

The Effect of Different Realism Designs of Virtual Agents on Students' Grades in Quiz App: The Mediating Role of Arousal and Valence

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Abstract

This study investigates the impact of various realism designs of 2D virtual agents on students' grades in a quiz app, focusing on the mediating roles of arousal and valence. A total of 134 electrical engineering students from four Malaysian polytechnics participated in this experiment. Four different types of virtual agents—cartoon-like, stylized, semi-realistic, and realistic—were embedded into the quiz app, each designed to guide students through answering 20 multiple-choice questions. Valence and arousal levels were measured using the Self-Assessment Manikin (SAM) questionnaire, and the quiz grades were recorded. The findings revealed that virtual agents with higher levels of realism (semi-realistic and realistic) were negatively associated with student grades, while the cartoon-like agent led to better quiz performance. Mediation analysis showed that both arousal and valence significantly influenced the relationship between virtual agent design and grades. The results suggest that overly realistic virtual agents may cause cognitive overload, thus hindering academic performance. In contrast, simpler, cartoon-like agents reduce distractions and improve learning outcomes. These findings have implications for designing virtual agents in educational settings, recommending that simplicity and reduced realism can enhance learning efficiency by minimizing emotional distraction and cognitive load.

Keywords: Arousal and Valence, Cognitive Load, Realism Design, Virtual Agents, Virtual Learning Environment

Introduction

Interactive learning has gained traction since the 1990s through the use of animated on-screen characters known as virtual agents (Baylor, 2011). These animated virtual agents can inspire users due to their high level of interactivity with human beings (Cassell, 2000). Interaction occurs both visually and verbally, as virtual agents can assume human roles (Clark & Mayer, 2016). They represent real individuals by providing instruction, offering feedback, and directing attention (Heidig & Clarebout, 2011; Moreno, 2005).

The design of a virtual agent's appearance is influenced by target audience preferences, cultural differences, and the specific roles they play. When analysing character appearance, visual design emerges as a crucial element. The choice of realism in design significantly impacts the presentation of virtual agents (Kogilathah, Ahmad Zamzuri, & Wee Hoe, 2019; Vicneas & Ahmad Zamzuri, 2020). Additionally, positive emotions in a multimedia-based learning environment can enhance learners' experiences, thereby facilitating cognitive processes and learning (Um, Plass, Hayward, & Homer, 2012). Recent studies on AI chatbots also highlight their potential to improve educational experiences, demonstrating enhancements in learning outcomes and student engagement, though challenges remain regarding their implementation (Deng & Yu, 2023; Okonkwo & Ade-Ibijola, 2021).

Previous studies indicate that realism factors affect students' emotions during learning. For example, cartoon-like agents (lower realism designs) tend to evoke moderate valence and arousal, which positively influences students' emotions in a Multimedia Learning Environment (Vicneas & Ahmad Zamzuri, 2020). This raises the question of whether similar effects occur in students' grades. This study aims to address this gap by examining the impact of various realism designs of virtual agents on students' grades in a quiz app. Specifically, this research will first explore the emotions elicited by the different designs of virtual agents, focusing on the dimensions of valence and arousal. Secondly, it will investigate the mediating effects on the quiz app performance of 4th-semester students from four Polytechnics on their grades in the interactive multimedia subject.

Virtual Agents in Multimedia Learning Environments

The role of virtual agents has expanded to aid the learning process in the field of education (Chou, Chan & Lin, 2003; Craig, Gholson, & Driscoll, 2002; Johnson, Rickel, & Lester, 2000; Mohammadhasani et al., 2018; Moundridou & Virvou, 2002; Nguyen & Robinson, 2023). Virtual agents serve a motivational role, increasing learners' engagement and fostering meaningful learning (Kim & Baylor, 2006; Kim & Wei, 2011; Lusk & Atkinson, 2007; Mohanty, 2016; Smith & Lee, 2023). These roles include acting as tutors, coaches, and actors (Payr, 2003), experts, motivators, and mentors (Baylor & Kim, 2005), learning companions (Kim, Baylor & Shen, 2007), change agents (Kim & Baylor, 2008), and lifelong learning partners (Chou et al., 2003).

Through these roles, virtual agents communicate and collaborate with learners to facilitate course content (Atkinson, 2002; Baylor & Kim, 2004; Clark & Mayer, 2016; Craig et al., 2002; Moreno, Mayer, Spires, & Lester, 2001; Wang, Chignell & Ishizuka, 2005; Lee & Park, 2021). This strategy helps stimulate learners' interest and keeps them focused on the provided content (Clark & Choi, 2005). When learners engage in learning tasks, positive social interactions are created and maintained between the virtual agent and the learners (Berry, Butler & Rosis, 2005).

