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Exploring Mixed Reality Group Activity Visualisations for Teaching Assistants to Support Collaborative Learning^{*}

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Abstract. This poster presents the intermediate results of our Mixed Reality (MR)-based visualisation prototype for teaching assistants (TAs) to support collaborative learning. Many universities have introduced TA programs; however, it is not easy for TAs to understand students' engagement states in collaborative learning activities due to their lack of teaching experience. The proposed MR-based visualisation overlays student activity states above each group location to facilitate decision-making for TAs as to whether support is needed or not. To examine the proposed solution's impact, we conducted an exploratory experiment using a prototype with a Wizard of Oz method. The results indicated that the prototype has the potential to support TAs in noticing groups that need support and increases their efficiency.

Keywords: mixed reality · collaborative learning · teaching support.

1 Introduction

Teaching assistant (TA) programs have been widely introduced in higher education. TAs play a significant role in providing instruction tailored to individual students' progress. However, most TAs do not have enough preparation to teach [5], so it is not easy to make appropriate decisions to support students. In previous studies for supporting instruction, Egi et al. [2] proposed a tablet-based TA support system for programming exercises. Holstein et al. [3] presented

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a Mixed Reality (MR)-based real-time teacher awareness tool. However, these studies focused on individual learning, and the rich analytics for supporting students were generated by learning management or intelligent tutoring systems. In collaborative learning involving group work, where multiple students work together and multiple groups proceed with their tasks simultaneously, it is more difficult to grasp each student's and the group situation. Previous studies show the effectiveness of analysing students' activity for understanding the quality of student group collaboration [1], and it is expected to be helpful if teachers and TAs know the learner's state in teaching activities. However, few studies have examined the effectiveness of visualisation methods and evaluated them in actual classes. This research aims to develop a collaborative learning support system for TAs based on student activity states. As an initial step, the study examined whether visualising activity states in group work using MR is effective for TAs.

2 Group Activity Visualisation Framework using MR

The proposed visualisation framework overlays students' and group activity states above each group location as shown in Fig. 1. The advantage of using the MR technique is that TAs can see students' activity state while looking around the classroom in real-time, so it is intuitive to understand which groups or students need support. The activity states are shown as binary to represent an active or a passive state, which is calculated using an engagement coding scheme explained later. The active state means engaged in tasks and taking an initiative, and the passive state means engaged in tasks but passively. The passive state includes the situation of stalled tasks so that the visualisation system can inform TAs of groups with passive students.

To calculate the activity state, we defined three types of engagement levels during group learning, as shown in Table 1. However, providing excessive support to students decreases their motivation to solve problems and reduces effective learning [6]. Therefore, we did not use these activity states directly but changed

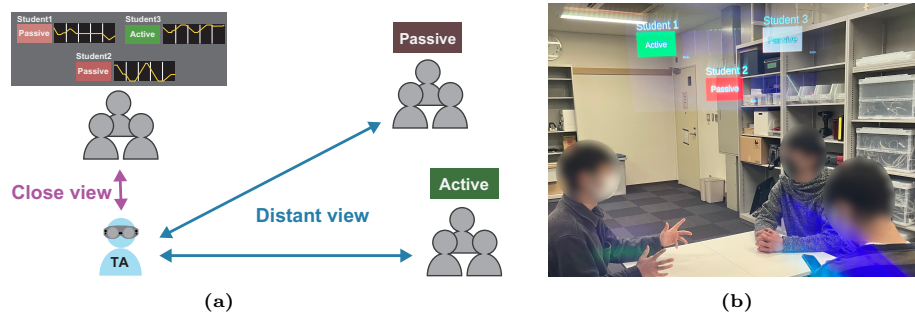


Fig. 1: (a) The system displays the activity level of the entire group at a distance and the activity level of an individual at a short distance. (b) Example of close view.

Table 1: Engagement coding scheme.

