Mellers and Stark (1996) contend that pictorial realism increases involvement and the sense of presence in a digital environment. Meanwhile, Nass, Isbister and Lee (2000) suggested that embodied conversational agents should accurately mirror humans and resemble the targeted user group as closely as possible. However, according to Liu, Massaro, Chen, Chan and Perfetti (2007), level of realism of agent may cause distress to the users, especially when the character mimics like human; which was based on the uncanny valley phenomenon highlighted by Mori (1970, 2012).

The concept of uncanny valley originally referred to the design of humanoid robots. In the late 1990s, the concept has been migrated across disciplines to animation industries where people began to refer the uncanny valley phenomenon for character designs as well. According to Mori (1970, 2012), a character that is too realistic or almost resembles a human would eventually cause viewers to feel fearful and horrified when viewing these characters which is also known as the uncanny valley phenomenon (Burleigh, Schoenherr & Lacroix, 2013; Butler & Joschko, 2009; Mohd Najib, 2015; Olivera-La Rosa, 2018; Schwind, Wolf & Henze, 2018a; Tinwell, 2015). For instance, too realistic animated characters in the Final Fantasy: The Spirits Within (Lee, Aida, Sakaguchi & Sakakibara, 2001) was claimed to be among the failure contributors of the



movie (Geller, 2008; Kaba, 2013). Besides, such realistic design in the film causes heavy financial loses, for example Walt Disney Studio's Mars Needs Moms (Zemeckis, Rapke, Starkey, Boyd & Wells, 2011) lost about \$150 million (Schwind, et al., 2018a). Likewise in the film Alita: Battle Angel (Figure 1.2), the character was highly criticized for the creepy look (Kummer, 2019; Schwind, et al., 2018a; Wizard, 2019). This is also supported by a study conducted by Tinwell, Grimshaw, Nabi and Williams, (2011), which found that the use of too realistic three-dimensional animated characters causes notable discomfort to the viewers.

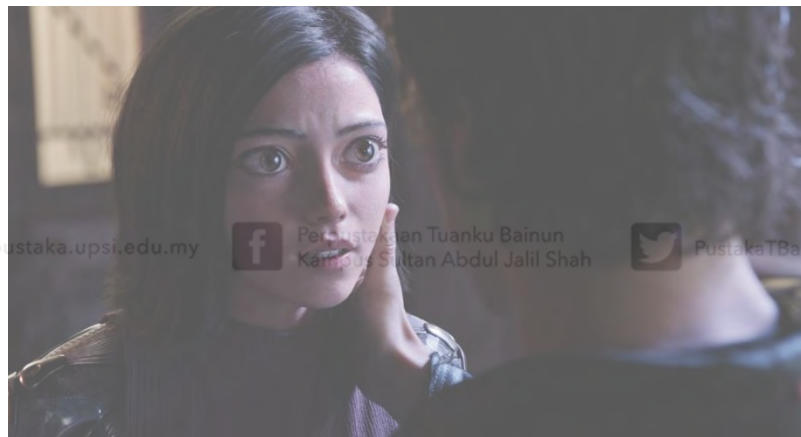


Figure 1.2. Alita: Battle Angel. Source: 20th Century Fox Movies (2019)

Since social relationship between the virtual agent and student is important, bigger prominence should be granted in designing phase of the virtual agent's appearance (Shiban et al., 2015). Adding to this, the ability of virtual agent in promoting positive emotions is very much related to character's realism influences (Mohd Najib, 2015). Correspondingly, the emotional effects on the different realism designs of virtual agents can be identified in the dimension of arousal and valence. These two dimensions represent the affective state experienced by students during their interaction with virtual agents. The affective experience of valence varies from pleasant-to-unpleasant state