The appropriate design is crucial for the development of virtual agents, as it determines the extent of their effectiveness in reaching learners. Some studies show that learners can become so influenced by virtual agents that they accept the agents as conversational partners throughout the learning process (Graesser & McNamara, 2010). On the other hand, some studies indicate that poorly designed virtual agents can lead to frustration and disappointment among learners (De Angeli & Brahnham, 2008; Chen, Zhang, & Li, 2023). This

outcome is often due to virtual agents' inability to influence learners' emotions effectively, despite their potential to enhance learning (Lester et al., 1997a, b). Human attitudes often change during interactions with artificial beings, which may affect the overall experience (Fussell, Kiesler, Setlock & Yew, 2008).

Frequent social interaction between virtual agents and learners helps address various sociocultural needs and provides cognitive support to learners (Anderson & Kim, 2022; Patel & Kumar, 2022). Moreover, interactive interfaces, such as virtual agents, help distribute cognitive tasks to learners in an interactive learning environment (Ciechanowski, Przegalinska, Magnuski, & Gloor, 2019). This aligns with the capability of virtual agents to support both cognitive processing and metacognitive skills (Clarebout & Elen, 2007) through flexibility, support, and scaffolding guidance (Biswas et al., 2004; Lin, Chen, Wu & Yeh, 2008). Consequently, learners gain a richer learning experience (Gulz, 2005; Ramirez et al., 2022), and an improved cognitive level can enhance students' performance in the learning process (Clark, 2017; Martinez & Huang, 2023).

Valence and Arousal

Emotions play an important role in human life. Emotional stimulation can directly influence a person's behavior (Winkielman, Berridge, & Wilbarger, 2005). Emotions are recognized through stimuli, referred to as affective experiences. Affective experience is related to psychophysiological indices differentiated by valence and arousal (Bradley & Vrana, 1993; Cacioppo, Petty, Losch & Kim, 1986; Foti & Hajcak, 2009; Lang et al., 1997b; Lang, Greenwald, Bradley & Hamm, 1993; Schupp et al., 2000). Therefore, valence and arousal are two primary dimensions used to examine human affective experience. Valence refers to a pleasant-to-unpleasant state, while arousal refers to a low-to-high state of excitement (Barrett & Russell, 1999; Kensinger & Corkin, 2004). Several studies have indicated that valence and arousal are independent of one another (Barrett & Russell, 1999; Carver & Scheier, 2014; Larsen & Diener, 1992; Reisenzein, 1994; Russell, 1980).

Typically, the circumplex model describes affective states with two dimensions, valence and arousal (Barrett & Russell, 1999). This model has been applied in educational settings to evaluate how emotional states, like excitement or boredom, affect students' engagement and cognitive performance (Kapoor et al., 2013). In the circumplex model, valence on the horizontal axis ranges from negative to positive, whereas arousal on the vertical axis ranges from low arousal to high arousal, as shown in Figure 2.9. The affective states fall within these two dimensions. Based on the model, excitement and astonishment are considered combinations of positive valence and high arousal, whereas boredom and depression are a mixture of negative valence and low arousal (Kapoor et al., 2013). At the same time, high arousal and negative valence contribute to a feeling of tension, while low arousal and positive valence contribute to a feeling of calmness.

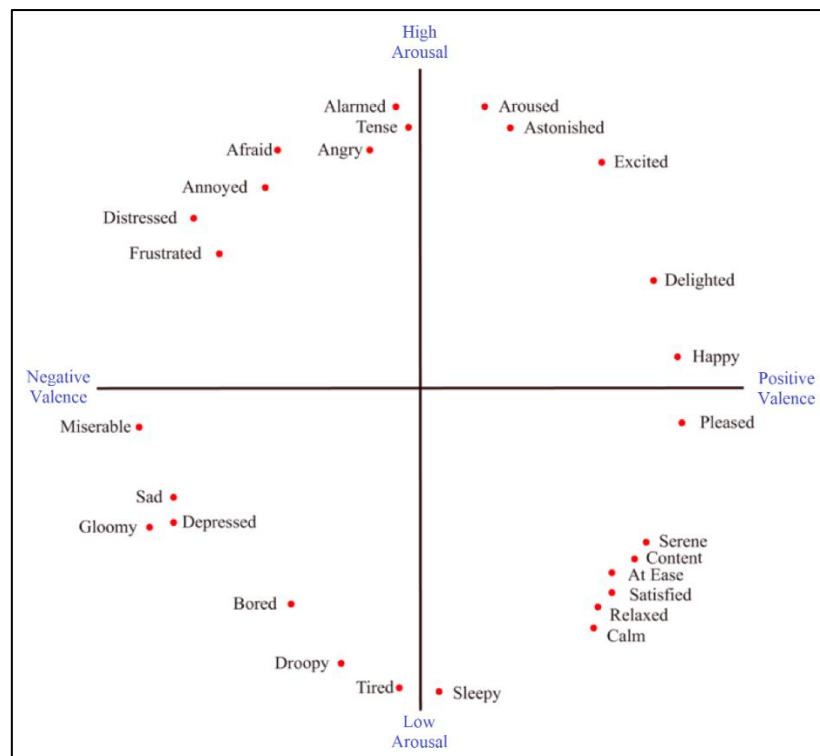


Figure 1. Russell's Circumplex Model of Affect (Russell, 1980). Source: Seo & Huh (2019)

