Embodying Historical Learners' Messages as Learning Companions in a VR Classroom

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ABSTRACT

Online learning platforms such as MOOCs have been prevalent sources of self-paced learning to people nowadays. However, the lack of peer accompaniment and social interaction may increase learners' sense of isolation. Prior studies have shown the positive effects on visualizing peer students' appearances in VR learning environments. In this work, we propose to build virtual classmates, which were constructed by synthesizing previous learners' time-anchored messages. Configurations of virtual classmates and their behavioral features can be adjusted. To build the characteristics of virtual classmates, we developed a technique called comment mapping to aggregate prior online learners'

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comments to shape virtual classmates' behaviors. We evaluated the effects of the virtual classmates built with and without the comment mapping and the amount of virtual classmates rendered in VR.

KEYWORDS

Online Learning; VR Classroom; Virtual Classmates

INTRODUCTION

With the rapid development of online learning platforms, more and more people start their self-paced learning by taking online courses. However, compared with traditional classrooms, online learners often fail to keep their motivation for learning due to the feeling of isolation [5]. To solve the problem, many studies tried to offer more channels for online learners to interact with others such as discussion forums and chatrooms [4, 13]. Nevertheless, these do not solve the problem effectively due to the low participation in these communication channels [10].

To improve learners' immersion, researchers simulated virtual classrooms in the Second Life or VR environments and transformed online users into virtualized instructors and learners to create realistic interactions [2, 3, 12]. Inside the virtual world, online learners can feel their presence and interact with other virtualized learners immersively. While the presence of virtualized learners increases online learners' motivations and social interactions, the mechanism requires the instructor and all online learners taking the same course simultaneously. Besides, the number of avatars available for learners to interact with is limited. Overfull virtualized classmates might cause negative impacts on learners' learning experiences due to the disturbances or distractions caused by a big group.

In this paper, we propose the notion of virtual classmates simulated based on previous learners' time-anchored comments [14]. Since virtual classmates are regenerated based on real learners' verbal responses, creators are able to manipulate the way of constructing virtual classmates, and virtual classmates can become more functional and potentially enhance learners' experience in a course.

Specifically, we propose a comment mapping method to group learners' comments based on the similarity of contents and types. Thus, multiple learners with similar verbal responses can be mapped to the same virtual classmate. We developed a VR classroom for online learners to watch video lectures with virtual classmates. We conducted a between-subjects experiment with two factors: comment mapping and the number of virtual classmates. Our findings show that comment mapping helps improve learning performance in the condition with fewer virtual classmates (five) and VR classroom could help learners concentrate on the course and immerse them into the virtual learning environment.

Virtualized & Virtual Learners: We use "virtualized learner" to denote the avatar of a real learner, who indeed controls the behavior of the avatar online. On the other hand, a "virtual learner" refers to an avatar whose behaviors are controlled by a computer.

Time-anchored comments are notes generated by real learners that are attached (anchored) to specific time points of a video, so that future video learners will be able to reread these comments when playing back the video [14].

RELATED WORK

Communication in Online Learning. Most online courses applied discussion forums for learners. Ezen-Can et al. [6] grouped similar posts for learners to quickly find the information they need. Sunar

Figure 1: The scene of the experimental condition with 5 virtual classmates as learning companions.

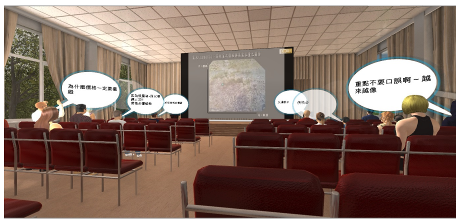

Figure 2: The scene of the experimental condition with 20 virtual classmates as learning companions.

Figure 3: The scene of the experimental condition of C5: non-VR environment.

et al. [17] analyzed posts in discussion forums to investigate learners' social behaviors and the impact of engagement on course completion. Although discussion forums let learners leave comments to interact with others, lack of instant response may lead to less engagement of learners. Hence, some researchers [4, 9, 13] grouped learners for synchronous online discussions and found the improvement of learners' innovations. However, in synchronous online discussions, the requirement for learners to take courses online simultaneously conflicts the flexibility of online learning.

Learning online with Virtualized Colearners. For non-VR platforms, Kostarikas et al. [12] integrated distance-learning platforms into Second Life (SL). Learners could learn in classrooms or laboratories, have quizzes, and interact with classmates. Chen [2] designed a task-based syllabus for students to learn English by completing meaningful real-life tasks in SL. Maratou et al. [15] created an immersive virtual environment that facilitates students' collaboration and realistic interaction for learning the development of a software project. Other studies [3] created multi-user environments to let students learn and communicate synchronously online.