while arousal varies from low-to-high state of excitement (Barrett & Russell, 1999; Kensinger & Corkin, 2004). However, very high arousal along with negative valence towards the virtual agent can produce negative feeling among students which lead to the occurrence of uncanny valley phenomenon (Mori, 1970, 2012). At this point, the appearance of virtual agent reached beyond the maximum possible degree of realism in human-likeness and it seen as eerie or disgusting among students. Consequently, students refused to accept the virtual agent as their learning companion. In addition, students' affective experiences influence their perceptions and behaviour. Thus, it becomes an important goal for students to recognize and use their emotions on the content of learning and the circumstances of learning. Pekrun, Goetz, Frenzel, Barchfeld and Perry (2011) and Ahmad Zamzuri and Mohd Najib (2016) have been highlighted the important of emotions in identifying cognition success in the learning process. According to the view of Ciechanowski, Przegalinska, Magnuski and Gloor (2019), virtual agents play an important role as interactive mediate to distribute cognitive tasks to the students in interactive learning environment. Hence, an enhancing and suitable design of virtual agent would be more susceptible for an emotions induction.

Commonly, the realism design of three-dimensional animated characters is higher in resembling the actual human compared to a two-dimensional animated characters (Mohd Najib, 2015; Walker, 2009). It means, the level of discomforts and human emotions will be more effected when three-dimensional animated characters are used, compared to two-dimensional animated characters (Mohd Najib, 2015; Walker, 2009). In addition, somehow the both 2D and 3D animation techniques produce a flat image on the screens (Walker, 2009). Therefore, this study will focus on various realism





designs of 2D characters only. Most studies on the impact of the realism design focused on the film industry and very less in education (Brutscher, 2013). Therefore, it is important to conduct studies that analyse the impact of different realism designs of the virtual agents in teaching and learning media.

Furthermore, the gender selection for virtual agent ultimately impacts learning process. Previous work indicated that precollege students with low prior knowledge benefit from the signalling by a young female animated pedagogical agent (APA) in instruction with multiple visual representations (Johnson, Ozogul, Moreno & Reisslein, 2013). In addition, according to Baylor (2011), the impact of the animated pedagogical agent on female students' motivation can be maximized by presenting the agent as female, young, attractive and cool. Female agent enhanced both male and female student motivation in learning (Arroyo, Woolf, Cooper, Burseson & Muldner, 2011).

Moreover, viewers were facing uncanniness in male human-like character (Tinwell et al., 2011). Other than that, elements of virtual agent should reflect the cultural value of the country where it was originated and tested (Minghua & Ping, 2010; Sloan, 2015). For instance, animation series such like 'Upin & Ipin' (Burhanuddin, Ainon, Mohd Nazmi, Mohd Faiz & Adam, 2007) and 'BoBoiBoy' (Nizam, Jean & Dzubir, 2011) that represent local culture of Malaysia attracted the local audience and consequently led to their success. Accordingly, female virtual agents with native look of Malaysian were selected for the investigation purpose of the current research. Thus, the look of the female virtual agents localise Malaysian Malay young lady as a subjective approach to cultural acceptance.





In addition, voice is a vital element in communication. Thus, past studies concluded that the presence of voice promotes deeper and better learning (Mayer & Estrella, 2014; Mayer, Sobko & Mautone, 2003; Moreno & Mayer, 2002). Atkinson (2002) found that participants who were exposed to the agent in combination with narrated voice instructions demonstrated better learning than participants who were exposed to voice-only instructions. However, agent with human voice is more preferred by the learners thus it engage them in learning compared to agent with machine voice (Atkinson, Mayer & Merrill, 2005; Baylor, Ryu & Shen, 2003; Mayer et al., 2003). Therefore, the current study principally used human voice in the development phase of virtual agent.