Physiological responses for different types of emotions are reliably linked to variations in arousal and valence (Barrett, 2006; Thompson & Nguyen, 2023). Negative emotions such as disgust, sadness, and fear result in different valence and arousal ratings (Bradley, Codispoti, Cuthbert & Lang, 2001). In contrast, positive emotions like happiness and satisfaction provide consistent results for valence and arousal evaluation (Javela, Mercadillo & Martín Ramírez, 2008). These variations allow categorization of emotional experiences into specific arrays of discrete emotions. There are various discrete emotions commonly associated with learning contexts, such as boredom, confusion, curiosity, hopelessness, shame, anxiety, anger, surprise, relief, hope, pride, and enjoyment of learning (D'Mello & Graesser, 2012; Pekrun et al., 2011). These emotions are related to achievement, self-regulation, motivation, and several other processes in a variety of ways. Positive emotions increase learners' intrinsic motivation by stimulating their curiosity to explore new knowledge, thus leading to better learning performance (Pekrun et al., 2011; Pekrun & Stephens, 2010; Ruiz & Hernandez, 2023).. These motivational capabilities are measured from the emotional information provided by valence and arousal (Lang, 2006; Lang et al., 1997b). Accordingly, low arousal with positive valence produces better overall cognitive-motor performance, while high arousal with negative valence results in poorer overall cognitive-motor performance (Lu, Jaquess, Hatfield, Zhou & Li, 2017).

In an educational setting, the presence of emotionally arousing components helps induce external mood and maintain it throughout the learning process (Isen, Daubman & Nowicki, 1987; Isen & Reeve, 2005; Um et al., 2012; Wolfson & Case, 2000). The induced emotional experiences can influence cognitive processing (Gomez, Zimmermann, Guttormsen Schär & Danuser, 2009; Um et al., 2012). Positive emotions can help learners pay closer attention to learning content (Park & Lim, 2007) and increase their cognitive interest and motivation (Um et al., 2012). Therefore, exploring different intensity levels of positive and negative emotions

is important. Several researchers have found that positive emotions are superior to negative emotions for learning.

In view of that, virtual agents can be used as emotionally arousing components to increase attention and improve memory for learning content (Joëls, Pu, Wiegert, Oitzl & Krugers, 2006). This aligns with the capability of different realism designs of virtual agents to generate different arousal and valence states. The various arousal and valence states can activate brain regions and stimulate different emotions. The emotionally arousing virtual agent is sufficient to boost learning as it captures more attention.

Accordingly, the measurement of valence and arousal in this research is based on learners' ratings of their affective experience when viewing different realism designs of virtual agents. Learners who express positive emotions during the initial viewing of the virtual agent may maintain interest throughout the learning process and consequently score better, whereas those who express negative emotions may show decreased interest and therefore score lower. This understanding of emotions can help in choosing appropriate realism designs for virtual agents. Suitable realism designs of virtual agents can influence learning and improve the efficiency of the learning environment.

Methodology

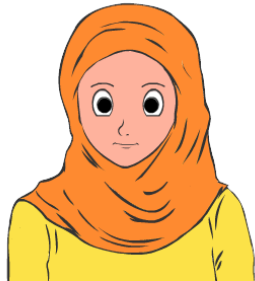
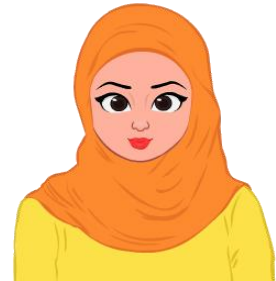


The objective of this study was to analyze whether valence and arousal caused by different realism designs of 2D female virtual agents act as significant mediators in determining students' quiz grades in a quiz app. Therefore, four different realism designs of virtual agents were developed and embedded into the quiz app. The virtual agents were present throughout the quiz app to guide the students in answering the 20 multiple-choice questions. The virtual agents were designed to provide responses based on the choices made by the students.

Virtual Agent

The fundamental goal of the study was to explore the effect of realism. Therefore, great emphasis was placed on designing the virtual agents with different levels of realism. The four different realism designs were developed to reflect the cultural value of the country in which they were created and tested (Sloan, 2015). In addition, female agents have been found to enhance both male and female students' motivation in learning (Arroyo, Woolf, Cooper, Burleson, & Muldner, 2011). Consequently, the virtual agents for this quiz app were female, modeled to represent a Malaysian Malay young woman. Past studies show that saturated and warm colors can stimulate greater feelings such as pleasure and excitement (Plass, Heidig, Hayward, Homer, & Um, 2014; Um et al., 2012). The strongest effects can be found between warm, light colors (e.g., yellow, orange) and dark or achromatic colors (e.g., gray) (Kaya & Epps, 2004; Plass et al., 2014). Therefore, the hijab for the virtual agents was orange, and the clothing was yellow.

