Empirical results for the use of facial expressions and body gestures in e-learning tools

Marwan Alseid and Dimitrios Rigas

***Abstract*—** In this paper, an empirical study investigating the use of avatars as virtual lecturers in e-learning interfaces is described. The primary focus is to present and discuss the experimental results related to users' views and evaluations of individual facial expressions and body gestures used in the experimental e-learning tools in both the presence and absence of interactive context. Three different e-learning platforms were built to be tested in the experiment each of which used a human-like avatar as a virtual lecturer in the presentation of three different lessons about class diagram notation. The experiment has been carried out employing the within-subject approach with 48 users each of them participated individually. The obtained results demonstrated the importance of specific expressions and gestures that can be used by virtual lecturers in e-learning tools to improve users' motivation and interest about the presented learning material. These results highlighted the need for further research to evaluate more facial expressions and body gestures.

***Keywords*—** Avatar, Body gestures, E-Learning, Facial expressions, Multimodal metaphors, Usability.

I. Introduction

E-LEARNING is a general term that is used to describe the learning process in which information and communication technology could be utilized [1, 2]. Recently, most of e-learning interfaces largely depend on text and graphics as an information delivery means. Making use of multimodal interaction metaphors such as speech, sounds and avatars with facial expressions and body gestures is still limited and need to be investigated more. The experimental study described in this paper is one of the main experiments in a research program that amid at exploring the usability aspects of multimodal e-learning systems. Previous experiment [3, 4] in this research showed that the inclusion of avatar, earcons and recorded speech could be beneficial in e-learning interfaces. However, it highlighted the need for further research to explore the contributing role of each of these metaphors. This experiment, examined the role of avatar's facial expressions and body gestures in an interactive e-learning interfaces. In this paper, results related to users' evaluation of these expressions and gestures are presented. Sections 2 and 3 present an overview of the relevant work in e-learning and multimodal interaction. In section 4, the experimental e-learning platforms are detailed. Section 5 describes the design of the experimental study while section 6 present and discuss the experimental results. Finally, section 7 provides the conclusion of this paper and the directions for future research.

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II. E-Learning

The accelerated developments in computer networks and machines resulted in facilitating easier and faster access to a huge amount of educational content. Therefore, research in the field of e-learning as well as the technologies employed in the development of e-learning applications has been increased. Scheduled and on-demand delivery platforms are examples of the technology used in e-learning [5]. Scheduled delivery platforms such as video broadcasting, remote libraries, and virtual classrooms imitates real learning environments but with time and place limitations. This technology has been enhanced by the on-demand delivery platforms that facilitate anytime and anywhere learning in the forms of interactive training CD ROMs and web-based training. The Internet technology could be beneficial for the learning process in terms of handling the learning content and monitoring students' progress [6]. It is expected that there will be about five million online learners within the next ten years [7]. In comparison with traditional learning, e-learning offers more flexible learning in terms of time and location and allows better adaptation to individual needs [6]. E-learning also enables online collaborative learning over the Internet [8] and could be used to suit a variety of pedagogical teaching approaches [9]. Additionally, e-learning could increase learners' motivation and interest about the presented material [10]. Nevertheless, technology needed in e-learning is not always accessible [11]. Furthermore, it was found that students felt uncomfortable using computers and missed traditional face-to-face interaction with teacher. Therefore, users' accessibility and their attitude in regard to e-learning should be enhanced [12].

Pedagogically, it is not always true that every e-learning virtual environment provide high-quality learning and so,

fundamental pedagogical principles must be applied to insure successful e-learning solutions [13]. According to Govindasamy [13], development and evaluation of e-learning involves learner and task analysis, defining instructional objectives and strategies, testing the environment with users and producing the initial version of the e-learning tool. Also, e-learning interfaces should be designed to support users' individual differences and enable them to learn independently[14].

III. Multimodal Interaction

Multimodal interaction is a human computer interaction in which more than one of human senses are involved. It could be utilised to enhance the usability of user interfaces. Multimodality allows conveying different information using different channels [15]. Also, it enables users to employ the most suitable communication metaphor to their abilities [16]. So, learning experience could be enhanced by the assistance of Information and Communication Technology (ICT) where visual, aural, haptic and other channels could be integrated in a multimodal approach to perceive and learn the communicated disciplines.

