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Shared Nods, Shared Presence: Enhancing Engagement in VR On-Demand Lectures

Takayuki NAGAI[a*], Takuma SHINOHARA[b]
[a,b]*Kyoto Institute of Technology, Japan*
*nagai@kit.ac.jp

Abstract: Asynchronous online lectures lack nonverbal cues such as peer nodding, which can decrease learner engagement. One key contrast lies in the ease of nonverbal communication among learners. In a physical classroom, students naturally observe peers' behaviors—such as nodding or note-taking—which can influence their own learning. Nodding, in particular, serves multiple roles in lecture settings, highlighting the importance of understanding its effects when designing online learning environments. To investigate the influence of learners' nodding on others in an asynchronous on-demand lecture, we developed a virtual reality (VR) lecture environment. This environment simulates a lecture hall containing virtual classmates (humanoid robots) and a front-facing lecture video. By reproducing nodding behaviors from previous learners at corresponding moments in the lecture, participants could experience an indirect form of nonverbal communication via these virtual classmates. Ten participants were asked to watch a real lecture video in this VR environment while wearing a headset that tracked their head movements and gaze. Results revealed that when the virtual classmates nodded, participants spent more time looking at them compared to the condition with no nodding. Post-experiment surveys further indicated that most participants felt less isolated in the VR setting. These findings suggest that shared nodding behaviors in VR can effectively promote social presence while mitigating the sense of isolation often associated with on-demand lectures. While nodding is a less-intrusive alternative to physiological data, privacy perceptions still warrant careful consideration.

Keywords: VR lecture environment, nonverbal communication, social presence

1. Introduction

Asynchronous online lectures often lack the nonverbal cues present in face-to-face settings, such as peer nodding, which can lead to decreased learner engagement. To address this challenge, our research proposes an approach of sharing learners' states to compensate for this loss of nonverbal communication. While multimodal learning analytics can utilize physiological data such as eye tracking, these approaches raise significant privacy concerns (Prinsloo et al., 2023). Our preliminary survey confirmed students' reluctance to share biometric data, leading us to focus on the less intrusive act of "nodding".

This study aims to investigate whether sharing peer nods can alleviate the sense of isolation and enhance social presence, which is often diminished in asynchronous online learning (Hollister, et al., 2022). Social presence, defined as "the degree of salience of the other person in the (mediated) interaction and the consequent salience of the interpersonal relationships" (Short, et al., 1976), is crucial in establishing a critical community of learners (Garrison, et.al. ,2000). To investigate this, we developed a VR lecture environment where nodding behaviors from previous learners are reproduced by virtual classmates. We then experimentally verified the impact of viewing these shared nods on subsequent learners' attention and their perceived sense of social presence.

2. Sharing Nodding in a VR Lecture Environment

We developed a VR lecture environment using a Meta Quest Pro headset, recording the user's gaze and head angular velocity every 0.133 seconds. In this virtual setting, the learner is seated centrally, with a lecture screen in front and four virtual classmates—represented by humanoid robots—in their field of view (Figure 1). The nodding animations for these classmates are based on motion-captured human data, and the nodding schedule for each can be controlled independently.

Figure 1. The developed VR lecture environment with virtual classmates.

We used an 800s video clip from an "Information Security and Information Ethics" lecture for the experiment. Before the main study, four pilot participants (unrelated to the main sample) watched this lecture in a VR setting that featured non-nodding virtual classmates; their nodding data, which was detected when the vertical head angular velocity exceeded a predefined threshold, were recorded for later use.

For the main experiment, we incorporated these recorded nod patterns into the virtual classmates. Ten new participants (all in their twenties from our institution) wore a VR headset that tracked their gaze and head movements. They were told the study aimed to examine the effect of others' presence in VR and were instructed to watch the lecture naturally. They were not informed about the nodding behavior.

To assess the effect of virtual classmates' nodding, the 800-second lecture was divided into two 400-second halves. The participants were then split into two groups of five: Group A experienced nodding classmates during the first 400 seconds and non-nodding classmates during the second 400 seconds, while Group B had the reverse arrangement.

After watching the lecture, all participants completed a brief questionnaire regarding their impressions of the VR environment and the virtual classmates.

Based on the gaze tracking data, we recorded which objects in the VR environment (e.g., the screen, virtual classmates, desks) each participant was looking at every 0.133 seconds. For analysis, we divided the 800-second video into 20-second zones and aggregated the gaze time on virtual classmates within each zone for every participant. We then compared the total gaze time between the nodding and non-nodding conditions for each group.

A detailed zone-by-zone analysis of gaze data indicated that participants' attention was often drawn to the virtual classmates when they first began to nod. However, gaze behavior was not always synchronized with individual nods, suggesting that it was also influenced by the lecture content itself. Consequently, to isolate the effect of "virtual classmate nodding," we employed a Difference in Differences (DiD) approach.

The results showed that Group A's average gaze time toward the virtual classmates, $\overline{D}_A$, decreased by 9.2s from the first half to the second half, whereas Group B's average gaze time, $\overline{D}_B$, increased by 11.3s (Table 1). If lecture content alone caused the gaze shifts, one would expect $\overline{D}_A$ and $\overline{D}_B$ to be roughly similar. In practice, however, a notable difference was observed. Welch's t-test showed a significant difference ($t=3.15$, $p<.05$), and the effect size, measured by Cohen's d, was 1.99. These findings suggest that nods significantly drew participants' attention.

Table 1. Learners' viewing time on all four virtual classmates (in seconds)

GroupA	1st half	2nd half	GroupB	1st half	2nd half
P1	23.5	3.2	P6	15.9	9.1
P2	9.5	2.4	P7	5.4	14
P3	10.2	0.3	P8	0.7	18.4
P4	2.2	0.4	P9	13.3	22.4
P5	10.3	3.4	P10	15.6	43.7

After the VR lecture, participants completed a short questionnaire (Q1–Q4) addressing concentration, social presence, and willingness to share nodding data (n=10). Questions Q1, Q2, and Q3 employed a five-point Likert scale. For Q1, which asked if the VR environment made it easier to concentrate, eight participants agreed, suggesting that the VR setting may enhance attention. All participants (Q2) noted reduced loneliness in the presence of virtual classmates, indicating a heightened sense of social presence. Over half of the respondents (Q3) were willing to share their nodding data, though some expressed reservations, highlighting that privacy remains a valid concern that needs to be addressed, even for less intrusive data. Lastly, Q4 was open-ended, inviting suggestions for additional virtual classmate behaviors, such as note-taking, signs of confusion, and laughter, thus pointing to potential avenues for broadening social cues in future designs.

3. Limitations and Future Work

While this pilot study suggests nodding can influence attention and social presence, its limited sample size means further research is needed to verify the direct impact on learning outcomes. Future work should incorporate larger samples and diverse behavioral cues (e.g., note-taking) to enhance learning in VR environments.

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