In conclusion, the realism design should be taken seriously, and virtual agent should be designed with the consideration of the emotional and psychological impact on human (MacDorman & Chattopadhyay, 2016; MacDorman, Green, Ho & Koch, 2009; Mohd Najib, 2015; Seyama & Nagayama, 2007; Tondur & Bardou, 2009). The close relationship between learning and emotion is not new but still very little is known about it (Cleveland-Innes & Campbell, 2012; Dirkx, 2008; Hascher, 2010; Pekrun & Frese, 1992; Pekrun, Goetz, Titz, & Perry, 2002b; Schutz & Lanehart, 2002; Värlander, 2008). Many previous studies only focused on virtual agent's appearance and limited on realism design of the virtual agent (Baylor, 2009; Rosenberg-Kima et al. 2008, Shiban et al., 2015; van der Meij, van der Meij & Harmsen, 2015; Zibrek & McDonnell, 2014). There was also study on effects of realism designs of animated virtual character on students' learning performance and emotions, but the study only focused on the relation between emotions and performance caused by the male virtual agents in the entire learning process and not in isolated (Mohd Najib, 2015). So far, previous studies





only focused on students' emotions on the entire learning process and not on emotions caused by character's appearance in isolated or vice versa. Therefore, the current study aims to address the gap by studying the effect of different realism designs of virtual agents. Firstly, the virtual agent's design in isolated on students' emotions in the dimension of valence and arousal will be measured. Secondly, students' emotions in the learning will be measured. Thirdly, the relationship between valence and arousal caused by different realism designs of virtual agents and students' emotions in learning will be studied. For that, four different realism designs of virtual agents in Quiz based Multimedia Learning Environment (Q-MLE) had been developed as experimental items and tested to analyse its effect, specifically on emotion caused by the virtual agents' realism designs and emotions in learning. The four prototypes for the current study namely realistic agent (Baylor & Kim, 2004; Beun, De Vos & Witteman, 2003; Ruhland, Zibrek, & McDonnell, 2015; Saidatul Maizura et al., 2010; Zell et al., 2015), semi-realistic agent (Saidatul Maizura et al., 2010; Zell et al., 2015), stylized agent (Mohd Najib, 2015; Schwind et al., 2015; Zell et al., 2015) and cartoon-like agent (Baylor & Kim, 2004; Gulz & Haake, 2006a; McDonnell et al., 2012; Ruhland et al., 2015; Saidatul Maizura et al., 2010) were amended base from the past studies.

In sum, the four 2D female virtual agent prototypes are as follows:

1. Cartoon-like agent

In this design the virtual agent was designed to match an iconic typical cartoon model (simplified geometry of the face) with audio narrative.





2. Stylized agent

In this design the virtual agent was designed with stylized features (cartoon character with exaggerated features) with audio narrative.

3. Semi-Realistic agent

In this design the virtual agent was designed with medium realistic (not as detailed as the realistic) with audio narrative.

4. Realistic agent

In this design the virtual agent was designed with realistic (designed very detailed and it resembles like human) with audio narrative.



1.3 Problem Statement

The different realism design of virtual agent may cause distress to the users, especially when the character mimics human; which was based on the uncanny valley phenomenon highlighted by Mori (1970, 2012). A character that is too realistic or almost resembles a human would eventually cause viewers to feel fearful and horrified when viewing such characters (Mori, 1970, 2012). Based on previous studies in the animation and the games industries, it clearly indicated that the realism factors had impact on the success of the animation and games (MacDorman & Chattopadhyay, 2016). Hence, a question arises if the same effects will befall on the virtual agent, specifically for education purposes.





Animated virtual agent has potential to engage students while increasing their positive emotion. This is due to the capability of virtual agent to hold a conversation in the form of animated character. Therefore, animated virtual agent can be used to assist the learners throughout the learning. However, the use of animated virtual agent would be an issue if it does not provide positive emotion as expected. In this case, learners would reject animated characters once they begin feeling “eerie” or begin to experience negative emotions due to the uncanny human realism of the animated characters where this is known as the uncanny valley phenomenon (Mori, 1970, 2012).