Sound and visual output are complement to each other and variety of information could be distributed across both. However, sound is more flexible because it can be heard from all sides without paying visual attention to the output device. Speech sounds could be used to communicate the current state of the system through auditory feedback [17]. It also could help users with visual disability [18]. Speech sounds could be categorized into natural speech and synthesized speech. Comparing to the synthesized speech which is created by speech synthesizers, natural speech has been found to be more understandable [19]. A study performed by Ciuffreda and Rigas [20] showed that speech sounds could contribute with other multimodal interaction metaphors such as graphics and non-speech sounds in improving the usability level of search engines interfaces in terms of learnability and memorability of users as well as reducing their errors and the time they spent in completing the required searching tasks. It was found that the incorporation of recorded speech and short musical sounds (earcons) helped users to perform different learning tasks more successfully [21].

A. Avatars

Avatar is another interface component through which both of auditory and visual human senses could be involved. It is a computer-based character that could be utilized to represent human-like or cartoon-like characters [22]. It has been used in interactive computer interfaces to communicate verbal and non-verbal information through facial expressions and body gestures [23]. Facial expressions show human emotions, feelings, and linguistic information through different modalities such as lip synchronization, eye gazing and blinking [24] however, body movements are usually used in every day life to confirm our speech. According to Gazepidis and Rigas [25], the most popular facial expressions are happy, interested, amazed, and positive surprised. It was found that users' satisfaction and their ability to understand and remember the provided knowledge has been enhanced by the incorporation of speaking avatar with facial expressions [26]. Also, facially expressive avatars were used to improve users' involvement and enjoyment in instant messaging applications [27]. Several studies have been carried out to evaluate the role of avatar as a pedagogical agent in e-learning. Results of these studies showed the positive contribution of avatars in terms of facilitating the learning process [28-30]. Furthermore, avatars could be employed in e-learning environments to enhance users' attitude towards online courses [31]. Fabri et al. [32] suggested that facially expressive avatars could be used to teach users with special needs (i.e. autism). A study conducted by Theonas et al. [10] demonstrated that the use of facial expressions particularly the smiling resulted in a more interesting and motivating learning experience and improved students' performance. Based on users' views, we tried in part of this research to find out which facial expressions and body gestures are more significant for the production of an expressive and attractive avatar to be used in multimodal interactive e-learning systems.

IV. Experimental E-Learning Platforms

To serve as a basis for this empirical study, three different e-learning platforms were built from scratch. These platforms has been designed to utilise speaking avatars as virtual lecturers in addition to textual brief notes and graphics across three instances of a multimodal interaction that offers an audio-visual presentation of three different lessons about class diagram notation. These three lessons communicated information about (1) classes and objects, (2) class naming and drawing, and (3) associations and multiplicity. The content of these lessons were adapted from [33] and its duration was 3.24, 3.28 and 5.9 minutes respectively. Although the presentation of these lessons varied among the three platforms, the content and the format was the same.

Fig. 1 shows a screenshot of the first platform which utilized an expressive avatar with facial expressions and so called Virtual Lecturer with Facial Expressions (VLFE). The second platform (see Fig. 2) provided an avatar with full body animation and gestures and called Virtual Lecturer with Body Gestures (VLGB). Upon completion of each lesson, both of the first and second platforms allowed the user to textually ask two questions related to the presented material. In order to insure consistency, these questions were the same for all users. The answers were provided by the speaking virtual lecturer with textual and graphical explanations. In the third platform (see Fig. 3), male and female avatars with facial expressions were included and shared the presentation of each lesson. Therefore, it has been named TVLFE or Tow Virtual Lecturers with Facial Expressions. Additionally, the last platform included two more avatars to represent male and female students. In contrast to the first and second platforms, the role of the latter tow avatars was to ask the questions

vocally. Furthermore, all experimental platforms offered the pause/play functionalities in its interfaces to provide more control on the learning process. Fig. 4 shows the facial expressions used in the experiment. The same 6 expressions were used in both VLFE and TVLFE. These expressions were grouped into positive (interested, amazed, happy and smiling) and neutral (neutral and thinking) expressions [34]. Also, in addition to walking and neutral, a set of 8 body gestures were used in the VLBG (see Fig. 5) and categorised into positive (hands clenching – front and back, open palms, pointing, chin stroking and hands steepling) and negative(arms folded and legs grossed) groups [35].

