Introducing eye blink of a student to the virtual world and evaluating the affection of the eye blinking during the e-Learning

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Abstract

Problem Based Learning (PBL) is an educational process by which problem-solving activities and instructor's guidance facilitate learning. The PBL is suffered from the current issues in the traditional education system such as enhancing quality, reducing cost and increasing access. Virtual e-Learning (VeL) can be overcome those issues and become a major way of delivering the knowledge. The VeL is in early stage and there are many ways to enhance the effectiveness of the VeL. The establishment of the non-verbal features, which are essential elements in the education process, [1] is a one way of improving the quality of VeL. One of the non-verbal features (Eye blink) is visualized in the VeL and the affection of that non-verbal feature to the VeL is accessed in this research. The eye blink, which is an important non-verbal feature of the real student [2], is mirrored in the VeL environment. The affection of the eye blink was evaluated through an experiment with the responses of the e-Learning participants. The experiment consisted by PBL sessions with and without eye blinking. The evaluated factors of the questionnaire showed that a high rate of positive responses during the sessions with the eye blinks than the session without the eye blinks and also the difference of the mean ranks is 25%. Further, Mann-Whitney U test is utilized to analyze the responses of the students to determine whether there is a significant difference in the sessions with and without the eye blinking. It is identified that the eye blink helps to enhance the effectiveness of the group discussion significantly over the effect size value (r) of the selected factors have more than 0.62 suggested a moderate to high practical significance when they utilized the eye blinks in the VeL.

Keywords: Virtual e-Learning (VeL); Problem-based learning (PBL); Eye blink; Non-verbal

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1. Introduction

The current pedagogical system is didactic continuously with the advancement of the technology. The education process happens with the teacher as a source of information, which encourages students for surface learning. Students are allowed to use their previous knowledge with newly acquired knowledge with the Problem-Based Learning (PBL) which is an ideal educational method while students are working as a group [3]. The PBL is a conception of knowledge, understanding and education profoundly different from the more usual conception underlying subject-based learning [4]. The PBL environments use problems as an instrument to improve student’s problem solving skills and to teach them new concepts [5].

Although the PBL is a valuable method to deliver the knowledge, it is also tackled the key issues of the education such as enhancing quality, reducing cost and increasing access [6]. The advancement of technology has been perceived the solution for those issues while providing the virtual space for the learning. A virtual learning environment is a set of teaching and learning tools designed to enhance a student's learning experience by including computers and the Internet in the learning process [7]. The PBL can conduct in the virtual space and that is an ideal way to establish the education process to obtain the maximum outcome with overcoming the problems of the conventional methods.

When the PBL conducts in the virtual environment, the communication plays an important role to establish an effective connection among the group members since the PBL based on the exchange ideas among the group members. The non-verbal owns the highest portion and only the 7% contribution is given by verbally in the communication process based on the Merabian’s model [8]. Some of the non-verbal cues are posture, eye blink, gestures with hands and arms, speech and tone of voice. The non-verbal cues are very important and powerful way to exchange ideas in any process including the education due to the following reasons [9].

- Non-verbal signals are powerful: Non-verbal cues express inner feelings
- Non-verbal messages are likely to be more genuine: because non-verbal behaviors cannot be controlled as easily as spoken words.

Currently, the virtual e-Learning environment is lack with the non-verbal communication which is necessary component for the PBL.

In addition, the virtual identity is very important in the virtual learning environment since it is one of the factors for the student engagement in the learning activities and it is based on the appearance of the avatar. Students will not engage in the process of learning unless they feel that they are engaged in the community of learning via the virtual identity [10]. The appearance of the avatar corresponds to the each student should be specialized. The identification of each student in the VeL environment is going to be achieved through the implementation of the real user non-verbal features in the corresponding avatar in the virtual environment.

