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Evaluation For Students' Learning Manner Using Eye Blinking System in Metaverse

Dana M. Barry[a], Nobuyuki Ogawa[b], Asanka Dharmawansa[c], Hideyuki Kanematsu[d], Yoshimi Fukumura[e], Tatsuya Shirai[f], Kuniaki Yajima[g], Toshiro Kobayashi[i]

[a]*Research Professor, Clarkson University, New York State, USA*
[b]*National Institute of Technology, Gifu College, Japan*
[c]*Graduate School, Nagoka University of Technology*
[d]*National Institute of Technology, Suzuka College, Japan*
[e]*Nagoka University of Technology, Japan*
[f]*National Institute of Technology, Suzuka College, Japan*
[g]*National Institute of Technology, Sendai College, Japan*
[i]*National Institute of Technology, Tsuyama College, Japan*

Abstract

For a virtual problem-based learning (PBL) class in Metaverse, an eye blinking system for avatars was introduced. It correlated their eye blinking behavior with an emotional response to various problems that they were asked to discuss on behalf of their users. Three Japanese college students joined the project where they discussed a simple and difficult problem, respectively. Teachers proposed online (mathematical problems) for them. Each session was 10 minutes in length. During the classes, the number of eye blinks was recorded for each student by using special software. After completing the PBL classes, the students answered questionnaires. Then the results were analyzed. All of the results suggested that the difficult question would make students' feelings unstable and increase the number of eye blinks. Using this system, teachers could analyze students' responses well to achieve a better outcome of virtual PBL.

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Keywords: Eye blinking system; Metaverse; Second Life; active learning; e-learning

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1. Introduction

Nowadays, the quality of classes is always a central concern for teachers also in higher education. Even though they might join the class every time, the educational and learning effectiveness for the class would be problematic, so long as they only concentrate on class content. Today we are now in the mid digital age. When students are at their homes, they are surrounded by lots of digitizing apparatus, personal computers, digitizing broadcasting systems, digitizing cell phones, tablet computers, etc. They are attracted to these high-tech items so it difficult for them to concentrate on a long lecture in a classroom. Will these youngsters, raised in digital environments, be satisfied and have high quality learning in classrooms with the one-directional and conventional face-to-face learning technique?

Some of the authors have proposed student-centered classrooms in various ways so far. One of the typical methods we proposed was the change from a teacher-centered classroom to a student-centered one. Problem Based Learning (PBL) is one of the powerful tools to realize such a class[1-3]. In PBL classes, students would initially discuss a problem proposed by the teacher. To enhance their discussion, they would search for and collect information to help them better understand and solve the problem. Then they would carry out experiments to complete some products, such as designing and building a small model for the house of the future. At the final stage, the students would give oral presentations, etc. about their project's results and a teacher would evaluate them. On the other hand, information communication technology (ICT) could make a great contribution for improving the quality of the class. Therefore, we have utilized ICT for PBL and have established the PBL model on the web as a method of e-learning. The utilization of Metaverse made it possible to realize a PBL virtual class on a trial basis. Virtual buildings and classrooms were built on a virtual island owned by Nagaoka University of Technology (NUT). Many kinds of classroom activities were carried out on this island to investigate the possibilities for learning and their availability from various viewpoints[4-15].

For those PBL classes, teachers' roles are very critical in order for the projects to be successful, even though the solution may not be well- known. First of all, the problem proposed by the teacher should be appropriate for the students' age and level of learning in order to have a successful class. During the activity, the teacher should take on the role of a facilitator or act like a sport's coach for the students. This means that the teachers should support the students' smooth discussions and work as a mentor. This situation should also be used for web-based PBL. Sometimes this might be difficult in the virtual class, since the lack of facial expressions prevents the sharing of emotions from the teacher. The situation would be almost the same for a mutual discussion among students. This lack of expression by both the teacher and students may be a serious demerit for virtual PBL, since facial expressions are generally one of the most important factors for discussion (whether it is done in real life or in a virtual one).

In this study, we introduced the eye blinking system into a virtual PBL class. A special type of software, developed by some of the authors, made it possible for the avatars to have an eye-blinking capability (that corresponded to each student participating in the project). By using this system, we investigated the effect that the discussion contents had on the eye blinking behavior of each student. This technique and information would work for both teachers and students in the future, so the virtual PBL classes would be useful to improve the quality of learning.