Table 1

The Design Elements of the Virtual Agents

Virtual agents	Design elements	The design
Cartoon-like	In this design, the virtual agent was designed to match an iconic typical cartoon model (simplified geometry of the face) with audio narrative.	 A cartoon-style illustration of a woman wearing an orange hijab and a yellow top. The face is simplified with large, round eyes and a small, straight nose.
Stylized	In this design, the virtual agent was designed with stylized features (cartoon character with exaggerated features) with audio narrative.	 A stylized illustration of a woman wearing an orange hijab and a yellow top. The face has exaggerated features, including large, almond-shaped eyes and a small, upturned nose.
Semi-realistic	In this design, the virtual agent was designed with medium realism (not as detailed as the realistic) with audio narrative.	 A semi-realistic illustration of a woman wearing an orange hijab and a yellow top. The face is more detailed than the stylized version, with realistic eye shapes and a subtle smile.
Realistic	In this design, the virtual agent was designed with realistic features (designed very detailed and resembles a human) with audio narrative.	 A realistic illustration of a woman wearing an orange hijab and a yellow top. The face is highly detailed, with realistic skin tones, eye shapes, and a natural expression.

Quiz App

The virtual agent appeared throughout the quiz app to guide students using multiple spoken dialogues, acting as a bridge between the content and students. The quiz app comprised 20 questions derived from the first chapter of the chosen subject. The students were required to answer these multiple-choice questions under the guidance of the virtual agent. At the end of the quiz, the scored marks were displayed to the students, and the results were recorded.

Instruments

The Self-Assessment Manikin (SAM) nonverbal pictographic questionnaire [50] was used to measure students' individual emotions in terms of valence and arousal based on different realism designs of the animated virtual agents. Each virtual agent design was rated by

students using a nine-point scale, with pictorial manikins representing varying values of valence (pleasant-to-unpleasant state) and arousal (ranging from low to high arousal).

Participants

A total of 134 electrical engineering students from four polytechnics in Malaysia participated in this research. Among them, 74 students were male and 60 were female, with an average age of 20.21 (SD = 0.65). The students represented different ethnic groups: 83.6% Malays, 11.2% Indians, 1.5% Chinese, and 3.7% others. The students were randomly divided into four groups corresponding to the different types of virtual agents: realistic, semi-realistic, stylized, and cartoon-like. The experimental study was conducted separately for all groups in a controlled lab environment.

Procedure

Before the experiment, students learned the first chapter of the chosen subject using the Curriculum Information Document Online System (CIDOS), which is a Learning Management System (LMS) used in all Malaysian polytechnics. On the day of the experiment, students were briefed on the purpose of the study and the role of valence and arousal in investigating the influence of realism designs of 2D virtual agents in the quiz app. They were also informed about the rules and regulations for using the quiz app. The selected virtual agent introduced herself to the students, and after a 5-minute interaction, the Self-Assessment Manikin (SAM) questionnaire was given to measure students' valence and arousal levels. Once the students rated their emotions, they were allowed to answer the quiz questions. Around 30 minutes were allocated for completing the quiz, and the scores were displayed upon completion.



Figure 2: Students Participating in the Research Using VLE in the Lab

Findings

In order to answer the research question, linear regression was used by using PROCESS macro for SPSS (Hayes, 2018) to test whether valence and arousal caused by different realism designs of 2D female virtual agents is a significant mediator in determining students' grades in the quiz app. Where mediator 1 (M1; valence) and mediator 2 (M2; arousal) are proposed to explain the relationship between an independent variable (X; cartoon-like, stylized, semi-realistic, and realistic agents) and dependent variable (Y; students' grades). This model is a

parallel multiple mediator model. The details of descriptive statistics for valence, arousal, and grade by different realism designs of virtual agents are shown in Tables 2, 3, and 4.