The real user non-verbal features are implemented in the VeL environment and it is helped to establish the non-verbal communication and the virtual identity of the real user in the virtual environment. The eye behavior is one of the potent non-verbal gestures among the non-verbal features because eye is the most expressive part on the face. It is called the window of the soul [2]. Eye blinking is important as the language of eyes is one of the most powerful and effective tools in the communication process [11, 12, 13, 14]. Therefore, eye blinking which is one of the major non-verbal communication methods is anticipated to introduce to the virtual e-Learning environment.

To establish the non-verbal communication in the virtual environment to conduct the PBL effectively and to identify the student attitude about the non-verbal feature in the virtual environment are the objectives of this research. Initially, the eye blink is considered as the one of the possible features to capture by using a web-camera [15] and an important element of the non-verbal features to introduce to the virtual the PBL [2].

2. Previous work

The effects of the PBL have been investigated from numerous studies since the origin. Establishment of the intellectually challenging, flexible and enjoyable learning environment is originated through the camaraderie and collaboration of the participants in the PBL [16, 17]. The PBL enhances the student’s professional skills and attitudes through the student’s ability to memorize concepts out of context with acquiring better study habits such as
more commitment, more focus compared to the conventional method [18]. There are several benefits that can be obtained through the PBL courses compared with conventional courses are listed below [19],

- PBL students have deeper understanding of their subject and better long-term recall of the knowledge they acquire. Students from conventional courses may cover a wider range of topics, but their ability to recall this information is likely to be short term.
- Students are engaged in an active learning process – they discover knowledge in the context of problems that they are likely to encounter in the real world.
- PBL is an integrated, holistic approach to learning that helps students to appreciate how the different threads of a subject are related to one another.
- The development of key skills such as group working, problem solving, critical reasoning, effective communication etc. is inherent in the way that PBL works.
- PBL forms a solid foundation for lifelong learning.

PBL method is better than the conventional method as the knowledge acquiring mechanism with the above facts. Not only the mechanism, but also the location is required to change from the conventional classroom to enhance the convenient of accessibility with the advancement of the technology.

The online learning is presented clear, direct benefits to students and to teachers with overcoming the location barriers as follows [20],

- Flexibility of time and place.
- Coping with increased student numbers.
- Sharing and re-use of resources.
- Collaborative work.
- Student-centered learning.
- Reducing the administration burden

The virtual e-Learning environment allows students to study and learn online, access learning resources, and interact with teacher, tutor and fellow students. The 3D virtual environment has significant advantages over web applications due to the easier of student engagement with employing avatar and obtain the virtual world experience via perform within the real world [21].

The avatar that represents the real user in the virtual world is played a significant role in the VeL and it can be identified with the following findings. A person with an attractive avatar willingly self-discloses more information to strangers than do those who have an unattractive avatar. Taller avatars are found to act more confidently during decision tasks [22]. Human-like and more realistic avatars tend to create more positive social interactions [23]. The virtual identity is one of the factors for the student engagement of the learning activity and it is based on the avatar appearance [10]. In addition, the relationship among the participants in the PBL is very important for the efficiency of the learning process because they have to identify the ideas of each other to solve the problem. There are some evidences in the real world that the student performance is increased through the non-verbal features. When the virtual lectures were used one of the non-verbal features and facial expressions, the students performed better (by 86%) in the lectures compared to the results of the lectures that were not used facial expressions. The appropriate use of smiling increased the interest of the students and consequently their performance [24]. Appropriate use of an avatar’s body animation has possibility to make the students feel more relaxed, focused, interested and less confused in a virtual learning environment [24]. Therefore the virtual identity and the non-verbal communication are important aspects of the virtual learning.