Since social relations between virtual agents and learners are important, a greater emphasis should be given in designing the realism level of a virtual agent. Different realism level of virtual agent will give different impacts on learners. Adequate realism levels of virtual agent might have an impact in simulating positive emotions among the learners. Consequently, students’ interest in learning can be increased as well. Clearly, the adequate realism level of the virtual agent is among the most important attribute to be identified, to obtain the maximum impact in learning. Although, different realism level of virtual agent would create different emotions among learners, it is still unclear on how to design the appearance of a virtual agent to improve students’ positive emotions. The relationship between learning and emotion is not something new but still very few numbers of researchers who have studied about it. Therefore, it is essential to conduct studies that address this phenomenon in instructional settings.

Moreover, past studies only focused on students’ emotions on the entire learning process and not on emotions caused by character’s designs in isolated. In view of that,





this study aims to address the gap by studying the effects of different realism designs of virtual agents. In particular, firstly, this study focus on emotions that arise after seeing the designs of the virtual agents (in isolated) in the dimension of valence and arousal, secondly on emotions that occurs in learning and finally its mediating effects on emotion in learning.

1.4 Significance of the study

As the power of computer technologies advances, the presence of virtual agent in the multimedia learning environment to play human instructional roles has increased dramatically (Johnson et al., 2000; Moreno et al., 2001). Most often, multimedia designers design the virtual agent based on their own preference without ever knowing how their work impacts a larger goal. Unsuitable design selection allows unreliable predictions of its effectiveness. In order to achieve a meaningful design, especially for instructional purpose, research based outcome should be used to guide the development of ideal multimedia design to elicit maximum effectiveness. Therefore, the findings of this research is a useful guideline for multimedia designers in developing virtual agent through the use of appropriate design.

In the twenty-first century, with emerging technologies, multimedia designers are able to design animated virtual agent easily using two-dimensional software technology. The uniqueness of this study exists in the fact that realism design is a key element in the design of virtual agents. In order to demonstrate the potential of this approach, it is important to develop appropriate realism design of a character that is





likeable to target audience. Certainly, appropriate virtual agent that designed using two-dimensional software technology can generate positive emotion in audience that can leave a lasting impression. Most of the studies focused on the use of virtual agent in education regardless of the effects of different realism designs of animated virtual agents in multimedia learning environments. Accordingly, studies on realism design of animated virtual agent need to look in detail so that the negative impact of students' emotions in learning can be avoided.

This research bridges the gap between education and design needs in the field of multimedia for teaching and learning. This study is an important contribution to create Multimedia Learning Environment (MLE) as new pedagogical model to transform the teaching-learning environment. A successful MLE uses virtual agent as the primary design component. It creates an environment that connects the content with the students on positive emotional level. Thus, this research provides a guideline to assist multimedia designer in the development of a virtual agent with appropriate realism design. Also, this research proposes to Ministry of Higher Education, an alternative and efficient way to deliver interactive multimedia design based educational materials using ideal virtual agents' realism design.

Moreover, addressing the specific factors involved in the research outcomes, such as background, colour, gender, age and narration are capable to provide a more expansive interpretation of the research. In view of that, the researcher discovered the best visual style and specific formats for presenting and applying in the MLE that suitable for multimedia learning. These effective formats aid multimedia designers to quickly create multimedia environments by eliminating the need to spend additional





time preparing multimedia learning environment in a more robust way for any other course material.

In addition, the use of virtual agent in quiz based MLE (Q-MLE) is a new approach in educational settings. This offers a significant opportunity to engage students with different learning styles. Consequently, the contribution of this study is obvious as the resulting outcomes can be capitalized as guidelines specifically on the choice of virtual agent to be used in MLE, intelligent tutoring system, games, and so on which were previously only explored in the animated film industry. With the role as instructional guide in the Q-MLE, the ideal virtual agent is capable to communicate and attract students' attention and enhances their interest in learning. In addition, the students will be very interested to learn independently. In fact, the Q-MLE aims to help the students to remember important terms or concepts that are pointed in the quiz. Indirectly, students will be well prepared for both their class and exams. On the face of it, they can improve their course grade as well.