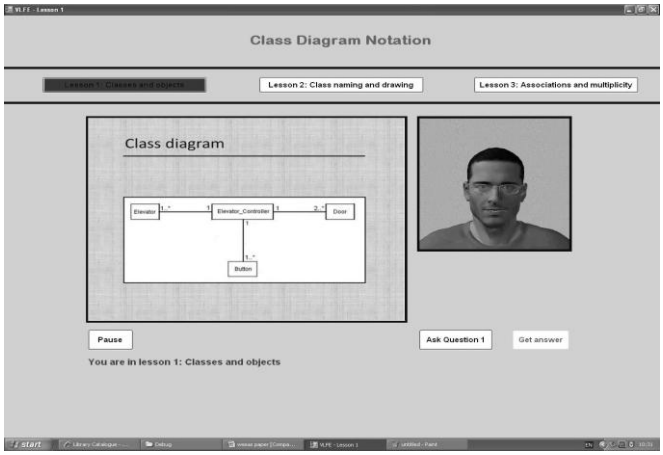

Fig. 1 An example screenshot of the virtual lecturer with facial expressions platform (VLFE)

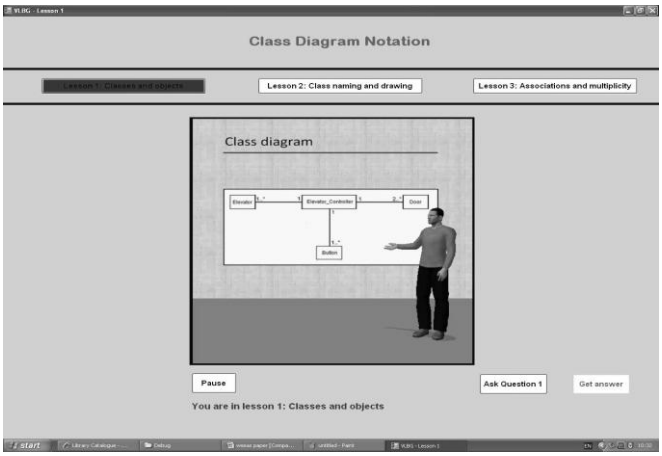

Fig. 2 An example screenshot of the virtual lecturer with full body gestures platform (VLBG)

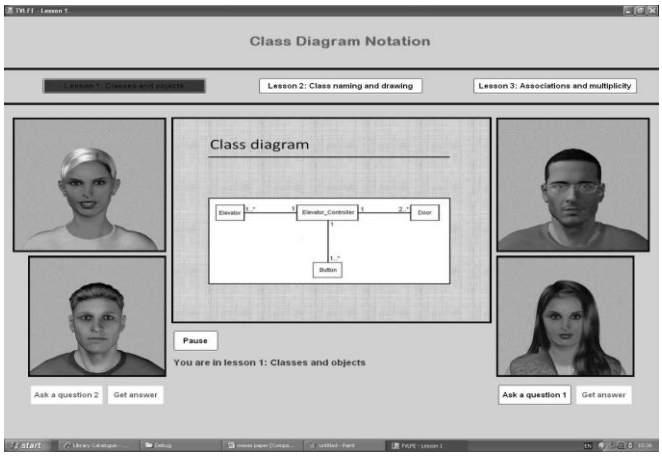

Fig. 3 An example screenshot of the two virtual lecturers with facial expressions platform (TVLFE)

V. Experiment

One of the main aims of this study was to obtain a detailed feedback for the use of particular facial expressions and body gestures in the presence and absence of interactive e-learning context, and to explore whether these expressions and gestures could attract users, motivate them and increase their interest regarding the presented learning material.

A. Hypothesis

Two main hypotheses have been formed. The first one stated that the positive facial expressions as well as the positive body gestures will also be rated positively by users when being used in a non-interactive context for the communication of learning material. The second hypothesis stated that specific facial expressions and body gestures will be more pleasant and attractive for users when used by an expressive avatar in an interactive e-learning.

B. Variables

The variable types considered in the experiment were controlled, dependant, and independent. The controlled variables depended on the experimenter to keep consistency throughout the experiment were all users performed the same tasks and none of them were aware of these tasks. The independent variables were the presentation methods of the facial expressions and body gestures therefore, non-interactive context, and the three experimental platforms. The dependant variables included users' ratings and selections of the presented facial expressions and body gestures.

C. Users

There were 48 users participated in the experiment in an individual basis. The majority of users were postgraduate students coming from a scientific background and their age ranged from 25 to 44 years. Also, most of them had no or limited experience in both of avatars and class diagram notation, and weekly used the computer ten or more hours. Seventy-three percent of those were male and the remaining users were female.