The virtual identity and the process of the communication especially for the PBL will be fulfilled with the implementation of the real user non-verbal features in the VeL environment. The eye blink is one of the potential non-verbal features, [2] is anticipated to introduce to the virtual learning environment. In the last few years, much research has focused on eye blink detection and one of the most commonly presently used techniques based on the Electromyograph (EMG) readings, which are obtained by using three small electrodes are attached to the skin with micro-pore tape around the orbicularis oculi muscle [25]. Although EMG-based system is effective in detecting the
eye blinks through muscle signals, EMG signal quality and electrical noise in patient environment are affected negatively. Several advantages can be obtained from the web-camera based system compared to the EMG such as ease of the setup, placement of the web-camera and nothing needs to be attached to the person. The web-camera is also a cheap, commercially available piece of hardware [26]. In addition, a blink approximately happens once every 2 to 4 seconds, and the average blink lasts about 250 milliseconds. A camera can capture images with not less than 15 frames per second easily. The eye blink can be possible to capture using a camera including a web-camera [27].

The effectiveness of the PBL in the virtual e-Learning environment can be enhanced with the fulfillment of the communication process and the increment of the virtual reality through the visualization of the non-verbal features of the real student in the virtual e-Learning environment via the avatar. The process of visualizing the eye blinks which is a main component of the non-verbal features [2] and the process of detecting the eye blinks using a web-camera are discussed in the next session.

3. Overview of the system

The outline of the system is shown in Fig. 1. The students and the teacher in the real world can access the virtual world directly. When they are engaging with the learning activities, the visualization system is activated and detected the real user eye blink. The acquired information is transferred to the VeL environment through a server.

Fig. 1. Overview of the System
The transferred information is appeared in the virtual environment through the face of avatar. When the real user blinks his eyes, it is appeared on the face of the corresponding avatar in the virtual environment. All the information is stored in the server and it can be utilized for the post analysis of the student behavior. The teacher can observe the students behavior directly and indirectly through the implementation of the visualization system. The teacher can use repository information of the server for the indirect observation of the student behavior as a post analysis. The direct observations of the student can be done easily since the students’ non-verbal behavior is appeared in the virtual environment and anyone can view it.

4. Methodology

Development of the visualization system and identification of the student response are the two major activities have to be completed in this research. There are three steps in the system development process of the system and those steps will be discussed in the next session. The responses of the students were obtained by conducting an experiment and the judgment of the process was explicated through a questionnaire, which was given after the experiment.

4.1. Development of the eye blink visualization system

The system needs to handle the both real user in the real world and the avatar in the virtual world. The development steps are pursued in the real world initially and then in the virtual environment. The establishment of the connection between two worlds is the last activity in the development process. The development steps for the visualization system can be mentioned as follows,

- Detecting eye blink of the real student
- Modifying the avatar in the virtual world
- Establishment of the mechanism to transfer the student information to the virtual world

4.1.1. Detecting eye blink of the real student

When the real student engages with learning activities in the virtual environment, the eye blink detection system is needed to activate. The procedure to detect the eye blink is illustrated as shown in Fig.2. A web-camera is initiated to obtain the real time video of the e-Learner. The video consists of set of frames and these frames are separated to analyse the each frame individually. Then the face detection of the frame is pursued with Haar-feature based cascade classification [28]. When the face is not detected, the procedure is started from the beginning. The region for the interest is notable to detect the eyes of the frame when the face is detected. The same method, Haar feature cascade classification is used to detect the eyes. If the eyes are not detected, it can be classified as a blink because at that time the face is already detected. When the eyes are detected, it is needed to be clarified whether eyes are open or not. Two measurements were used to identify whether the eyes are open or not. The amount of white and black pixels of the eye region and the ratio of the width to height of the eyes are the measurements, which are used to clarify whether the eyes are open or not. When the eyes are open, it is classified as “Not blink” and the “Blink” is identified when the eyes are close. The eye blinks of the real student can be detected using this procedure.