1.5 Theoretical framework

Basically, human brain is attracted and capable to respond fast to the elements that has been seen and heard in multimedia learning. In accordance to that, there are various theories that support multimedia learning such as Baddeley's (1986) model of working memory theory, Paivio's (1981) dual coding theory and Sweller's (1988) cognitive load theory. In addition, the work of Mayer (1997) makes the cognitive theory of multimedia learning becomes popular. According to Mayer's multimedia learning cognitive theory,





learners in multimedia learning environment (MLE) go through material in verbal (such as on-screen text or narration) as well as pictorial form (such as photos or illustrations, and dynamic materials such as video or animation). Therefore, Mayer's multimedia learning cognitive theory is the basis for the construction of conceptual framework of this study. Based on Mayer (2009), still image with words also called as multimedia. Usually, in instructional design method, the designers only give important to the usage of technology to deliver the multimedia. The design based on the perspective and learner's limitation is often ignored.

Apparently, there are three types of memory system involved in multimedia learning which are sensory memory, working memory and long term memory. According to the principle of limited capacity, in a certain period of time, limited information only can be processed in the working memory (Mayer, 2009). In order to overcome this problem, the use of two channels (information-processing) at once is capable to process the received information efficiently which result to a meaningful learning (Mayer, 2009).

Therefore, Mayer's cognitive theory divides information channels into two main components, which are verbal channel and visual channels (Mayer, 2009). In this manner, a multimedia user goes through three main cognitive processes. In the first cognitive process, audio and text selection process occurs with the use of working memory through verbal channel. At the same time, image or graphic selection process occurs with the use of working memory through visual channel. In the second cognitive process, the selected audio and text are translated into a verbal mental model while the selected image and graphic are translated into a visual mental model. Consequently, in



the third cognitive process, both the verbal mental model and the visual mental model will be combined. With the assistance of existing knowledge, both combined models will be used for the formation of schemes that will be registered permanently in long term memory (Mayer, 2009). These cognitive processes are illustrated in Figure 1.3.

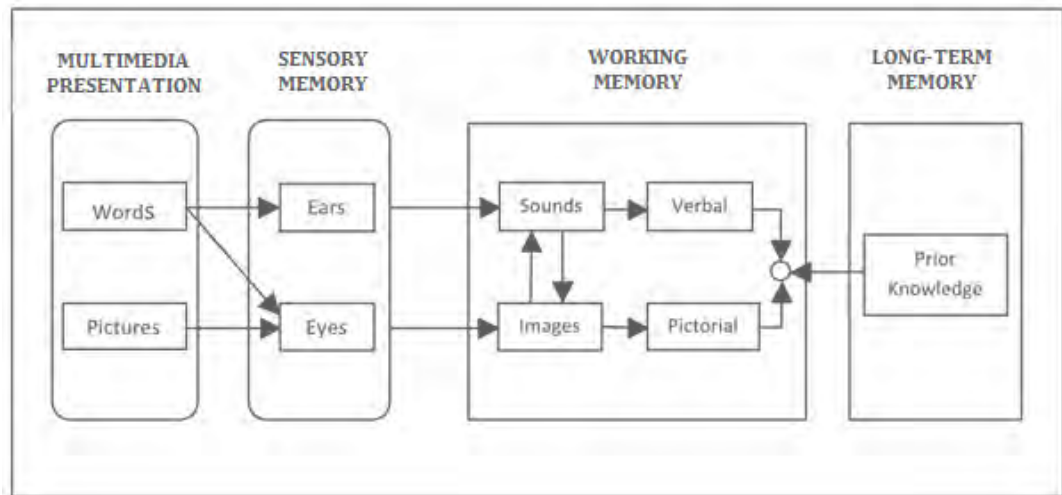


Figure 1.3. Mayer's Cognitive Theory of Multimedia Learning. Source: Mayer (2009)

An animated virtual agent is able to talk and hold a conversation with human users. The implementations of animated virtual agent in MLE, is capable to interface with user throughout the learning. From the point of Mayer's cognitive theory, the use of animated virtual agent in MLE could potentially involve the utilization of visual and verbal channels. This is due to the concept that an animated virtual agent is working on facial animation combined with audio-visual speech processing. Lip movements of animated virtual agent will be processed through the visual channel while the audio and text processed through verbal channels.