2. Experimental

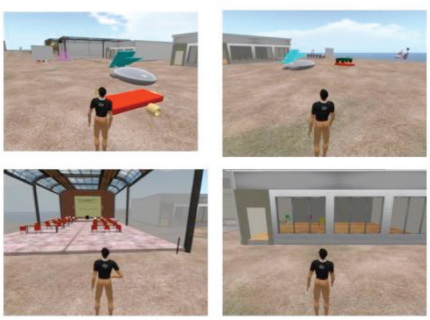

Fig.1: Appearance of the virtual island of NUT.

2.1 Class environment[4-17]

First of all, the virtual place for learning was built and prepared for the following PBL class. It is located on the virtual island owned by Nagaoka University of Technology (NUT) in Second Life, a well-known type of Metaverse. Metaverse is a virtual three-dimensional world where avatars do everything on behalf of us. Fig.1 shows the appearance of the island. Some classrooms were built there. They actually have rooms with walls, ceilings, windows, doors, desks, chairs, podiums, etc. The classrooms are surrounded by land so the students are free to make some virtual products there. The island is actually a virtual school and campus. Usually a lecture is given in classrooms. However for this project, the students were just required to have discussions with each other. Therefore, they carried out the activities outside of the classroom.

2.2 Introduction of Eye blinking System

The behavior of the non-verbal features of a person consists of a broad area including facial expression, head motion, eye behavior, gestures, and poses. It is difficult to implement all of these non-verbal behaviors in the virtual class. Among those non-verbal characteristics, the eye blink is important since it is an indicator of a cognitive load[16] and it originates from the eyes, which are the most expressive components of the face[17]. Hence, the eye blink capacity was incorporated into the virtual class because it is the main characteristic of the non-verbal environment. To establish the eye blink characteristic into the virtual learning environment, several steps were required.
They are as follows: 1) Detect each student's eye blink, 2) modify each avatar to represent the eye blink of its user, 3) transfer the identified eye blink information into the virtual environment and, 4) visualize each student's eye blink in the virtual learning environment.
The first step, detecting a student's eye blink, is done using the web-camera video continuously as a real time process. The video consists of frames that are captured frame by frame so that each frame can be analyzed. The Haar-feature cascade classification[18] is utilized to detect the face on the frame. When the person's face is detected, the process continues to the next step. Otherwise, the process has to be restarted at the beginning. The next step is the detection of the eyes by a similar method, the Haar feature-based cascade classification. Then the eye may or may not be identified. If the eyes are not identified, but the face is detected, it can be classified as a blink since the Haar features are trained for the positive images, which are consistent with open eyes. Although the face is detected, the eyes may not be detected due to the closed status of the eyes which can be classified as an eye blink. When the eyes are detected, it is necessary to identify whether the eyes are open or closed. Two measurements are used to clarify it. The ratio of the width to height of the eyes and the number of black and white pixels of the eye regions are the two measurements. The decision can be obtained whether eyes are open or closed by using the declared measurements. When the eyes close, it can be identified as an 'Eye Blink' and 'Blink' is recognized through the open eyes. The eye blink detection has 81% accuracy.
The second activity is modifying the avatar to represent the user's eye blink. The head model of the avatar is prepared in the real world by using graphic software and then exported to the virtual learning environment. The eyeballs and the eyelids are prepared using primitives (prims) in the virtual environment. Next the eyeballs and eyelids are attached to the head model. Then the completed head model is coupled to the avatar and modified to represent the user's eye blink. The rotation mechanisms of the eyelids are used to represent the eye blink of the avatar.
The information regarding the behavior of this non-verbal feature is required in order to transfer it to the virtual environment as needed in the last and the third steps for the process of visualizing the eye blink of the real user in a virtual learning environment. The service of the external server is obtained as an intermediary to transfer the information from the real world to the virtual world through a Wide Area Network (WAN). PHP and JavaScript are used to send the information from the real world and Http request is utilized in the virtual world to obtain the real e-Learner information. The behaviors of the non-verbal features of the real e-Leaner are successfully transferred to the virtual world through the server using this procedure.
Finally the four steps are successfully completed: detection of the real user's eye blink, the avatar modification, the establishment of a connection from the real world to the virtual world, and the visualization of the real user's eye blink in the virtual environment through the face of the avatar. When the real user blinks, it is visualized in the virtual environment.

2.3 Procedure of PBL

Three students from the National Institute of Technology, Gifu College, joined this project virtually. Using special software developed by one of the authors, they synchronized their eye blinking eye behaviors with those of their avatars in advance. Then one of the teachers gave them the first problem. The problem was shown in the chat box sent by a remote teacher. The first problem was just a mathematical calculation that students can solve easily. They were allowed 10 minutes to discuss the problem with each other and to solve it.