Table 2

Descriptive Statistics for Valence

Virtual agent	Mean	Standard Deviation	N
Realistic	7.21	1.32	34
Semi-Realistic	7.46	1.04	35
Stylized	6.44	1.34	32
Cartoon-like	5.82	1.55	33

Table 3

Descriptive Statistics for Arousal

Virtual agent	Mean	Standard Deviation	N
Realistic	6.53	1.66	34
Semi-Realistic	6.94	1.43	35
Stylized	5.78	1.66	32
Cartoon-like	5.30	1.72	33

Table 4

Descriptive Statistics for Grade

Virtual agent	Mean	Standard Deviation	N
Realistic	84.82	5.33	34
Semi-Realistic	85.43	4.72	35
Stylized	86.91	4.86	32
Cartoon-like	90.00	5.18	33

The multicategorical variable analysis involved three comparisons. Each virtual agent design was compared against the cartoon-like agent, resulting in three groups: group 1 (X_1 : stylized agent versus cartoon-like agent), group 2 (X_2 : semi-realistic agent versus cartoon-like agent), and group 3 (X_3 : realistic agent versus cartoon-like agent). Mediation analysis was tested using the bootstrapping method with bias-corrected confidence estimates (Hayes, 2018; Preacher & Hayes, 2008). In the present study, the 95% confidence interval of the indirect effects was obtained with 5000 bootstrap resamples (Hayes, 2018; Preacher & Hayes, 2008). The summary of the results is shown in Table 5.

Table 5

Regression Coefficients of the Mediation Model

	Path	f.	Coef	SE	t	p	95% CI			
							Lower	Upper		
Stylized versus Cartoon-like (X ₁)	a ₁₀		0.61	0.		.06	-		1.26	
		9	328		1		0.029	8		
	a ₁₁		0.47	0.40		.23	-		1.27	
		8	2		6		0.317	3		
	Total		-	1.24		.01	-		-	
	effect (c ₁)	3.094	7		4		5.562	0.626		
	Direct		-	1.08		.06	-		0.11	
	effect (c ₁ ')	2.035	5		3		4.182	3		
	Semi-realistic versus Cartoon-like (X ₂)									
	a ₂₀		1.63	0.32		.00		1.00		2.27
	9	1		0		5	3			
a ₂₁		1.64	0.39		.00		0.86		2.41	
	0	3		0		3	7			
Total		-	1.22		.00		-		-	
effect (c ₂)	4.571	0		0		6.985	2.158			
Direct		-	1.14		.21		-		0.82	
effect (c ₂ ')	1.440	6		1		3.708	8			
Realistic versus Cartoon-like (X ₃)										
a ₃₀		1.38	0.32		.00		.749		2.02	
	8	3		0				7		
a ₃₁		1.22	0.39		.00		.444		2.00	
	6	6		2				9		
Total		-	1.22		.00		-		-	
effect (c ₃)	5.177	9		0		7.607	2.746			
Direct		-	1.12		.01		-		-	
effect (c ₃ ')	2.668	7		9		4.898	0.438			
b ₁		-	0.47		.03		-		-	
	1.031	5		2		1.971	0.090			
b ₂		-	0.38		.02		-		-	
	0.880	8		5		1.647	0.112			
Indirect effects										
a ₁₀ b ₁		-	0.54				-		0.10	
	0.638	3				1.965	7			
a ₁₁ b ₂		-	0.44				-		0.33	
	0.421	0				1.444	5			
a ₂₀ b ₁		-	0.94				-		-	
	1.689	5				3.796	0.108			
a ₂₁ b ₂		-	0.69				-		-	
	1.442	1				2.976	0.224			
a ₃₀ b ₁		-	0.80				-		-	
	1.430	8				3.219	0.087			
a ₃₁ b ₂		-	0.63				-		-	
	1.079	0				2.564	0.103			

From the parallel multiple mediator model (Figure 3), the direct effect (c_1') of the stylized agent in comparison with the cartoon-like agent (X_1) was negatively associated with students' grade (Y_1) ($\beta = -2.035$, $t(130) = -1.8750$, $p = 0.063$). This indicates that, with other variables controlled in the model, the stylized agent in comparison with the cartoon-like agent scored 2.035 units lower on the students' grade scale. Hence, the effect is not statistically significant. In addition, the relationship in comparison with the cartoon-like agent, stylized agent is positively related to valence (a_{10}) ($\beta = 0.619$, $t(130) = 1.889$, $p = 0.061$). In brief, for path a_{10} , it is found that the stylized agent (compared to the cartoon-like agent) increases valence by 0.619; though the effect is insignificant. On the other hand, the relationship in comparison with the cartoon-like agent, stylized agent is positively related to arousal (a_{11}) ($\beta = 0.478$, $t(130) = 1.191$, $p = 0.236$). In other words, the stylized agent (compared to the cartoon-like agent) increases arousal by 0.478; this effect is insignificant. The total effect (c_1) of the stylized agent in comparison with the cartoon-like agent was negatively associated with students' grades through valence and arousal ($\beta = -3.094$, $t(130) = -2.480$, $p = .014$), meaning the stylized agent decreases students' grades compared to the cartoon-like agent. This effect is significant.