However, the appropriate design of animated characters plays an important role for the effective multimedia learning through the use of both visual channel and verbal channel. This is because the realism factor of an animated character will affect the students' level of comfort and their emotion throughout the learning process, especially through the use of animated characters that are too realistic (MacDorman et al., 2009; Minato, Shimda, Ishuguro & Itakura, 2004; Tinwell et al., 2011). This effect may also have an impact on the success of the animated instruction that used for learning. Thus, it is important for the study to be conducted in order to see the effect on the learning by applying different realism design on animated virtual agent.

Appropriately, uncanny valley phenomenon highlighted about the effects exists from the usage of a realistic animation character. Based on the theory, the different level of a character's realism will affect the comfort and human emotions (MacDorman, 2006; Mori, 1970, 2012). This phenomenon illustrates through the uncanny valley graph as shown in Figure 1.4.

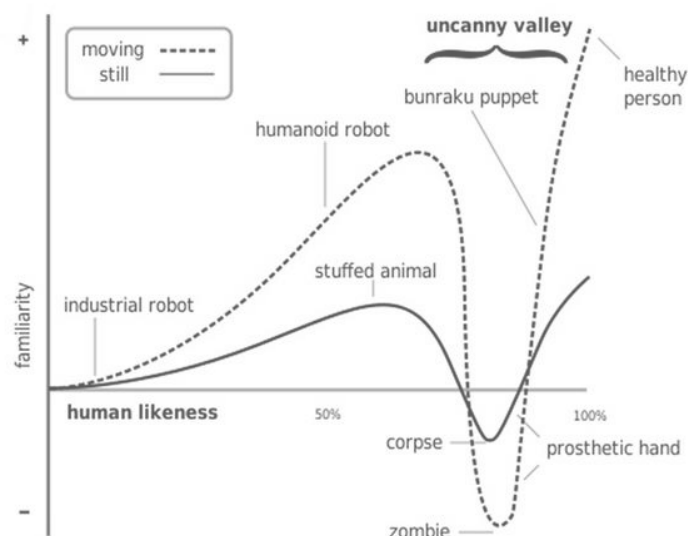


Figure 1.4. Mori's Graph of the Uncanny Valley. Source: Mori (2012)



Based on the Figure 1.4, the uncanny valley phenomenon divides characters into two main categories, namely, dynamic characters and static character. The results shows that human emotions arise towards positive when the character is more like humans (human likeness). However, when both dynamic and static character are increasingly dire, human emotional level decreased to a negative to the extent of 80 to 85 percent. The decline in the level of human comfort in this graph is called uncanny valley. The level of human emotions rise back to positive when the characters are real people (MacDorman, 2006; Mori, 1970, 2012). As conclusion, the uncanny valley effect is higher to the dynamic character compared to the static character. Therefore it is important to build a graph to analyse the relationship between the levels of human emotions with realism animation instruction level, especially animated agent.



Darwin (2009), Pekrun, Goetz, Titz and Perry (2002a), Russell (1980), Ekman, Friesen and Ellsworth (1972), Izard (1971) and Schlosberg (1954). These theories and data made a major contribution to perspective on emotion. For the current study Russell's Circumplex Model of Affect (1980) was used to analyse students' emotion on the designed character.

Russell introduced Circumplex Model of Affect in 1980. According to Russell (1980), affective states occurs from the behaviour of two independent neurophysiological systems. The model represented the variations and similarities among the affective states as two orthogonal and bipolar dimensions. Valence on the horizontal axis ranges from negative to positive whereas arousal on the vertical axis ranges from low arousal to high arousal (Figure 1.5). Consequently, any affective states



will fall in this two dimensions. For example, excitement and enthusiasm would be considered combinations of pleasure and high arousal, while boredom and depression would be a mixture of displeasure and low arousal (Kapoor, Czerwinski, MacLean & Zolotovitski, 2013). Consequently, the measurement of valence and arousal can determine the occurrence of uncanny valley on the virtual agents (Cheetham, Wu, Pauli & Jancke, 2015). In addition, circumplex models also have been used to test stimulus of emotion words, emotional facial expressions, and affective states (Rubin & Talarico, 2009).