Carry out the calculation:

$$(x+y)(3x+2y) - (x-2y)(5x+6y) = ? \qquad (1)$$

Then the next problem was given to them in the same way. The second problem was more complicated, since there were many possible answers that the students could come up with in 10 minutes.

"Propose a problem of differential equations describing a phenomenon relating to environmental and energy problems."

Students discussed each problem in Metaverse using the voice function. During their discussions, their eye blinking behaviors were recorded. After everything was finished, another teacher gave them questionnaires to complete offline.

3. Results and discussion

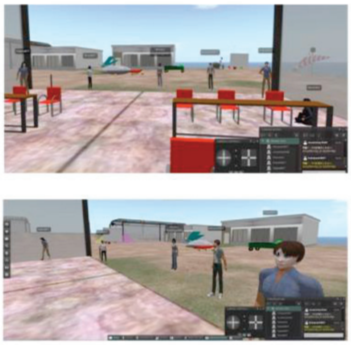

Fig.2: Discussion scenes on the virtual island of NUT.

3-1. Questionnaire results

Fig.2 shows some scenes of the students' discussions. Students and teachers both had their own avatars and joined the project. They enthusiastically devoted themselves to the discussions. The usage of the voice function (which allowed verbal expression/emotion) might be one of the reasons for their enthusiastic discussions. If they would have only used the chatting function, then the discussion would have been limited.

After the discussion, the students answered the questionnaires. The questions are provided below.

Q1: Did you enjoy the class?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q2: Was the teacher friendly to you?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q3: Could you communicate with other colleagues?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q4: Was the conversation in Metaverse easy?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q5: Was it easy to carry out the activity in Metaverse?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q6: Was the first problem easier?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q7: Could you relax for the first problem more than for the second one?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q8: Was the discussion for the first problem easier than that for the second one?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q9: Would you like to join such a project in the future?
(1) Very much (2) Pretty much (3) Neutral (4) Not so much (5) Not at all

Q10: Feel free to write your impressions and ideas below.

Figs. 3 – 10 show the results of the questionnaires. Fig. 3 shows that the students enjoyed the activity relatively well. Also they were able to handle their avatars in Metaverse.

Fig.4 shows the students' impression of their teachers. For this short project, the teachers' role was not so important. They just proposed problems and were actually timekeepers this time. Therefore, their contact time with the students was not so long. The results in Fig.4 reflect this situation.

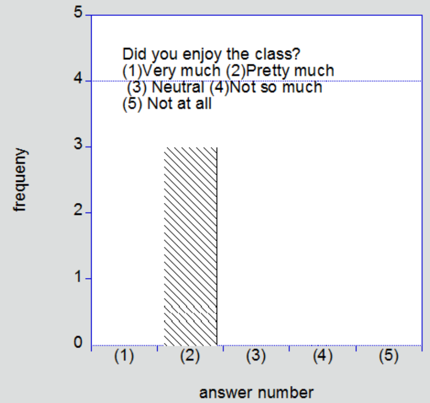

Fig.3 Results for questionnaire number 1.

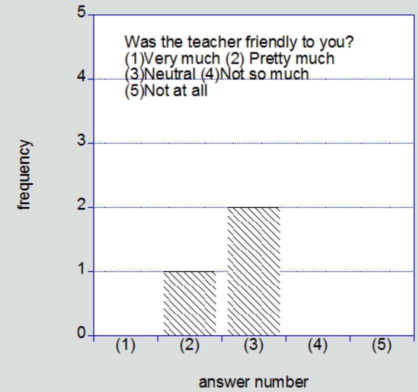

Fig. 4 Results for questionnaire number 2.

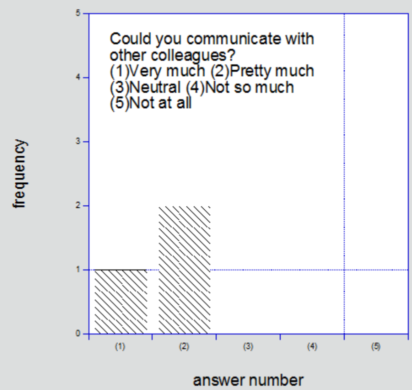

Fig.5 Results for questionnaire number 3.

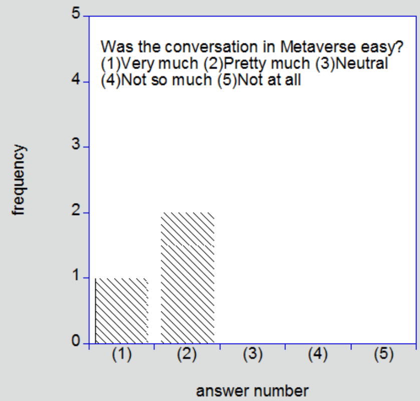

Fig.6 Results for questionnaire number 4.