Level	Coding scheme
Active (2)	Engaged in tasks and takes initiative. e.g., Talks about tasks, works on tasks proactively.
Passive (1)	Engaged in tasks but passively. e.g., Reads documents, listens to other members speak.
Not Engaged (0)	Not engaged in tasks. e.g., Talks about things unrelated to tasks.

the activity state gradually. Specifically, Active is coded as 2, Passive as 1, and Not Engaged as 0, and the moving average of these values over the last 60 seconds is the activity level. Let us define the state of a student S_i at a time t as $A_{S_i,t}$, then the activity state at the time is defined as:

$$A_{S_i,t} = \frac{1}{60} \sum_{k=t-59}^t S_{i,k} \quad (1)$$

The group activity state used the 60-second moving average of the product of students' activity states belonging to that group. Specifically, the group activity $A_{group,t}$ belonging to students S_1, S_2, S_3 at time t is defined as:

$$A_{group,t} = \frac{1}{60} \sum_{k=t-59}^t S_{1,k} S_{2,k} S_{3,k} \quad (2)$$

Since a group with a Not Engaged student needs assistance, we used this definition where the group value is set to 0 if there is even one Not Engaged student.

With regard to the implementation, we used MR to visualise the activity states. Although MR has the advantage of intuitive visualisation, the cognitive load increases when excessive information is presented in MR systems [4]. Therefore, the proposed system suppressed the cognitive load by dynamically changing the information presented. Specifically, the proposed framework turns the displays according to the distance between each group and TAs as shown in Fig. 1 (a). When the distance between each group and a TA is far, only the activity level of the entire group is displayed. At a near distance, detailed information on each student using a line graph is displayed, which displays the progress of the activity state. This method ensures that the amount of information for TAs is not too much when looking at the entire classroom. We used Magic Leap One (<https://www.magicleap.com>) and Unity(<https://unity.com>) to implement the proposed MR-based visualisation framework.

3 Evaluation

3.1 methodology

We conducted a trial lesson to examine the effectiveness of the proposed visualisation framework. The learning activity was physical programming using

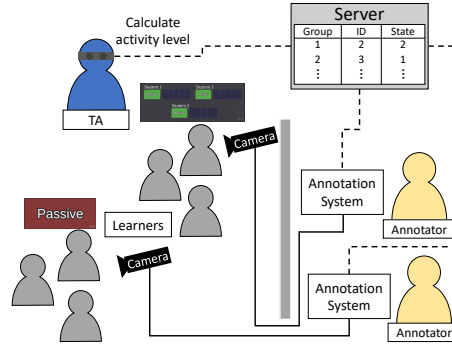


Fig. 2: Annotator inputs activity level in real time based on the group’s video and sends it to the server. The system calculates the activity level using these data.

micro: bit (<https://makecode.microbit.org/>). We designed the lesson based on group work with three students in each group. The 46 undergraduate and graduate students (29 females and 17 males, mean age:22.5 (SD :3.1)) participated in the experiment, all of whom had little programming skill. We conducted the experiment over two days; 24 students joined on the first day and 22 on the second. The lesson consisted of six sessions of 20-minute long exercises. Students were divided into six groups (two groups consisted of two students on the second day due to member absence) and they were assigned programming tasks to complete by themselves, referring to supplementary materials. We designed a within-subjects experiment involving two conditions: the condition of no MR-based system (noMR conditions) and the condition of using the proposed system (MR condition). Six graduate students with programming skills joined the experiment as TAs, and each TA participated in two sessions with each condition. For the MR condition, we used the Wizard of Oz (WOZ) methodology, a research method of interaction with a mock system controlled by a human, for collecting student engagement levels to avoid the effects of estimation accuracy. We assigned eight annotators to groups and they observed the group activity in real-time and input the engagement level of each student. As shown in Fig. 2, every student engagement level input by annotators is sent to the server in real-time. The visualisation module refers to these labels in the server to calculate the student and group activity state. Note that annotators input activity levels in both conditions.

For the analysis, we measured the number of times that TAs supported groups marked by annotators and the TAs’ movement distance using LiDAR (Light Detection and Ranging), a remote sensing method, for objective evaluation. As a measure of subjective evaluation, we asked TAs to answer questionnaires about the system usability and mental workload after each condition. For usability, we used the System Usability Scale (SUS), and the mental workload is a 10 Likert-scale original questionnaire based on the items of NASA-TLX. In addition, we collected responses to five original questions as shown in Table 2.