Learning Online with Virtual Colearners. To enhance the realism of virtual colearners, Chatzara et al. [1] portrayed the emotions of agents with facial expressions and body movements in traditional e-learning environments. Besides emotions, other studies attempted adding personality to agents. Yamada et al. [20] proposed an application of socially intelligent agents for enhancing e-learning. Fatahi et al. [7] used a virtual tutor and a virtual classmate to assist learners' learning. All of these studies used pre-designed dialogues to respond to the learners based on their feedback. Instead of pre-designed dialogues [1, 7], we used time-anchored comments which were left by previous real learners in the same course to make the virtual classmates behave more like real ones.

METHOD AND SYSTEM

We developed our system on Unity and utilized 3D character models made with MakeHuman (http://www.makehuman.org/) as the virtual classmates. The time-anchored comments collected in [14] were used in this study. In the scene, users would see the course video playing in front of the classroom and the virtual classmates present comments in dialogue boxes with body motions. As entering text comments without a user-friendly interface in VR can complicate the experimental tasks, we disabled the comment leaving function in the time-anchored commenting system [14]. To make virtual classmates characteristic and more realistic, we developed two techniques, comment mapping and motion mapping.

Comment Mapping. In the process of building virtual classmates, the method of distributing real learners' feedback into virtual classmates can influence learners' sensation and recognition of virtual classmates. Randomly assigning real learners' comments to virtual classmates may cause inconsistent characteristics of virtual classmates. Therefore, we developed comment mapping techniques to make characterized virtual classmates such that learners may feel their classmates more realistic and referable for learning, e.g., affecting learners' strategies to learn from virtual classmates' comments.

We clustered real online learners by their interactive and self-expression features of leaving comments and assigned the comments from the learners in the same group to the same virtual classmate. We applied the content analysis method [18] to classify a comment into seven categories: general conversation, notes, opinion, question, complaint, compliment and others. Then, we represented the commenting behaviors and contents of a learner by a 7D vector formed by the numbers of comments left by the learner in seven categories. Finally, we used k-means clustering to group similar learners into same virtual classmates by using the Euclidean distance in 7D space as the clustering distance, where k is the number of virtual classmates.

Motion Mapping. To be more realistic, a virtual classmate also performs a motion that matches the emotion of a comment s/he presents. We applied the analysis approach [18] to classify the emotion of each comment into four categories: angry, sadness, joy and relief, based on its valence and arousal. We adopted a MOCAP database [19] which contains body motions with different kinds of emotions. Given the emotion of a comment to be presented, a motion was randomly picked from the corresponding emotional category of the database since there are multiple motions in each category.

EVALUATION STUDY

We conducted a between-subject experiment in a lab setting and recruited 100 participants (54 females, aged 18 to 35 years old, M=22.7) who had prior experiences on online learning sites. The lecture and time-anchored comments used in the study was collected from a previous study [14], including a fifteen-minute course video, "Introduction to Economics", and 413 time-anchored comments left by a total of 50 online learners (21 females).

To understand virtual classmates' influences on learning experiences, we identified two experimental factors - comment mapping and the number of classmates - with four conditions (C1-C4): (with or without comment mapping) x (20 or 5 virtual classmates). In the with-comment-mapping condition, we applied our comment mapping techniques to know its influence on learners' learning experiences and behaviors. Otherwise, we randomly mapped the comments. For the number of virtual classmates, participants were randomly assigned to 20-classmate or 5-classmate conditions (Figure 1and2) since we wanted to know the limitation for a person to interact with others from the space constraint in the VR environment. Moreover, to evaluate the VR classroom's affects, we added a non-VR environment (C5) as the baseline condition(Figure 3), using the time-anchoted system proposed by Lee et al.[14].

Experimental Conditions:
C1: 5 virtual classmates with comment mapping (5M)
C2: 5 virtual classmates without comment mapping (5R)
C3: 20 virtual classmates with comment mapping (20M)
C4: 20 virtual classmates without comment mapping (20R)
C5: Time-anchored system (non-VR environment)

Experimental Measures:
Learning Outcome. We measured participants' learning outcome by the difference of the scores of pretest and posttest. The questions in both tests were designed based on the contents of the video.
Survey. To understand the participants' learning experiences, we designed a survey(14 questions, 5-Likert scale) to measure perceived social interactivity [8, 21] and perceived focus attention [16].