D. Tasks

Prior to the experiment, four tasks were required from each user. In the first task, facial expressions were individually shown along with their titles assuming that these expressions will be used by a virtual lecturer. User had to give his/her rating; positive or negative, in regard to the usage of each expression in the absence of learning context. The second task was selecting two expressions that user did like and two that he/she did not like. The third and fourth tasks were similar to

Fig. 4 Facial expressions used in the experimental e-learning platforms

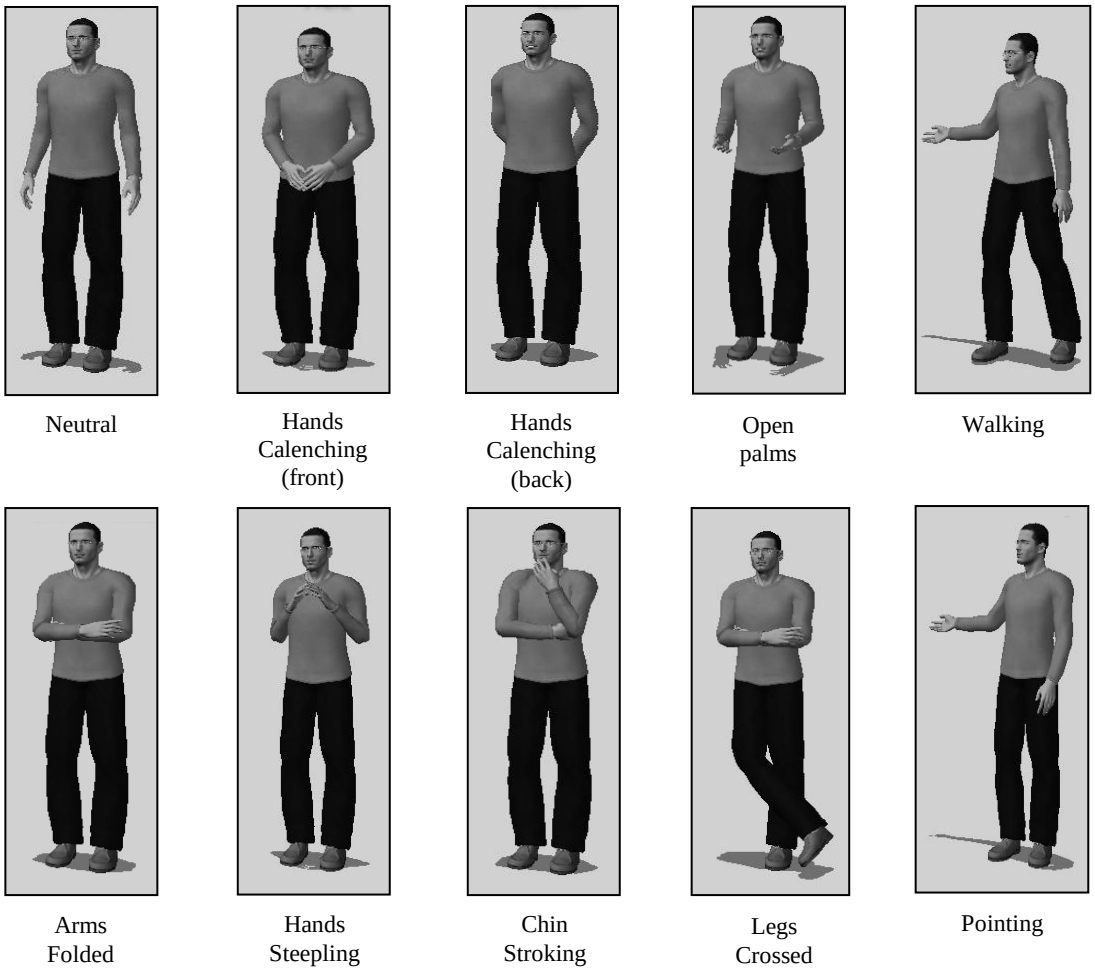

Fig. 5 Body gestures used in the experimental e-learning platforms

the first two tasks but this time body gestures were presented. Another three post-conditional tasks were required each of which asked users to rate positively or negatively each expression or gesture used by the virtual lecturer(s) in the tested interface.