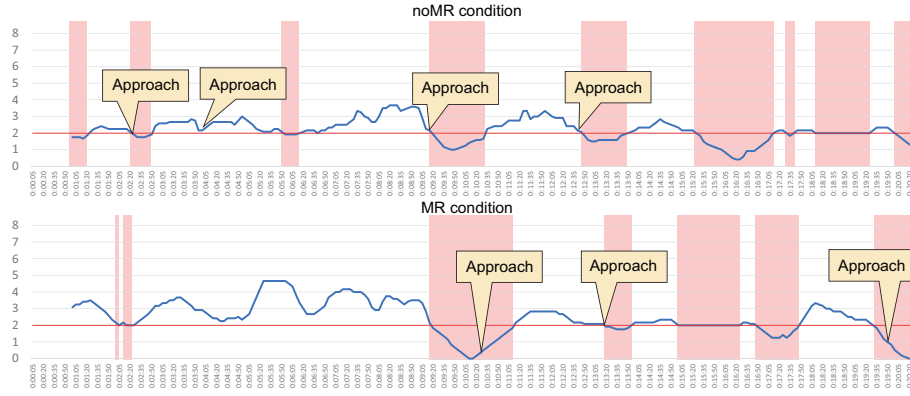


Fig. 3: The graph shows the group activity states of group 5 at sessions 3 and 4 on the first day, with the timing of TA assistance.

Table 2: The results of TA’s questionnaire ((Strongly Disagree 0 – Strongly Agree 5)).

Item	Questionnaire Items	Mean (<i>SD</i>)	
		noMR	MR
1	I could notice the group needed observation or assistance.	3.33 (1.03)	3.67 (1.03)
2	I could approach the group needing assistance with appropriate timing.	3.33 (0.82)	3.33 (1.03)
3	The overall system displayed data clearly.	-	4.00 (1.10)
4	In student assistance, I utilised the feature that changes the visualisation with the distance.	-	2.00 (1.10)
5	The graph in the details view helped to understand each student’s state.	-	2.22 (0.82)

3.2 Results and Discussion

Our sample size is small for statistical analysis; therefore, we report the descriptive statistics values and qualitative assessment of the data from TAs. Regarding the objective evaluation, the number of support provided, which means TAs approaching the groups to support them, was 9.83 (*SD*: 4.91) in the noMR condition, and 10.83 (*SD*: 6.88) in the MR condition. The assistance number slightly increased by using the proposed system. The mean movement distance with the noMR condition was 298.9 m (*SD*: 74.8), and the MR condition was 252.3 m (*SD*: 49.5). Although the number of assistance is almost the same across conditions, the movement distance in the MR condition was shorter than in the noMR condition. Fig. 3 shows the group activity states of group 5 at sessions 3 and 4 on the first day, with the timing of TA assistance. The red lines in each graph represent the threshold value for changing the panel between Active and Passive. Also, the tags represents the TA assistance timing. In the MR condition (lower graph), the TA could assist the group after the group activity state went under the threshold, while in the noMR condition (upper graph), the same

TA helped before the group activity level fell below the threshold. These results indicate that the visualisation prototype helps TAs to notice groups that need support.

Regarding the subjective evaluation, the mental workload of the noMR condition was 5.75 (SD : 1.96), and the MR condition was 5.39 (SD : 1.61). The results are not much different between the two conditions. However, the result of the SUS was 53.8 (SD : 17.3), and it varied with each individual. Regarding the original questionnaire about whether they could notice the groups that needed support, TAs scored higher at the MR condition than at the noMR condition. In contrast, the questionnaire about whether they could support the group with appropriate timing showed no difference. One TA reported, *“It was a great help to understand the timing when assistance was needed”* in the comments. On the other hand, another TA reported that *“even if the system displayed ‘Passive,’ some groups did not need support because they tackled the tasks that lie ahead compared to the other groups.”* This indicates that TAs still had to make final decisions of whether an intervention was needed or not. The decision of whether students need support or not is influenced by multiple factors such as the class goal, task, and progress which are not considered in the visualisation prototype provided. Regardless, initial results and participant comments indicate that the proposed framework has the potential to support TAs in terms of initial alerting and potentially prioritising of support for their intervention decisions. Finally, regarding the feature of detailed view, most TAs did not find it helpful. One TA reported that he had his hands full with checking group activities and approaching them, so he had no room to check each student’s activity level in a one-to-many situation with limited time. We need to confirm the efficiency of the close view feature with a long-term experiment.

4 Conclusion

In this study, we proposed an MR-based visualisation framework that displays students’ activity state to assist TAs. The proposed framework overlays student activity states directly above the group location and turns the display content based on distance. The experiment results indicated that the proposed framework has the potential to help TAs, particularly for detecting which groups need immediate attention and prioritise them to improve the efficiency of their practice. In the future, we will incorporate a student activity state estimation model to the proposed framework and evaluate the system with a larger number of students.

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