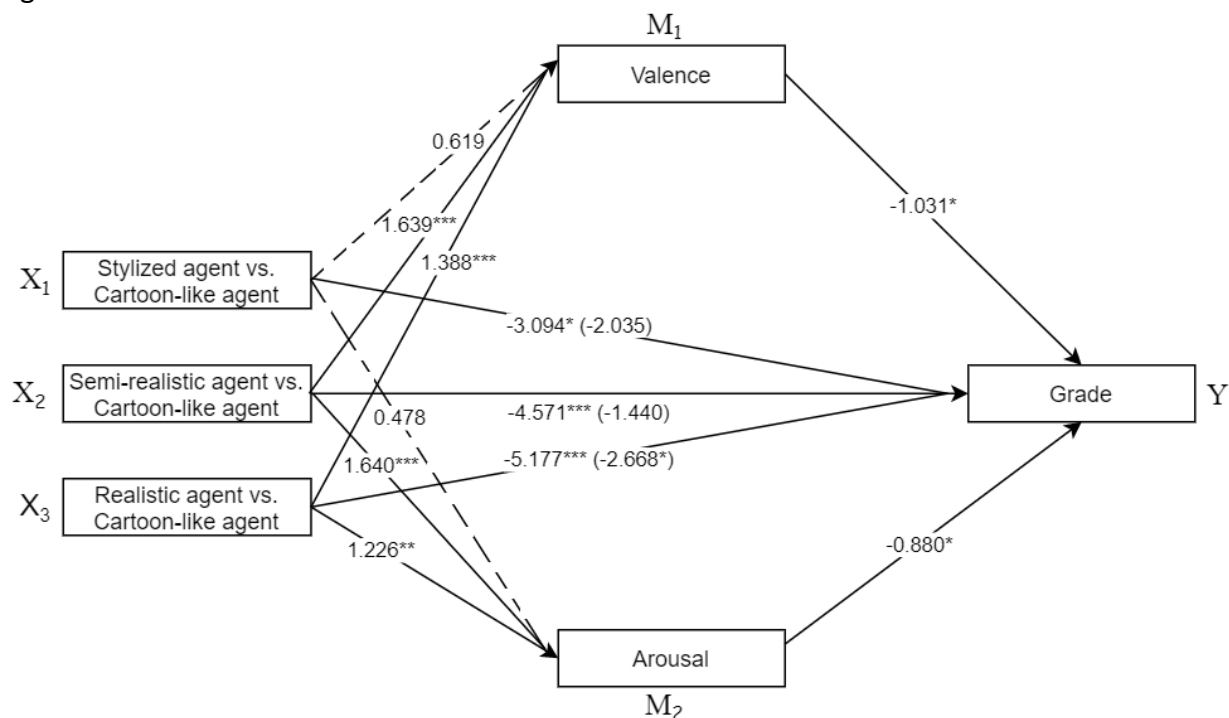


Figure 3. The mediating effect of valence and arousal in the relationship between different realism designs of virtual agents and students' grade.

Notes: The figure shows regression coefficients. The dashed line represents non-significant coefficients.

* $p < .05$, ** $p < .01$, *** $p < .00$

Secondly, for the direct effect (c_2') of the semi-realistic agent in comparison with the cartoon-like agent (X_2), the relationship was negatively associated with students' grade (Y_2) ($\beta = -1.440$, $t(130) = -1.256$, $p = .211$). This indicates that other variables are controlled in the model; the semi-realistic agent in comparison with the cartoon-like agent scored 1.440 units lower on the students' grade scale. Hence, the effect is insignificant. Additionally, the relationship in comparison with the cartoon-like agent, semi-realistic agent is positively related to valence (a_{20}) ($\beta = 1.639$, $t(130) = 5.111$, $p = .000$). In brief, for path a_{20} , it is found that the semi-realistic

agent (compared to the cartoon-like agent) increases valence by 1.639; the effect is significant. Besides, the relationship in comparison with the cartoon-like agent, the semi-realistic agent is positively related to arousal (a_{21}) ($\beta = 1.640$, $t(130) = 4.174$, $p = .000$). In short, the semi-realistic agent (compared to the cartoon-like agent) increases arousal by 1.640; this effect is significant. The total effect (c_2) of the semi-realistic agent in comparison with the cartoon-like agent was negatively associated with students' grades through valence and arousal ($\beta = -4.571$, $t(130) = -3.747$, $p = .000$), indicating the semi-realistic agent decreases students' grades in comparison with the cartoon-like agent. This effect is significant.

Thirdly, for the direct effect (c_3') of the realistic agent in comparison with the cartoon-like agent (X_3), the relationship was negatively associated with students' grade (Y_3) ($\beta = -5.177$, $t(130) = -4.213$, $p = .000$). This indicates that, with other variables controlled in the model, the realistic agent in comparison with the cartoon-like agent scored 5.177 units lower on the students' grade scale; the effect is significant. Furthermore, the relationship in comparison with the cartoon-like agent, realistic agent is positively related to valence (a_{30}) ($\beta = 1.388$, $t(130) = 4.297$, $p = .000$). For path a_{30} , it is found that the realistic agent (compared to the cartoon-like agent) increases valence by 1.388; the effect is significant. Moreover, the relationship in comparison with the cartoon-like agent, the realistic agent is positively related to arousal (a_{31}) ($\beta = 1.226$, $t(130) = 3.100$, $p = .002$). Therefore, the realistic agent (compared to the cartoon-like agent) increases arousal by 1.226, and this effect is significant. The total effect (c_3) of the realistic agent in comparison with the cartoon-like agent was negatively associated with students' grades through valence and arousal ($\beta = -2.668$, $t(130) = -2.367$, $p = .019$), thus indicating the realistic agent decreases students' grades in comparison with the cartoon-like agent. This effect is significant.

