Experiences with Low-to-Medium-Effort Hybrid Teaching

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Abstract—The pandemic forced our institution from classroom teaching to complete online remote teaching. After the pandemic we are faced with questions of how we will continue with remote and especially with hybrid teaching formats. This includes the development of effective setups for hybrid and remote teaching scenarios – and to determine which setup is to be preferred in which context. Furthermore we have to find didactic formats to use in remote and hybrid teaching settings.

In this paper we present our experiences with the evolution of a hybrid teaching setup as it grew while we detected and incorporated more and more requirements. Our main goal was to overcome several issues related to technical handling during the hybrid lectures, and to simultaneously create a motivating environment for students.

The setups considered demand for different effort in terms of technical investment and operations. The most important idea was to separate presentation and video conferencing to different computers, thus tremendously simplifying the handling.

One setting is then evaluated for a cohort of the module Software Development during summer term 2022. Evaluation results are very promising. We further coin several didactic issues for hybrid teaching scenarios.

Index Terms—Hybrid teaching, Virtual Classrooms, Digital transformation

I. INTRODUCTION

The pandemic forced our institution from classroom teaching to complete online remote teaching. After the pandemic many teachers as well as students are glad or even enjoy it, to be back in physical classrooms after several semesters of remote teaching during phases of lockdown. However, the situation is still not completely stable and some students, as well as teachers might occasionally be in quarantine or belong to vulnerable groups that should stay at home in order to avoid an infection.

After the hard lockdown in summer term 2022 our students were faced with a heterogeneous and spontaneously changing set of offered formats in the range from in-classroom, hybrid and complete online teaching in their different courses. At our university, teachers were requested to make offers for students that were required or preferred to stay at home – although, in pre-pandemic times we would not have thought about hybrid teaching in order to enable participation of sick students at our lectures. This situation might very well continue for a couple of semesters thus being a driver to empower hybrid teaching formats.

Now time has come to reflect teaching formats explored in the past phases of emergency remote teaching. One might especially ask which evolutionary formats are worth to be incorporated into post-pandemic education. Hybrid teaching as used in the context of this paper is seen as defined by Ulla and Perrales [1] as "synchronous teaching of students in the classroom and online using an online platform". We use the generic term video conferencing system (VCS for short) instead of the term online platform. VCS subsumes the different systems used for synchronous online teaching like Big-BlueButton (bigbluebutton.org), zoom (www.zoom.us), google meet (meet.google.com), MS Teams (https://www.microsoft.com/en-us/microsoft-teams/group-chat-software), Cisco Webex (www.webex.com), and the like.

Switching to such a hybrid setting adds potential additional communication channels between a lecture's participants (teacher and students) as shown in Figure 1: we have two sources of audio from classroom to video conference session (VCS), namely teacher's voice and spoken contributions from the audience. Furthermore, we have to consider two potential channels in the other direction: audio and chat messages from participants of the VCS session. Here we assume that a teacher will not also write chat messages during a hybrid lecture. The latter communication channels add additional mental load at least to the teacher. On the other hand, the relationship aspect between persons in class and in VCS loses quite a lot of its emotional dimension due to the replacement of the immediate communication channel in the physical classroom. The latter is even worse when students do not switch on their cameras. Addressing these emotional aspect requires development of other non-technical, i. e. didactic,concepts.

In this paper we describe the evolution of a hybrid setting for teaching a course on Software Development during two semesters, starting with a simple setting and proceeding to more complex settings as we became more and more aware of the important requirements involved.