E. Procedure

In order to fulfill the aim of the study, a within-subject approach was employed in carrying out the experiment. The experiment was explained to each user and started by filling the pre-experimental questionnaire for user profiling. Then, the pre-experimental tasks were performed. Thereafter, 2-minute video recording was presented demonstrating the experimental platforms. Once this recording had finished, three lessons about class diagram notation were introduced in an interactive learning context. The order of these lessons was constant for all users but each experimental platform had to be used for the presentation of only one lesson. In order to control the learning effect and to make sure that all experimental platforms had been equally used for the presentation of each lesson, these platforms were assigned to the three lessons on a systematic random rotation basis. Upon the completion of each lesson, user has been asked to answer 4 questions related to the

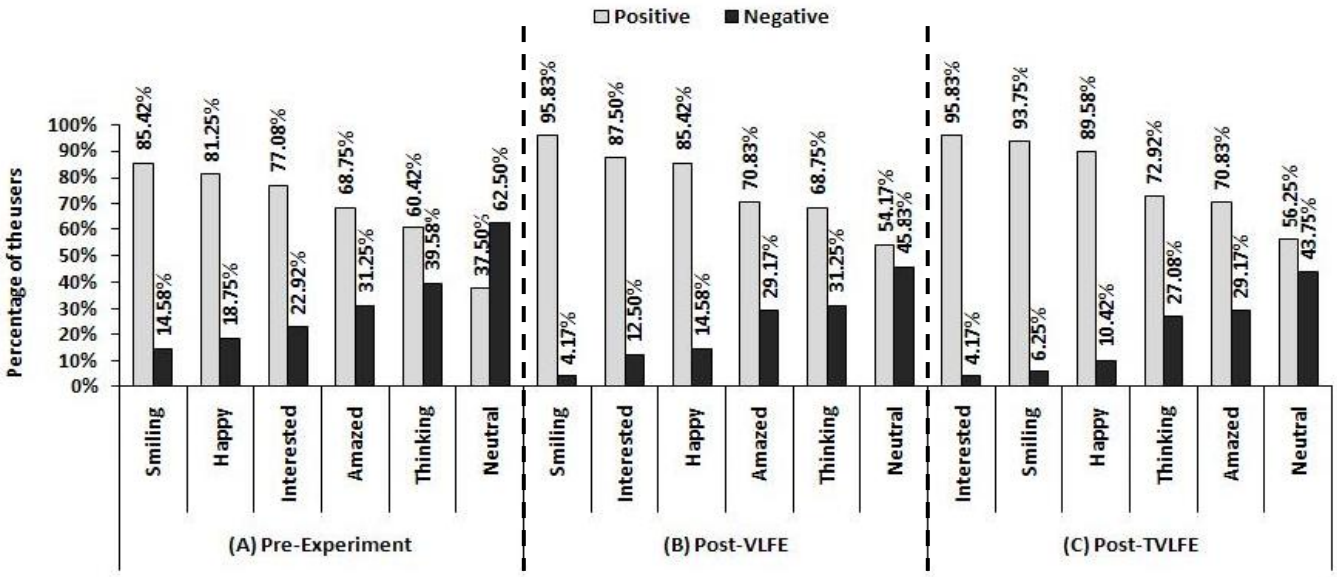

Fig. 6 Users' views of facial expressions used in the study prior to the experiment (A), and after experimenting each of the platforms: virtual lecture with facial expressions (B) and two virtual lecturers with facial expressions (C)

delivered learning material and to execute the post-conditional tasks. Also, user has been informed to answer satisfaction questionnaire regarding his/her experience with the applied interface.

VI. Results and Discussion

Fig. 6(A) shows how users evaluated each facial expression used in this study prior to experimenting any of the three experimental platforms. It could be noticed that more than 65% of the participants believed that the positive expressions such as smiling, happy, interested and amazed could be used positively by the virtual lecturer. The percentage for smiling expression reached about 85% and dropped down for the happy, interested and amazed expressions to about 81%, 77% and 68% respectively.

Table I. The Chi-square values for the facial expressions used in the absence of interactive learning context (significant values are shown in bold)

Facial Expressions	χ^2	CV	P	df
Neutral	3.00	3.84	0.05	1
Interested	**14.08**	3.84	0.05	1
Amazed	**6.75**	3.84	0.05	1
Happy	**18.75**	3.84	0.05	1
Smiling	**24.08**	3.84	0.05	1
Thinking	2.08	3.84	0.05	1

For the thinking expression, the results were less significant with 60% positive views. On contrast, the neutral expression had about 37 % of users' positive views which means that they had a negative impression about it. Table I shows the χ^2 values for these expressions. Positive expressions such as interested, amazed, happy, and smiling obtained positive significant results whereas the neutral expressions (i. e. neutral and thinking) did not show any significance.

Fig. 6(B) and Fig. 6(C) demonstrates that users' feeling became more positive in regards to the majority of the same facial expressions used by the virtual lecturers in interactive e-learning environment provided in both of VLFE and TVLFE platforms. This is, in particular, for the neutral expression were the percentage of positive views improved from 37% to about 55% in both VLFE and TVLFE conditions. All other expressions were positively rated by higher percentages with some differences. Comparing to post-VLFE, the interested, thinking and happy expressions obtained better results in post-TVLFE with 18%, 12% and 8% increments respectively. On the other hand, smiling scored the higher positive percentage in post-VLFE. Lastly, users' rating was the same for amazed expression after experimentation of both VLFE and TVLFE.