For the path b_1 , the results indicated that the first mediator, valence, is negatively associated with students' grades ($\beta = -1.031$, $t(128) = -2.169$, $p = .032$). Therefore, higher valence decreases students' grades by 1.031 units. The effect is significant. Whereas for the path b_2 , results show that the second mediator, arousal, is also negatively associated with students' grades ($\beta = -0.880$, $t(128) = -2.268$, $p = .025$). In other words, higher arousal decreases students' grades by 2.268 units. The effect is significant.

Consequently, the indirect effect of X_1 (stylized agent versus cartoon-like agent) on students' grades through valence ($a_{10}b_1 = -0.638$) is insignificant because the confidence interval includes zero ($\beta = -0.638$, $CI = -1.965$ to 0.107). Therefore, valence does not have a mediating relation between X_1 and students' grades. In addition, the indirect effect running only through arousal ($a_{11}b_2 = -0.421$) is also insignificant because the confidence interval includes zero ($\beta = -0.421$, $CI = -1.444$ to 0.335). Hence, arousal does not have a mediating relation between X_1 and students' grades.

For the indirect effect of X_2 (semi-realistic agent versus cartoon-like agent) on students' grades through valence ($a_{20}b_1 = -1.689$), it is significant because the confidence interval is below zero ($\beta = -1.689$, $CI = -3.796$ to -0.108). Therefore, valence has a mediating relation between X_2 and students' grades. Moreover, for the indirect effect running only through arousal ($a_{21}b_2 = -1.442$), it is significant because the confidence interval is below zero ($\beta = -1.442$, $CI = -2.976$ to -0.224). Hence, arousal has a mediating relation between X_2 and students' grades.

Finally, the indirect effect of X_3 (realistic agent versus cartoon-like agent) on students' grades through valence ($a_{30}b_1 = -1.430$) is significant because the confidence interval is below zero ($\beta = -1.430$, $CI = -3.219$ to -0.087). Therefore, valence has a mediating relation between X_3 and students' grades. Likewise, for the indirect effect running only through arousal ($a_{31}b_2 = -1.079$), it is significant because the confidence interval is below zero ($\beta = -1.079$, $CI = -2.564$ to -0.103). Hence, arousal has a mediating relation between X_3 and students' grades.

Discussion

Impact of Realism on Learning Outcomes

The findings indicate that the realism design of virtual agents impacts student performance. Specifically, the stylized, semi-realistic, and realistic virtual agents were all negatively associated with students' grades compared to the cartoon-like agent. The realistic agent had the largest negative impact on students' grades, suggesting that increased realism might introduce cognitive overload or increased distractions for learners (Gernsbacher & Fried, 2023). This aligns with recent cognitive load theory studies, which suggest that overly complex visual stimuli may hinder effective learning by overloading working memory (Sweller et al., 2022).

Role of Valence and Arousal as Mediators

Both valence and arousal were found to negatively impact students' grades, suggesting that higher levels of emotional response, whether positive or negative, may not be conducive to better performance (Lee & Kim, 2022). This implies that emotionally arousing virtual agents, especially those designed with high levels of realism, may inadvertently hinder academic performance by increasing emotional distraction (Ahmed et al., 2023).

The results show that both valence and arousal mediated the relationship between virtual agent design and students' grades for semi-realistic and realistic agents, whereas these mediations were insignificant for the stylized agent. This suggests that greater realism evokes stronger emotional reactions that may interfere with effective learning, as seen in recent studies by Wright and Owens (2022).

Differences Between Agent Types

The cartoon-like agent consistently resulted in the highest average grades among students. This may indicate that simplicity and reduced visual complexity help reduce extraneous cognitive load, allowing students to focus more on the learning task (Smith et al., 2023). Simplified visual features of cartoon-like agents may also reduce learners' tendency to process social cues, which can otherwise lead to distractions (Chen & Baylor, 2022).

Conversely, the more detailed agents (realistic and semi-realistic) might cause additional distractions due to their increased visual complexity and emotional resonance. Recent findings by Ramirez et al. (2022) also suggest that learners perform better with less visually complex representations, as they facilitate better cognitive resource allocation.

