Part of the Course, not just a Spectator: Mixed-Reality Opportunities in University Teaching for Asynchronous Collaboration

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Fig. 1. In this workshop paper we envision two ways of using mixed reality in teaching: a) staggered experimentation and b) re-experiencing courses on-site. (Figure generated by ChatGPT with the following prompt: "draw a cat acting as a human which is wearing a vr glass and standing in a university lecture hall")

The integration of Mixed Reality (MR) into university teaching opens new possibilities for asynchronous collaboration and immersive learning experiences. This paper explores two MR-based approaches: (1) enabling staggered experimentation, where students perform laboratory tasks sequentially while reliving prior steps through MR-enhanced recordings, and (2) re-experiencing past lectures in their original setting using MR glasses, allowing students to virtually attend a previously recorded lecture as if they were present. These methods aim to enhance engagement, collaboration, and accessibility while addressing challenges such as interactivity limitations, privacy concerns, and technical feasibility. The paper discusses potential benefits, drawbacks, and future research directions for MR applications in higher education.

CCS Concepts: • **Human-centered computing → Computer supported cooperative work**.

Additional Key Words and Phrases: Mixed Reality, Asynchronous Collaboration, University Teaching

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1 Introduction

Augmented reality (AR) or mixed reality (MR) glasses such as the Apple Vision Pro[1] open up new possibilities for university teaching. This workshop paper introduces ideas how mixed reality can be used to make lectures and other university courses interactive despite time or geographical distances at the same time.

[1] https://www.apple.com/apple-vision-pro/, last access 03.03.2025

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Especially in university teaching, there is often the problem that events such as lectures cannot be attended due to time or geographical differences. Video streaming has become common since 2020, but does not offer the same added value, as interactions with other students, with the lecturer or with the course content are challenging. We want to narrow this gap with the two ideas presented here, i.e., we present opinions here according to the types of research contributions in Human-Computer Interaction (HCI) defined by Wobbrock and Kientz [20].

2 Background and Related Work

This section looks at the background to augmented reality and (university) teaching.

2.1 Definitions

There are definitions that describe the individual aspects of the extension of reality. We follow the definitions of mixed reality continuum between real and virtual environments by Milgram and Kishino [11] as the overall term for the aspects listed here.
Augmented Reality (AR): Overlaying the real environment with digital information [1, 7, 12, 16].
Augmented Virtuality (AV): Overlaying the virtual environment with real-world information.
Virtual Reality (VR): Fade out the real environment and display a virtual world, "make the viewer feel as if he/she were actually embedded in the scene" [3, 16].

2.2 Digital Teaching

In the field of geographically asynchronous teaching, Ullrich et al. [18] have developed a remote student-robot, via which remotely connected students can follow a lecture and signal alerts using light signals. In this setup, from a teacher's perspective, all remote students are "bundled" into one device. Furthermore, it is not possible to move the head to the left or right as the device's camera is fixed.

Other researchers have looked at the general acceptance of geographically asynchronous courses and found generally positive perceptions among the people involved [10, 19]. Many of these papers were written in direct temporal relation with the Covid-19 pandemic, so the result is not necessarily applicable to the present day. Murphy et al. [14] focus on remote high school teaching, where students note that they prefer "to chat and not talk on Skype". This shows the need for asynchronous collaboration.

2.3 AR in Teaching

There are already numerous approaches as to how AR can be used in teaching. For example, Billinghurst and Duenser [2] have described teaching methods in which books in particular have been brought "to life" using AR. Station work is described in the paper by Cuendet et al. [4]. In both cases, however, there is no collaboration with remote viewers.

Draxler et al. [5] have investigated individual learning using a VR smartphone application. In this workshop paper, however, the focus will be on glasses-based MR.

3 Idea 1: Staggered Experiments Across Time and Users

In many study courses, such as chemistry or physics, experiments have to be carried out. Several students often have to work together on a project, which requires them to come together in time. Assuming that subtasks of an experiment can be carried out one after the other, an MR application could provide a remedy.

The person working on the previous subtask of the experiment records their activities using several cameras and, if necessary, microphones. The person does not necessarily have to wear MR glasses. The recorded data can be used to create MR elements with the help of volume rendering methods such as Gaussian splatting [6]. The same also applies to situations where the experimenter/instructor wants to pre-record parts of an experiment.