Table II. The Chi-square values for the facial expressions used in the presence of interactive e-learning context (significant values are shown in bold)

Facial Expressions	Post-VLFE	Post-TVLFE	CV	P	Df
Neutral	0.33	0.75	3.84	0.05	1
Interested	**27.00**	**40.33**	3.84	0.05	1
Amazed	**8.33**	**8.33**	3.84	0.05	1
Happy	**24.08**	**30.08**	3.84	0.05	1
Smiling	**40.33**	**36.75**	3.84	0.05	1
Thinking	**6.75**	**10.08**	3.84	0.05	1

The χ^2 values for these expressions after being used in an interactive e-learning context are shown in Table II. In spite of the large shift of users' rating of the neutral expression, its χ^2

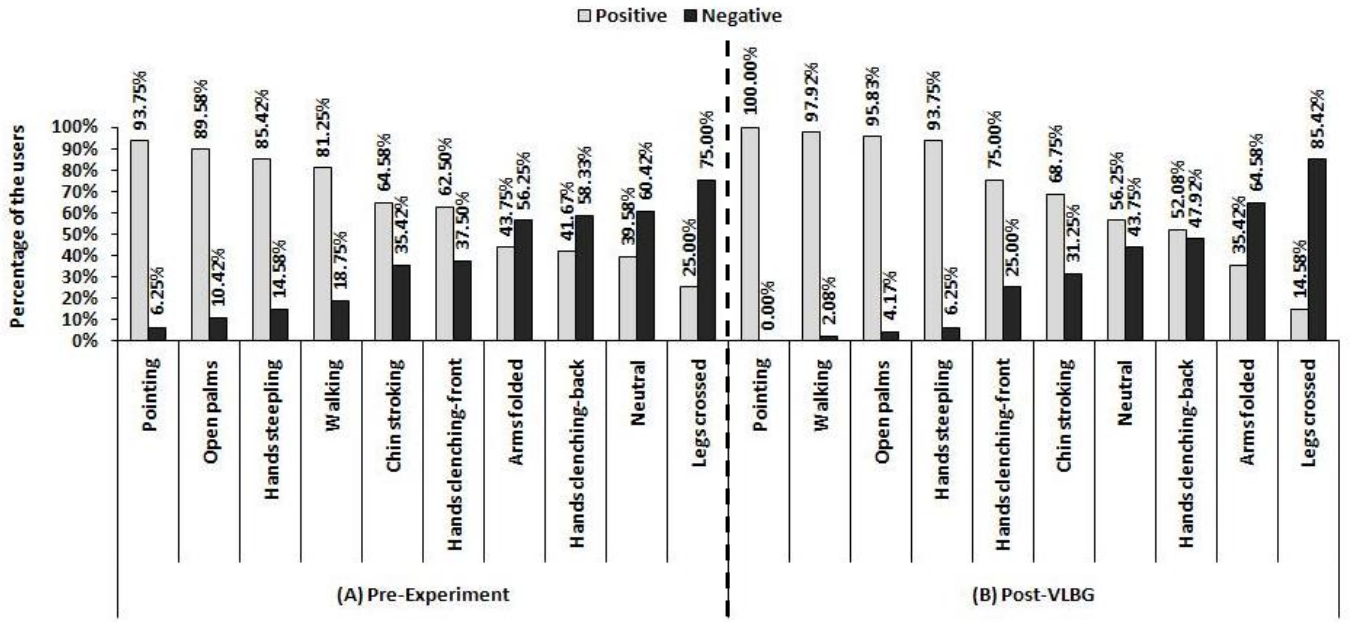

Fig. 7 Users' views of body gestures used in the study prior to the experiment (A) and after experimentation of the virtual lecture with body gestures platform (B).

value did not reach a positive significant level whereas users' evaluation of the thinking expression became significantly more positive. The other expressions preserved their positive significant results.

Fig. 7(A) shows users' evaluation of body gestures when presented to them individually in the absence of any interactive e-learning context. For the positive group, it could be seen that these body animations were evaluated positively. The pointing posture obtained 93% positive score, followed by 89% for the open palms and 85% for the hands steepling. A lower positive score was found for the chin stroking (64%) and front clenching of the hands (62%). However, the back clenching of hands which has been supposed to be positive gesture was perceived negatively by 41% of the users. For the negative gestures, about 75% of the users showed a negative feeling regarding the legs crossed. This percentage dropped down to about 56% for folding the arms. What is more, 60% of the users believed that neutral situation gives a negative impression, and another 81% of them found that the use of walking could be positive.