II. RELATED WORK

This work is related to several areas that have been considered in the literature either separately or in conjunction. Here we summarize the most important findings with respect to different aspects that brought forward our own work.
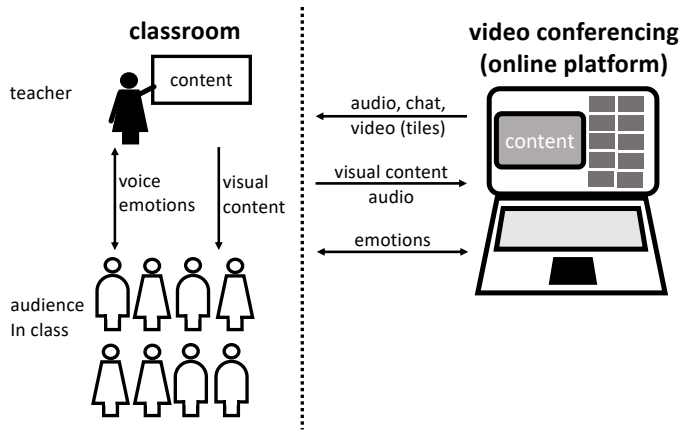
Fig. 1. Communication channels in hybrid setting. In addition to the communication channels in a classroom we have to consider several new channels between video conference and classroom as shown on the right-hand side.

A. Vocabulary and Conceptualization

There is still no really thoroughly agreed vocabulary for all kinds of hybrid and virtual/online formats and corresponding technology. We just consider a few references here:

In accordance with [1] and [2] we consider hybrid teaching as teaching and learning activities where

- teacher and students are in the same time window (which is non-controversially considered as "synchronous teaching and learning")
- a part of the students together with the teacher are in the same classroom, and the other part of the students is geographically dispersed.

The geographically dispersed students are sometimes said to be participating "virtually" [2], or "online" [1] using a video conference [2] or an online platform [1].

Schwarz and Günther [3] agree with the terms "synchronous" and "online" in this context, but they allow hybrid courses to be combined with pre-recorded video lectures besides live discussions in video conferences, which does not correspond with our point-of-view.

B. Technical Design

A couple of papers deal with different aspects of technical designs for hybrid teaching: Annelies Raes for example describes a setting where large screens display integrate the tile images of the VCS-participants in the lecture hall [4]. Rehatschek designed a streaming environment that concentrates on simultaneously streaming with high resolution from several lectures rooms to large remote audiences of 500 and more participants each [2]. In this setting also specialized personnel is needed to operate the system. These solutions require quite some effort which is beyond our intention and budget.

C. Instructional Design (didactics)

In this paper we focus on technical issues. These, however, cannot be considered without a close look on the instructional design the technology is used for.

Hybrid settings as discussed in this paper are also known as HyFlex teaching and learning [5]–[7], where students can choose to attend class either in an assigned face-to-face environment or in an online environment. This concept includes the possibility of asynchronous participation. However, HyFlex is a much broader concept aiming at instructional settings that are far beyond the scope of this paper [7].

Some papers like e. g. Nõuakas et al. (2022) report on challenges with hybrid teaching, solely concentrating on those students participating in the remote session.

D. Production Design

Evaluation of production aspects of hybrid teaching formats is just gaining more attention due to experiments forced by pandemic and post-pandemic requirements. Thus related research is yet sparse. However, we can refer to a bunch of literature and related findings from multimedia and video learning in general [8].

An important question is the effort that should go into our production design. Therefore, we concentrated on literature that can be considered for an answer to the question of camera angles, screen layouts, and the like.

Alemdag reports results of a meta-analysis considering motivation, cognitive load and social presence of instructor-present videos [9]. Her conclusions are two-folded: on one hand "the effects of instructor presence on learning and social presence were not statistically significant". On the other hand she points out that "instructor presence as a social cue might be one motivational factor that can also increase cognitive engagement with instructional videos."

Chew [10] falls back on classical theories of embodiment and performance and claims "that the teaching-body is integral to the performing of presence in online synchronous videoconferencing." Although his analysis is performed from teachers' points of view and considers synchronous remote teaching only we deem that the findings are relevant for the context of hybrid teaching.

Richard E. Mayer has performed considerable research on principles that influence the effectiveness of instructional video, e. g. [11]–[13]. Especially interesting for our work are the principles described in [12] that are worth to be considered and adopted for hybrid settings: dynamic drawing, gaze guidance, generative activity, perspective, subtitle and seductive detail (we will refer to these principles below).