By watching the recording in MR, the current student can see what the previous students have already done and, thus, continue the experiment efficiently. The advantage of MR in contrast to video recording is that the experiment setup is shown from every perspective at the current location. Another advantage is that there is no need for a difficult-to-formulate and often incomplete handover and that any errors can be retraced afterwards.

One disadvantage might be that no questions can be asked due to the time-related asynchronousness as interactions between the individual students conducting the experiment are only possible in one direction. A workaround might be that at the time of viewing the past experiment steps, the processor participates via MR. They would then no longer be on site locally, but in time, which would enable effective asynchronous collaboration.

4 Description of the 2nd Idea: Relive a Lecture

The idea has its origins in the fourth book of Harry Potter (Harry Potter and the Goblet of Fire) [17], where the main character falls into a "pensieve" (a shallow bowl filled with water and a memory) and can then relive said memory as a passive spectator. No interaction with the outside world is possible in the book.

This idea could also be applied to (university) courses: A lecture would have to be recorded with the help of several cameras and microphones in the lecture hall. The aim is to be able to relive the exact course in the original room. If students want to watch or re-watch the lecture, they could use MR glasses to relive the experience in the lecture hall. However, they would need to be physically present in the same lecture hall where the lecture originally took place.

The advantages include realistic learning, a focus on the content due to fewer distractions in the lecture hall and the possibility of integrating interactive learning methods. This requires the lecturer to work through the learning content.

Interaction with other MR participants is possible so that synchronous collaboration is created. Other approaches for collaboration include interrupting the simulation to answer questions from the MR audience. To do this, the lecturer must have reworked the event and integrated questions. These questions might be assessed using AI, for example, so that active participation in the event is enforced. This would be an ansynchronous approach, but it could be answered synchronously by the MR students. The absence of the questioner may open up the inhibition threshold for interactions in the group, as there is no immediate reaction to incorrect ideas and thus an active discussion can be created within the MR audience.

The superiority to a video recording and the effort required to provide an MR application must be examined. In favor of using MR is that more learning styles (according to Kolb [9]) are addressed, as the environment is included. [13, 15]

As an addition, a similar approach can be used in synchronous, on-site lectures in case students want to re-play previous parts of the current lecture, e.g., to recall the explanation of a definition that was presented a minute ago.

5 Discussion and Limitations

Wearing MR glasses makes it difficult to interact directly with people who are not currently wearing MR glasses. Overcoming this obstacle is a problem that still needs to be solved.

In a university teaching context, this means that no natural interaction is possible when following a lecture in real time using MR at a different location. Equipping all students (remotely and in the lecture hall) with MR glasses would be possible, but is certainly beyond any financial scope.

<table>
<tr><th colspan="2"></th><th colspan="2">Time factor</th></tr>
<tr><th colspan="2"></th><th>synchronous</th><th>asynchronous</th></tr>
<tr><td rowspan="2">Geographical factor</td><td>synchronous</td><td>lecture</td><td>stagged experiments
relive lectures</td></tr>
<tr><td>asynchronous</td><td>stagged Experiments</td><td>-</td></tr>
</table>

Table 1. Distinction between synchronous and asynchronous university courses in terms of time and location.

The ideas presented in this workshop paper are based on the fact that recorded elements are calculated into MR applications. Depending on the graphics model, this can require a lot of resources. Another potential challenge is data protection. Not all recorded persons want to have their faces or statements recorded. However, there is a solution here, as personal data (face, voice) is anonymized using AI due to the temporal asynchrony, meaning that any conclusions about the original person can be removed.

5.1 Comparison of the Time and Geographical factor

Table 1 shows the space-time matrix developed by Johansen [8] - a distinction between synchronous and asynchronous activities in terms of time and location. The ideas presented here have been included in the schema. In addition, an "original" lecture was added, which is synchronous in terms of both location and time. Teaching methods that take place asynchronously in terms of time and location were not considered in this workshop paper and are part of future work.

The first idea can be added in two fields: Should the creator of the recording participate while the current student is viewing it, this would be temporally synchronous but geographically asynchronous. Apart from that, the two ideas are primarily locally synchronous and temporally asynchronous.

6 Conclusion and Future Work

The use of MR glasses in education offers many opportunities to expand previous teaching approaches.

In this workshop paper, two ideas are presented: The first is about working on experiments at different times, the second about following a lecture repeatedly. These ideas should be tested in reality using suitable prototyping and checked for usability. The quality of the calculated MR applications should also be checked, as they should be very close to reality.

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