Fig.5 and Fig.6 show the results for the students' impression about the conversations. The results suggest that they did not have serious difficulty communicating with other colleagues in Metaverse. According to the authors' impression, this is a change for users in Metaverse, and it suggests that the voice function used this time increased the communication availability drastically as compared with text-based communication.

Fig. 7 shows results about students' impressions about the usability of Metaverse. Their impressions were relatively positive just like those in Fig.5. When our research using Metaverse began, the handling and usability caused some problems for the students. However, these results suggest that they have been gradually becoming popular among younger generations so far.

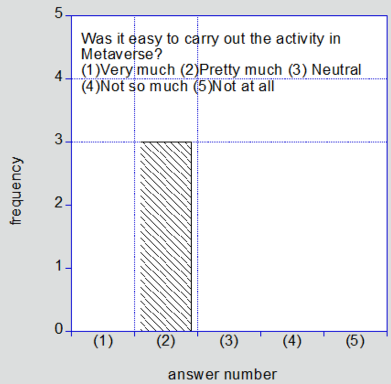

Fig.7 Results for questionnare number 5.

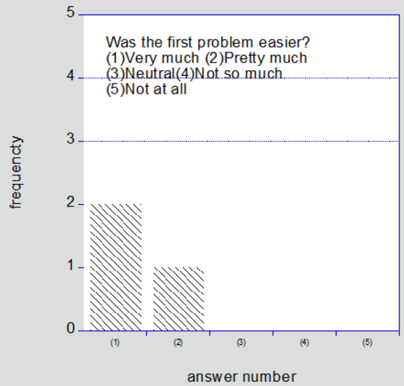

Fig.8 Results for questionnaire number 6.

Fig.8 and Fig.9 show students' impressions about the difficulties of the problems proposed by the teachers. Fig.8 clearly shows that all students felt the first problem was easier. Since the first problem was just a calculation, we can judge this to be an absolute and objective truth. Fig.9 shows how the students could relax in regards to the first question. Since both results were compatible completely, students could relax and enjoy the easier question.

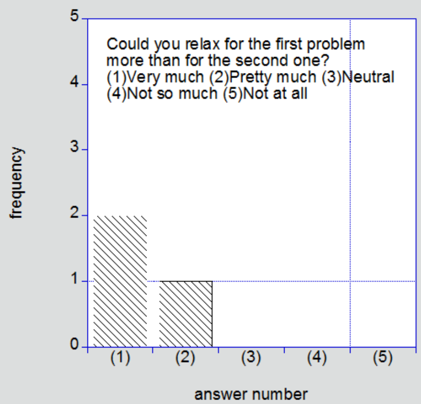

Fig.9 Results for questionnaire number 7.

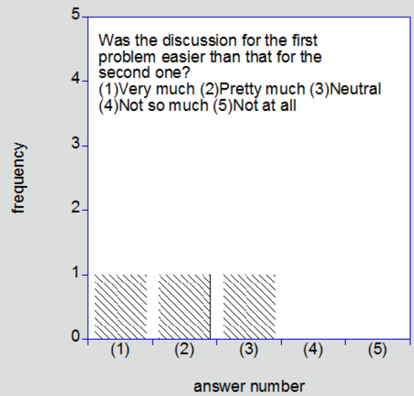

Fig.10 Results for questionnaire number 8.

Fig.10 shows the results for their impressions about the difference between the discussion's difficulty for the first and second problems. It seems like they tended to feel the discussion was easy for the first problem, the easier one. However, the extent differed from person to person. This suggests that the difference between the first problem and the second was not so large and that they could discuss the more difficult question relatively well.

Fig.11 shows their expectations about the project in the future. It corresponds to the results in Fig.3. We can assume that enjoyable projects could enhance students' motivation, even though the problems may be simple or difficult.

From all of these results, some points became very clear. Particularly, students felt that the second problem was very difficult for them, as we expected in advance. Actually, they wrote such an impression as an answer for the questionnaire concretely. Did their impressions affect their eye blinking behaviors? If so, how much? We investigated them

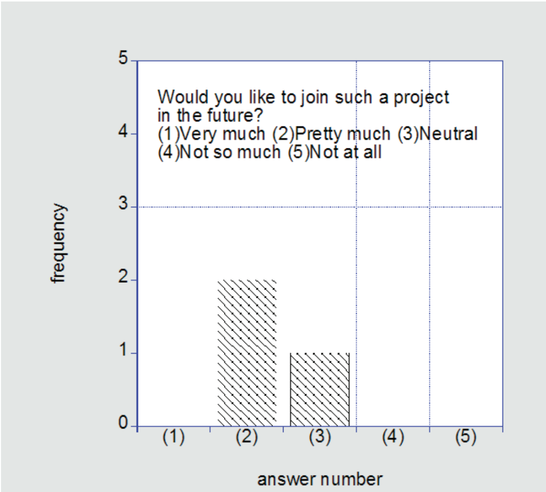

Fig.11 Results for questionnaire number 9.