III. GOALS, REQUIREMENTS, AND TECHNICAL EVOLUTION

This section describes the evolution of the technical setup as it evolved and is still evolving, driven by an increasing set of requirements and ideas. As university policy required us to use either BigBlueButton or zoom as video conferencing system we used zoom throughout this work.

Our overall goal is to create an appropriate environment for both groups, those students in classroom and those participating via VCS. The targeted audience size is around 60 participants altogether.
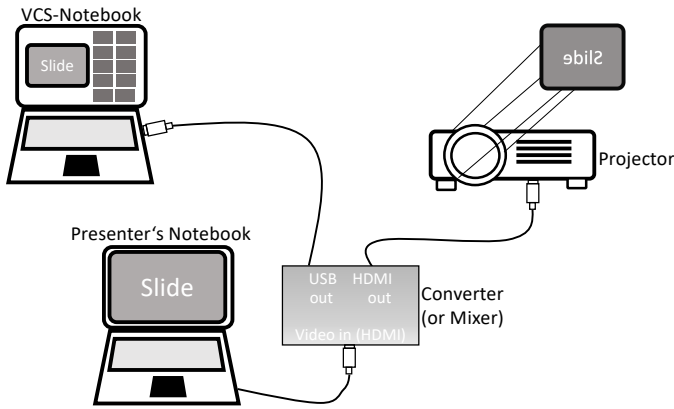
Fig. 2. Core idea of the setup with a separation of video conferencing and presentation (slides or application windows) onto different computers using converter hardware.

A. First Step: Low-effort solution

When we came back to classroom teaching we still were in some kind of emergency mode. We started with hybrid teaching in winter term 2021/22 with the probably simplest and lowest-budget-setup consisting of a notebook connected to the digital projector in classroom, integrated notebook webcam and screen sharing into the VCS. This setup happened to be extremely confusing as it tremendously increased the mental load for the teacher. Main trouble came from switching screen sharing between slide presentation and demonstrations in the integrated software development environment, and keeping an eye on the video conferencing session. Trouble increases even more by the fact that the presenter view for slides itself involves displaying different views on two different devices. An installation of multiple screens at the teacher's desk did not really help as the situation is made even more difficult since at least one screen must be shared via a digital projector.

This brought up the first requirement to design a setup that can be handled easier by the teacher and helps him or her to focus on teaching.

The basic idea to overcome the above mentioned trouble of handling content as well as the VCS simultaneously was to separate these two concerns onto two computers. Therefore, we introduced a second computer to run exclusively the VCS. This can be a notebook as well as a stationary computer in the lecture hall, it does not have to be a high-ended machine. This then requires some conversion hardware to split the presentation computer's screen to the digital projector and simultaneously feed it as (camera) input to the second computer hosting the VCS. The idea of this setup is shown in Figure 2. The converter hardware receives the content to be shown to the audience via HDMI, and transfers it to the projector while simultaneously providing it as (webcam) input to the VCS notebook. Unfortunately, the set of available converter devices is yet very limited. For the concrete setup we made good experience with video switchers from the ATEM Mini series manufactured by Blackmagic Design Pty. Ltd. (https://www.blackmagicdesign.com).

This setup fulfills the requirement of separating VCS and presentation to different computers. This turned out to make the handling much easier for the teacher. Once the video conference is set up she or he can focus on the content to be shown on the projector – and of course on the audience.

One minor drawback of this solution is that the shared screen image is transferred to the VCS via an input that is seen as webcam input by the conferencing software and might be compressed more aggressively than screen-sharing – as is currently done in fact by zoom. As a consequence image quality deteriorates. However, neither students nor teachers encountered major issues with this effect.

B. Second step: low-to-medium-effort solution

A significant drawback of the solution of step one turned out to be the fact that the teacher's image is still captured through a webcam, namely the VCS notebook's webcam. The streamed or recorded image of the lecturer should look so that he or she does not have to be ashamed of it during the lecture and possibly on recordings afterwards.