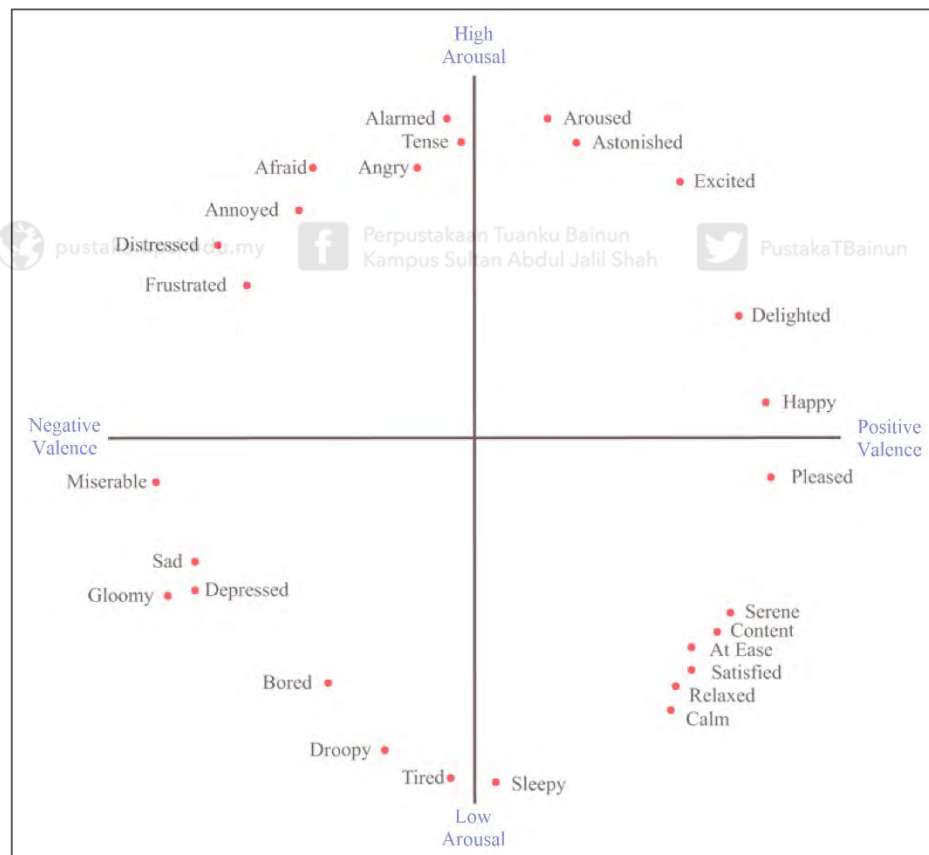


Figure 1.5. Russell's Circumplex Model of Affect (Russell, 1980). Source: Seo & Huh (2019)



1.6 Research Objectives

In conclusion, this study looked at relation of the uncanny effects of different realism designs of animated virtual agents on students' emotions.

The self-assessment manikin (SAM) nonverbal pictographic questionnaire was used to measure students' individual emotions in the dimensions of valence and arousal on the different realism designs of the animated virtual agents. Whereas, the Short-Form Learning-related Achievement Emotions Questionnaire (SF-L-AEQ) was used to measure students' emotions in learning.

Accordingly, the specific objectives of the study are as follows:



- a) To design four different realism designs of the 2D female virtual agents namely realistic, semi-realistic, stylized and cartoon-like agents.
- b) To develop a Quiz based Multimedia Learning Environment (Q-MLE) with four different realism designs of the 2D female virtual agents.
- c) To analyse the effect of different realism designs of the 2D female virtual agents on students' valence.
- d) To analyse the effect of different realism designs of the 2D female virtual agents on students' arousal.