4.1.2. Modifying the avatar in the virtual world

The avatar cannot blink in the virtual world even when the user requested. Hence, the head model is created to represent the real user eye blinks and the eye blinks can be activated based on the commands of the real user. The head shape is created in the real world as an initial step and it is exported to the virtual environment. The texture is applied to the head shape to obtain the realistic view of the head. The eyes and eyelids are prepared by using the objects in the virtual world and applied the suitable texture to obtain the realistic appearance. The eyes and eyelids are attached to the head shape to complete the head model. An appropriate hair, which is available in the virtual world, is also attached to the top of the head model and then the complete head model is attached to the avatar. The eye blink can be managed or activated by the user commands using the rotation mechanism of the eyelids.
4.1.3. Establishing the mechanism to transfer the student information to the virtual world

The real user eye blink information should be transferred to the virtual environment to visualize the eye blink of the real user in the virtual world through the avatar. There was no any method to transfer the real world information to the virtual world directly. Hence a server is used as an intermediate to bridge the two worlds. The information can be stowed in the server and it is an added advantage of the information transferring process. The detected information is transferred to the server initially and then it is shifted to the virtual world through HTTP request.

4.1.4. Visualizing the real user eye blink in the virtual world

Having completed the above three steps, the real user eye blink can be visualized in the virtual environment as shown in Fig. 3. The avatar is blinked the eyes when the real user blinks his/her eyes. It takes few seconds to visualize the eye blink in the virtual world since the time takes to transfer the user information from the real world to the virtual world. The time duration may change based on the network condition.
4.2. Affection of the non-verbal in the virtual e-Learning

When the real user non-verbal information is visualized in the virtual environment, the next task is to identify the affection of the non-verbal behavior during the VeL through an experiment.

4.2.1. Aim

This experiment was conducted to identify the affection of eye blink to the e-Learner during the VeL sessions and to identify the possibility of conducting the experiment with the eye blink visualization system. The attitudes and the feelings about the e-Learning session of the student with and without eye blinking were needed to identify with the intention of assessing the affection of the eye blink to the e-Learner.
4.2.2. Hypothesis

Researchers found that the human-like representations with higher realism produced more positive social interactions [29]. Therefore, the avatar appearance with eye blinking is made a huge effect to the viewer. It may increase the positive feeling and better attitudes of the e-Learners.

4.2.3. Experiment Environment

The experiment was designed with two sessions; with and without eye blinks and it was conducted as a group discussion by using the PBL mechanism. A questionnaire was delivered after the each session with a small brake to obtain the opinions of the participants.

The group discussion of the PBL was held outside the classroom with breezy air in the virtual environment as shown in Fig.4. The voice was used to communicate among the participants and an excel sheet was used to solve the problem.

4.2.4. Procedure

There were six students that participated to the experiment including one female student. These participants belong to different nations namely Sri Lanka, India and Nepal. They used English language to communicate among them. They all are following the postgraduate course and majoring in the field of Management and information systems science.

An introduction session was held prior to the experiment to explain about the purpose of this observation, the way of accessing the virtual environment and the eye blink visualization system. The experiment was included two sessions and both sessions were based on the PBL with same condition except the eye blink visualization. The first session was conducted with the eye blink visualization system and the second session was conducted without the eye blink visualization system. All students were participated to the two sessions. The group discussion and the problems were based on the mathematical background. Students used large excel sheet which was possible to edit by any of the student. Each session was conducted roughly about 15-20 minutes to complete.

5. Result and discussion

The responses of the participants were obtained through a questionnaire to identify their attitudes and feelings about the reflection of their eye blinking in the VeL environment. We use the Mann-Whitney U test to evaluate the responses of the participants. The Mann-Whitney U test evaluates whether the medians on a test variable differ

![Fig. 5. Mean Rank for the Students’ response during the Group discussion](image-url)
significantly between the sessions with and without eye blinking by using the response of the questionnaire. We have two independent questionnaires for two sessions with and without eye blinking and evaluated two questionnaires concurrently. Each questionnaire was consisted a Likert scale responses. The mean rank values as shown in Fig. 5 provide the information regarding the output of the actual Mann-Whitney U test in SPSS and it shows that the mean ranks for the two questionnaires (with and without eye blinking).