As can be seen in Table III, the open palms, pointing, hands steepling, chin stroking, and walking obtained positive significant ratings when has been presented in a non-interactive context. As far as the negative gestures are concerned, the legs crossed gesture obtained negative significant results. The remaining gestures did not show significant results neither positively nor negatively. Fig. 7(B) reveals that including specific body gestures in interactive e-learning interfaces could be attractive for users. In comparison with the pre-experimental results, users' positive feeling was improved in regards to all positive gestures as well as the neutral and walking when these gestures have been used by the virtual lecturer.

Table III. The Chi-square values for the body gesture used in both the absence and presence of interactive e-learning context (significant values are shown in bold)

Body Gestures	Pre-experiment	Post-VLBG	CV	P	df
Neutral	2.08	0.75	3.84	0.05	1
Hands clenching-front	3.00	**12.00**	3.84	0.05	1
Hands clenching-back	1.33	0.08	3.84	0.05	1
Open palms	**30.08**	**40.33**	3.84	0.05	1
Arms folded	0.75	**4.08**	3.84	0.05	1
Pointing	**36.75**	**48.00**	3.84	0.05	1
Hands steepling	**24.08**	**36.75**	3.84	0.05	1
Chin stroking	**4.08**	**6.75**	3.84	0.05	1
Legs crossed	**12.00**	**24.08**	3.84	0.05	1
Walking	**18.75**	**44.08**	3.84	0.05	1

In particular, the positive scores of neutral and hands clenching (back) were rose around 17% and 11% respectively. Also, the pointing was positively rated by all users and 93% to approximately 96% of them found hands steepling and open palms positive. For other gestures in the positive group, users' positive rating was 75% and 68% for front hands clenching and chin stroking respectively. Concerning the negative gestures, participants in the experiment confirmed their evaluation of both arms folded and legs crossed were the negative score for these gestures increased approximately10%. The χ^2 values for users' views about all gestures after being used in the experimental VLBG platform (refer to Table III) exhibits that the positive gestures (i. e. front clenching of hands, open palms, pointing, hands steepling, and chin

stroking) as well as walking gesture obtained positive significant results whereas the negative gestures such as arms folding and legs crossing showed negative significant results. Although users largely change their perceptions of the neutral and back clenching of hands, these gestures showed no significance.

Fig. 8 presents users' selections of the facial expressions and body gestures when shown to them individually in the absence of any interactive e-learning interface. Users were asked to choose two expressions that they mostly liked and another two that they did not like. It could be observed from Fig. 8(A) that the positive expressions were liked by more than about 55% of those users who selected it specially the smiling with 86% (χ^2=18.78, CV=3.84, P=0.05, df=1) and happy with 81% (χ^2=12.50, CV=3.84, P=0.05, df=1). Also, users' expressed their liking for the interested and amazed expressions though the χ^2 values of these expressions were 1.09 and 0.18 respectively showing no significance. The neutral and thinking expressions were selected to be significantly strongly disliked. The χ^2 values for neutral and thinking were 21.13 and 6.43 respectively. On the whole, the users were satisfied better with positive facial expressions.

Fig. 8(B) shows users' choices of the 2 gestures they liked and the 2 gestures they did not like. The open palms gesture was liked by all users who selected it, followed by the pointing with 91% liked percentage. This percentage was ranged between 68% and 88% for the remaining positive gestures excluding the back clenching of the hands. In spite the fact that this gesture (i.e. hands clenching-back) has been regarded as a positive one, results showed that it was the most hated among all gestures. In addition, the gestures legs crossed, neutral and arms folded were not satisfactory because these gestures were disliked by users noticeably. Table IV shows the χ^2 values for users' selections of the applied body gestures when being presented prior to the experiment in the absence of any interactive e-learning context. Users who selected the arms folded, neutral, back clenching of hands, and legs crossed gestures significantly expressed their antipathy in regards to these gestures. The front clenching of hands as well as the chin stroking were selected to be liked by users however its χ^2 values were not significant. The remaining gestures were significantly liked by users who selected it.