Experimental Procedure:
Firstly, we introduced the experiment procedure and asked the participants to take the pretest. Then, we explained the system interface and experimental conditions (C1-C5), and assisted the participants to wear head-mounted display. After finishing the video lecture, the participants would take a posttest and complete the questionnaire which measured their perceived social interactivity and focus attention.

RESULTS AND DISCUSSION

Following the analysis procedure recommended by [11], we removed the outlier data by excluding z-score greater two for each of the dependent measures.

Learning Outcome. We computed one-way ANOVA with learning outcome (i.e., posttest minus pretest scores) and used a Scheffé Test for the post-hoc analysis. We found that C1 (M=71.28, SD=2.872) had a significantly better learning outcome than C2 (M=55.47, SD=4.371), C3 (M=59.58, SD=3.491) and C5 (M=60.3, SD=4.485) (Figure 4). Besides, we performed two-way ANOVA to analyze the cross-condition variance of C1 to C4. There was a significant interaction effect between the number of classmates and comment mapping on learning outcome ($F(1,70)=6.742$, $p=0.01 < .05$).

Social Interactivity. As C1-C5 failed to pass the homogeneity test, we performed Welch's ANOVA and used a Dunnett's T3 test for the post-hoc test. We found the social interactivity score of C1 (M=2.9181, SD=0.14035) was significantly lower ($F(1,35)=4.550$, $p=0.040$) than C4 (M=3.3395, SD=0.17797)(Figure 5).

Focus Attention. Since the measurement results in C2 (M=3.5972, SD=0.11635) did not fit the normal distribution, we computed Welch's ANOVA with focus attention scores as dependent variables and used a Dunnett's T3 test for the post-hoc test.The difference between C3 (M=3.87, SD=0.15) and C5 (M=3.36, SD=0.20) approached an acceptable level of statistical significance ($p=0.054$)(Figure 6).

Summary of findings. When learning with fewer virtual classmates using the comment mapping technique, online learners had better learning outcome than those without comment mapping. The result implied that the effect of comment mapping may be moderated by the number of virtual classmates since learners have their limitations to interact with a large amount of avatars.

In terms of social interactivity, surprisingly, we found that learning with 20 virtual classmates without comment mapping resulted in significantly higher social interactivity than learning with 5 classmates with comment mapping. We considered that because of the comment mapping, the participants in C1 might focus more on the classmates who mentioned course-related comments than those in C4. Therefore, they reduced their social interactions and their learning performance was improved. Finally, the results showed that participants had higher focus attention in C3 than in C5.

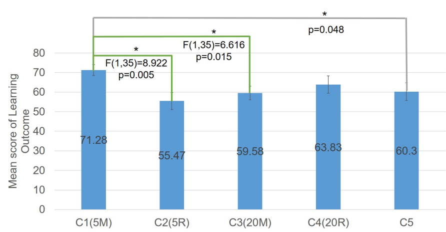

Figure 4: The results of learning outcome.

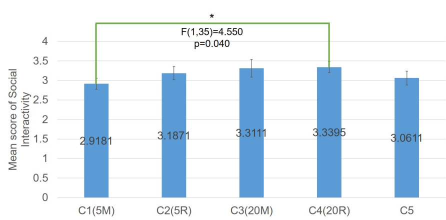

Figure 5: The results of Social Interactivity

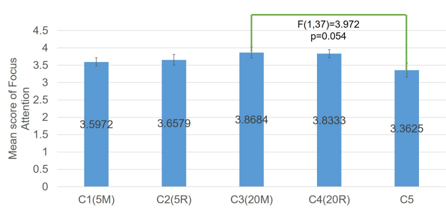

Figure 6: The results of Focus Attention

CONCLUSION AND FUTURE WORK

We propose the comment mapping method to analyze and assign real learners' time-anchored comments to virtual classmates. The results suggest that comment mapping is helpful when the number of classmates is smaller (five). On the other hand, having 20 classmates without comment mapping helped improve social interactivity. We believe the comment mapping approach could enhance online learning experiences and stimulate future research on the virtual characters in the context of online communities. In the future, we will adopt other mapping functions to enrich the characteristics of virtual classmates, e.g., filtering out negative comments or giving appropriate comments based on a learner's learning status. Furthermore, we will identify a clearer influence of the number of virtual classmates on online learners in VR classrooms.

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