, using the special software. The results are described in the next section.

3-2. Blinking Eye Behaviors

Blinking eye behaviors for the students were recorded during their discussions about the first and second problems.

Fig.12 shows the change of blinking eye behaviors during the discussion for the first problem. The number changed during the 10 minutes of discussion. Even though the behaviors and the absolute values changed from student to student, they only fluctuated in a range of 5 – 20 times per minute.

Fig.13 shows the change of blinking eye behaviors during the discussion for the second problem. The number fluctuated during this 10 minute discussion too. However, the range was different between the two cases. In Fig.13, the range shifted up and the number tended to exceed 20 times per minute and reached almost 30 times per minute. The difficulty of the problem and uneasiness or uncomfortable feelings obviously tended to increase the number of eye blinks.

To carry out successful PBL and to achieve a great outcome in PBL, teachers should be good coaches and mentors who are able to moderate and motivate students. In real life, it is sometimes easy for teachers to read students' faces and expressions to obtain information about their feelings, etc. However, this is more difficult to do in virtual classes. Therefore, the eye blinking system may play a critical role in improving virtual classes in the near future.

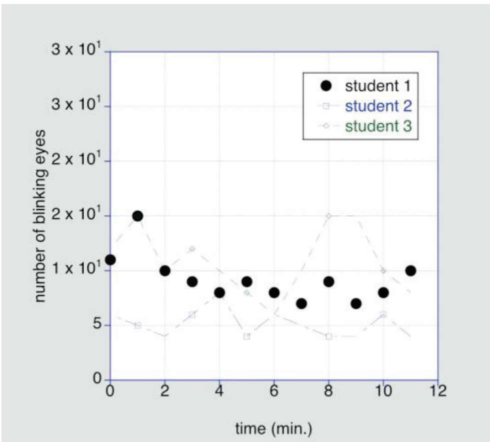

Fig. 12 Change of eye blinking behaviors for the first problem.

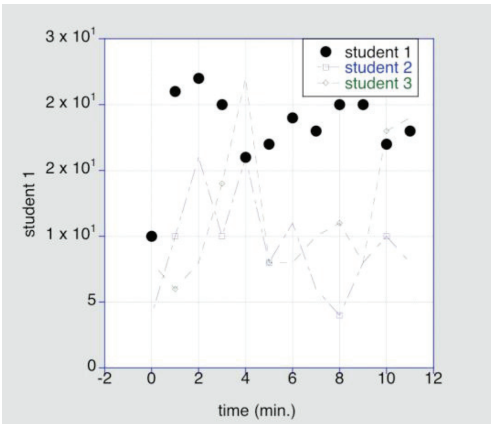

Fig.13 Change of eye blinking behaviors for the second problem.

The possible applications of this work are not restricted to the virtual PBL class, when the eye blinking behavior could reflect the psychological situation in the user's mind. Since it might be able to reflect the extent of anxiety, confidence, etc. for users, it could be used in various types of e-learning, e.g. the virtual learning of foreign languages and practical conversation affected by Willingness to Communicate (WTC)[19]. It may also be applied to safety problems of drivers or telemedicine or e-medicine in the near future. From the various viewpoints, this topic should be further investigated.

4. Conclusions

A unique Eye blinking system for avatars in Metaverse was incorporated into a virtual PBL class. Three students joined the class. Teachers gave them two mathematical problems to discuss and solve. Each activity took 10 minutes. During the sessions special software was used to record the number of eye blinks for each avatar (which corresponded to a specific student user). The correlation between students' feeling and the difficulty of the problems used in the PBL classes was discussed. The following experimental and discussion results were obtained from this virtual activity.

(1) Students enjoyed the PBL class and looked forward to participating in another one.
(2) Students could tell and feel the difference between the two problems proposed for the class. One of them was easier and the other was more difficult.
(3) The number of the students' eye blinks increased with the difficulty of the problems.
(4) This work shows that when teachers use the eye blinking system, they can evaluate students' attitudes to achieve higher outcomes for virtual PBL.

Acknowledgements

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