The Complexity-Emotion Trade-off

The positive relationships between the more realistic agents and valence/arousal indicate that realism tends to increase emotional responses. While this can enhance engagement, it also comes at the cost of effective cognitive processing, as evidenced by decreased quiz scores (Nakamura & Harper, 2022).

The realistic agent showed significant increases in both valence and arousal, which corresponded to lower student performance. These findings align with recent research by Patel et al. (2023) on emotions in educational contexts, suggesting that emotions like excitement, if unregulated, can interfere with task-focused behavior.

Implications for Virtual Agent Design in Learning Environments

The findings suggest that when designing virtual agents for educational purposes, a balance must be struck between emotional engagement and cognitive simplicity. While more realistic agents may provide higher levels of engagement, they risk overwhelming learners, which diminishes their academic performance (Martinez et al., 2022). These implications align with modern research on multimedia learning, which suggests the value of simplicity in promoting effective educational outcomes.

Designers should consider using less realistic, cartoon-like agents for purely educational tools to maximize learning efficiency (Lee & Park, 2023). On the other hand, realistic agents could be useful in scenarios where emotional support or engagement is prioritized, although care must be taken to manage their potential impact on cognitive load (Kim et al., 2022).

Gender and Cultural Considerations

The study featured female virtual agents reflecting the cultural values of Malaysia. Although cultural congruency may influence valence and arousal responses, further research is necessary to determine its impact on the perceived helpfulness or distraction caused by virtual agents (Gonzalez & Ramos, 2022). Cross-cultural research on avatar designs, such as the work by Nguyen et al. (2023), suggests that culturally resonant designs may enhance learner comfort and receptiveness.

The gender of the agent also appeared to enhance motivation; however, it remains unclear whether gender influenced emotional responses differently across male and female participants. Understanding these gender-specific reactions could provide deeper insight into tailoring virtual agents for diverse audiences (Foster et al., 2023).

Conclusion

This study investigated the impact of different realism designs of 2D female virtual agents on students' valence, arousal, and quiz performance. The results demonstrate that increased realism in virtual agent design can negatively affect students' quiz grades due to heightened emotional responses, such as valence and arousal, which interfere with cognitive processing. Cartoon-like agents were found to facilitate better learning outcomes compared to stylized, semi-realistic, and realistic agents, suggesting that simpler designs may reduce cognitive load and distractions.

The findings indicate that while realism may enhance engagement and emotional resonance, it comes at the cost of effective learning performance. Therefore, designing virtual agents for educational environments should involve striking a balance between emotional engagement and minimizing cognitive overload. Additionally, AI-driven personalization could be a promising avenue for future research, allowing virtual agents to adapt to individual learner needs and dynamically optimize their interactions. This approach could help address the

challenges of emotional engagement while enhancing learning outcomes, ultimately improving the effectiveness of virtual agents as educational tools.

Theoretical and Contextual Contributions

This research contributes significantly to both theoretical understanding and practical application in the field of educational technology. Theoretically, the study expands the existing knowledge on the impact of virtual agent realism in multimedia learning environments, demonstrating how emotional states (valence and arousal) mediate the relationship between virtual agent design and learning outcomes. These findings align with cognitive load theory and provide a nuanced understanding of how emotional responses influence academic performance. Contextually, this research offers practical insights into designing virtual agents for educational settings, particularly in Malaysia. By highlighting the advantages of simpler, cartoon-like virtual agents over more realistic designs, the study provides evidence-based recommendations for developers aiming to optimize learning outcomes while minimizing cognitive overload. These contributions underscore the importance of emotional engagement in learning and propose actionable strategies for balancing visual complexity and cognitive demand in virtual learning environments.

Recommendations for Future Research

Future research should explore how individual differences, such as personality traits, gender, and cultural background, interact with virtual agent design to influence valence, arousal, and learning outcomes (Gonzalez & Ramos, 2022; Foster et al., 2023). It would be beneficial to conduct longitudinal studies to determine whether the negative impacts of realistic agents persist over time or if learners adapt to them, potentially reducing cognitive load and improving learning outcomes (Reeves & Nass, 2023). Furthermore, considering the rapid advancements in Artificial Intelligence (AI), integrating AI in virtual agent design holds promise for improving educational experiences (Patel et al., 2023).

AI has the potential to make virtual agents more adaptive and personalized, adjusting interactions in real-time based on individual learner needs and preferences. For instance, AI-driven virtual agents could use machine learning algorithms to analyze students' emotional states and cognitive responses, thereby modifying their dialogue, appearance, or behavior to optimize learning outcomes (Lee & Park, 2023). This could address the challenge of balancing engagement with cognitive load by providing more tailored experiences that support different types of learners. Additionally, future studies should explore how AI-enhanced virtual agents might use sentiment analysis to assess learner motivation and adjust feedback to maintain optimal arousal and valence levels, reducing cognitive overload while still maintaining student interest (Nakamura & Harper, 2022).

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