Table IV. The Chi-square values of users' selections of the body gesture presented in the absence of interactive e-learning context (significant values are shown in bold)

Body Gestures	χ^2	CV	P	df
Neutral	**9.94**	3.84	0.05	1
Hands clenching-front	1.60	3.84	0.05	1
Hands clenching-back	**22.15**	3.84	0.05	1
Open palms	**20.00**	3.84	0.05	1
Arms folded	**9.00**	3.84	0.05	1
Pointing	**15.70**	3.84	0.05	1
Hands steepling	**9.94**	3.84	0.05	1
Chin stroking	2.58	3.84	0.05	1
Legs crossed	**17.64**	3.84	0.05	1
Walking	**4.26**	3.84	0.05	1

The results of the experiment demonstrated that specific facial expressions and body gestures could be more appealing and attractive when being used by virtual lecturers in an

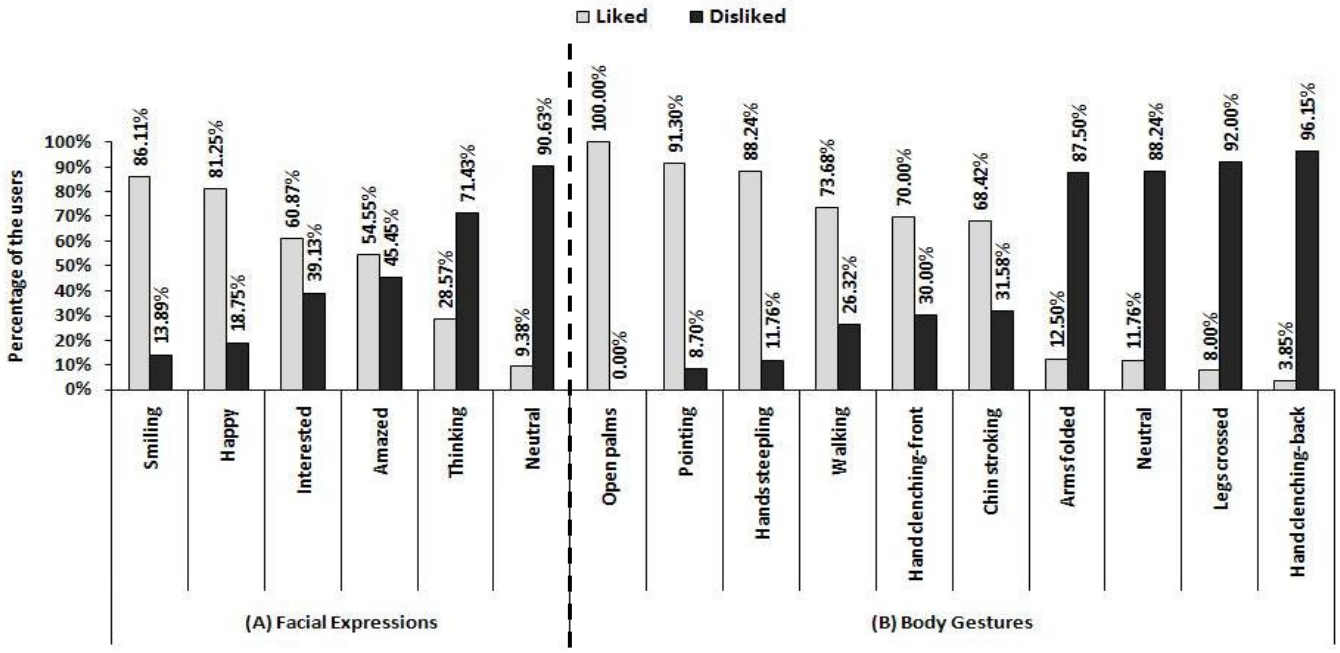

Fig. 8 Users' selections of facial expressions (A) and body gestures (B) used in the study prior to the experiment.

interactive e-learning context. These results have supported what have been hypothesized.

VII. Conclusion and Future Work

The conducted empirical study reported in this paper aimed at investigating users' evaluation of facial expressions and body gestures when shown in the presence and absence of interactive e-learning interfaces. This investigation was carried out by employing a within-subject testing of three experimental platforms. These platforms incorporated avatars as virtual lecturers with facial expressions and body gestures to present three different lessons about class diagram notation. The obtained results demonstrated that the expressions interested, happy, smile and amazed were the most satisfactory for users. As far as the body gestures are concerned, the pointing, walking, open palms, hands steepling and front clenching of hands were the most positively perceived by the users. We believe that the results of this research will contribute in the design and production of a more attractive avatar to be used as a virtual pedagogical agent in e-learning applications. However, still there is a need for further research to examine more facial expressions and body gestures in this domain.

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