Table 1. Test Statistics for the responses of Group discussion

<table>
<thead>
<tr>
<th></th>
<th>Effect Size (r)</th>
<th>Mann-Whitney U</th>
<th>Wilcoxon W</th>
<th>Z</th>
<th>Asymp. Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>-0.74</td>
<td>3</td>
<td>24</td>
<td>-2.559</td>
<td>0.011</td>
</tr>
<tr>
<td>Friendly</td>
<td>-0.66</td>
<td>5</td>
<td>26</td>
<td>-2.272</td>
<td>0.023</td>
</tr>
<tr>
<td>Reliable</td>
<td>-0.62</td>
<td>6</td>
<td>27</td>
<td>-2.166</td>
<td>0.03</td>
</tr>
<tr>
<td>Like to engage</td>
<td>-0.91</td>
<td>0</td>
<td>21</td>
<td>-3.146</td>
<td>0.002</td>
</tr>
<tr>
<td>Helpful to conduct the conversation</td>
<td>-0.62</td>
<td>6</td>
<td>27</td>
<td>-2.166</td>
<td>0.03</td>
</tr>
<tr>
<td>Contribution from the group members</td>
<td>-0.62</td>
<td>6</td>
<td>27</td>
<td>-2.166</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Fig. 5 shows that the mean ranks are significantly different during the two sessions. The mean ranks of all variables in the questionnaire which is given after the session with eye blinking are greater than the variables in the questionnaire relating to the session of without eye blinking as the hypothesized. The evaluated factors of the questionnaire is shown that high rates of positive responses during the sessions with the eye blink than the session without the eye blink and the difference of the mean ranks is 25%.

The Table 1 shows only the actual significance variables value of the test. Specifically, the test statistics table provides the test statistic, effect size (r), U value, Z value as well as the asymptotic significance (2-tailed) p-value and the target significance level (α) is 0.05. The Mann-Whitney U test output indicates that the P-value (Asymp. Sig) for some considerable variables are less than 0.05 value. So that, at α =0.05 level of significance, there is enough evidence to conclude that there is a difference in the median scale of that particular variables in the questionnaires of with and without eye blinking. Those variables are indicating in the Table 1. Those selected factors indicate that the effect size value (r) for each has more than 0.62 suggested a moderate to high practical significance when they utilized the eye blink in the VeL environment.

The student feelings and attitudes towards the eye blinking in the VeL environment were high according to the result of mean rank. Some specific factors which are wrapped in to the indicator of effectiveness of the communication were evaluated highly based on the P-value of median scale.

6. Conclusion

Although the non-verbal features are very essential elements of the learning process [1], they are lack in the VeL environment. The eye blinking which is one of the major elements of the non-verbal features [2] of the real e-Learner is visualized in the VeL environment through an avatar after completing the several processes in this research. When the real e-Learner blinks, it is reflected in the VeL environment through the avatar. An experiment was conducted with the eye blink visualization system to identify the possibility of implementing the non-verbal features in the VeL and to identify the affection of the eye blink to the e-Learner through their attitudes and feelings. The experiment was successfully conducted and it was indicated that the eye blink can be visualized in the VeL environment successfully. The responses of the e-Learners were positive with the implementation of eye blink since the mean ranks from Mann-Whitney U test are greater from the 25% when they utilized the eye blink. Especially the effectiveness of the communication factors was responded very highly during the group discussion.

7. Future work

The real user eye blink is visualized in the VeL and an experiment was conducted using the eye blink visualization system in this research. The next target is introducing another possible non-verbal characteristic such
as head pose, hand gesture to the virtual environment and conducting an experiment only with the head poses visualization system at first and then with the both eye blink and head pose.

References

27. Kresimir D., Mislav G. and Marian S.B., Recent Advances in Face Recognition, Printed in Croatia, 2008.