- e) To analyse the effect of Quiz based Multimedia Learning Environment (Q-MLE) with different realism designs of the 2D female virtual agents on students' emotions in learning.
- f) To analyse whether valence and arousal caused by different realism designs of 2D female virtual agents are significant mediators in determining students' emotions in learning.

1.7 Research Questions

- a) Is there any significant effect of different realism designs of the 2D female virtual agents on students' valence?
- b) Is there any significant effect of different realism designs of the 2D female virtual agents on students' arousal?
- c) Is there any significant effect of Quiz based Multimedia Learning Environment (Q-MLE) with different realism designs of the 2D female virtual agents on students' emotions in learning?
- d) Are valence and arousal caused by different realism designs of 2D female virtual agents are significant mediators in determining students' emotions in learning?



1.8 Hypotheses

H1. There will be significant effect of different realism designs of the 2D female virtual agents on students' valence.

H2. There will be significant effect of different realism designs of the 2D female virtual agents on students' arousal.

H3. There will be significant effect of Quiz based Multimedia Learning Environment (Q-MLE) with different realism designs of the 2D female virtual agents on students' emotions in learning.

H4. Valence and arousal caused by different realism designs of 2D female virtual agents are significant mediators in determining students' emotions in learning.



1.9 Limitations

- a) This research was focused on multimedia design and its effect on students' emotions. This research does not involve research in the field of any courses content involves.
- b) This research involved participants from seven polytechnics out of 16 and students' age between 19 to 23.
- c) This research was fully focused on realism designs of virtual agents and not on facial expression.





- d) Only female agents with native looks of Malaysia were used in the research.

Clothing kept the same across agents so as to avoid confounding the results.

- e) Human voice was used to the virtual agents in the research.

1.10 Operational definition

- a) Arousal

Arousal describes through emotional experience that enrich with excitement or calm.



Animated characters that are iconic match a typical cartoon model (simplified geometry of the face).

- c) Multimedia learning environment

A multimedia learning environment is an app or software program combination of text, audio, video, animation and graphic designed for educational purposes.

- d) Realistic agent

Animated characters that are closely looks like human (designed very detailed and it mimics like human)





e) Semi-realistic agent

Animated characters that are medium realistic (not as detailed as the realistic).

f) Stylized agent

Animated characters that are stylized (cartoon character with exaggerated features).

g) Uncanny valley

A character that is too realistic or almost resembles a human would eventually cause viewers to feel fearful and horrified when viewing these characters which is known as the uncanny valley phenomenon.

h) Valence

Valence is a fundamental component of emotional responding and it refers to the pleasant-to-unpleasant state.

i) Virtual agent

Virtual agents, are animated life-like characters generally used in virtual learning environments to facilitate learning tasks.





1.11 Summary

Virtual agent is one of the pedagogical agent in human–computer interaction systems. Animated virtual agent acts as computer generated animated character, lifelike video character or only a man/woman on a site that can talk and hold conversation or telling story to the learners. Virtual agent has realism speech, interactive and the persuading emotions which could increase students' emotions and subsequently motivation. However, mistakes in selecting the virtual agent in the instruction animation development will have a negative impact on students. It is because, level of realism on agent may cause distress to the users, especially when the character mimics like human based on uncanny valley phenomenon. Therefore, this study focuses on the realism impacts of virtual agents on students' emotions in learning. Students' emotions on this Quiz based Multimedia Learning Environment (Q-MLE) measured using Self-Assessment Manikin (SAM) and Short-Form Learning-related Achievement Emotions Questionnaire (SF-L-AEQ). For that, four prototypes of animated virtual agents with varies realism designs as the experimental group were developed. The findings of this research is guideline for the development of animated characters in order to give maximum impact to increase students' positive emotions towards learning.