The findings of [9] indicate that instructor-present videos have a significant impact on increasing motivation. According to this, we definitely wanted to be able to show the teacher to the remote audience. This seemed even more important to us as our teaching sequences are 90 minutes long.

During winter term 2021/22 we further had the opportunity to make some experiences with an ad-hoc hybrid teaching setup based on an USB docking station which allowed to simultaneously connect several cameras and microphones to the teacher's notebook thus allowing to show whiteboard drawings as well as sharing slides and applications windows running on the notebook [14]. The cameras (Logitech StreamCam, www.logitech.com) are stationary and attached to gooseneck mounts and allow some flexibility with respect to orientation. During the lecture it does not need any manual operation. Thus no additional personnel is required.

In this second step we also improved the sound quality by connecting a RØDE wireless go microphone (www.rode.com) with the ATEM switcher. The transmitter was attached to the teacher's collar.

C. Third step: medium-effort solution

Major drawback of step 2 is that the camera images will appear on different tiles in the video conference.

To overcome this problem we use further features of our converter device: Having one or more HDMI-cameras at hand we can establish kind of an image direction by using the mixer device's switching capabilities. These capabilities provide means to alternatively show slides, teacher and black or whiteboard respectively. This, however, increases the cognitive load for handling the setup – which we initially wanted to reduce. However, we had no problem to offload this work to a student who can also have an eye on the video conference. For him or her it was no big deal to observe the teacher and occasionally press a button to make the cut between different inputs while attending class. The setting was optimized to

be operated with four buttons on the ATEM mixer selecting between four camera angles and image compositions as visualized in Figure 3.

Such a setting might bring us closer to implementing some of the good practices found in [12], as:

- Displaying the teacher drawing to a white board in high video quality adheres to the principle of *dynamic drawing:* "People learn better from a video lecture when the onscreen instructor draws graphics on a board while lecturing rather than referring to already drawn graphics".
- Switching between camera angles supports adhering to the principle of *gaze guidance*: "People learn better from a video lecture when the onscreen instructor shifts gaze between the audience and board while lecturing rather than looking only at the audience or board".
- Since "people do not learn better from a multimedia lesson when extraneous video is added" (*Seductive details* principle) we tried to use the picture-in-picture angle (No., 4 in Figure 3) sparingly. However, we felt that in long sequences a cut was required every now and then and therefore did not want to work without this angle.

The results cited by Alemdag [9] also strongly support the need for establishing some kind of video directing, e. g. switching between camera angles.

Our budget is quite limited therefore it is important to keep cost low and not to require trained staff that supports every single lecture. Our budget admitted a student assistant that might be also one of the lectures' participants. To this person the handling must add as low additional load as possible. That means we need an easily operable setup that can be controlled with just a few buttons, yet not confusing for the teacher. This setting is shown in Figure 3.

Parallel to streaming the classroom images to VCS session we put a high-quality recording of the stream online to the learning management system. This recording is also produced by the ATEM mixer on the fly. This brings our setup close to the HyFlex course design model [7].

Figure 4 shows our setting as installed in the lecture room. Everything can be packed in two carrier boxes and is set up and teared down within 5-10 minutes.

IV. DIDACTIC ASPECTS

Didactic aspects of these settings require more attention; we just briefly summarize a couple of findings here.

Motivation to actively participate in classroom activities and academic discourse between participants must be possible in any teaching and learning environment. Having experimented a lot with inverted classroom settings and interactive in-class activities before the pandemic the setting must support those activities as well. We found that cooperation of students using paper or flip charts can be moved to online whiteboarding [15] as e. g. miro boards (www.miro.com).

Setting up group activities e. g. in the context of inverted classroom happened to be more complicated than expected. The organization of breakout rooms was complicated due to students that attended in classroom and simultaneously in the VCS-session: automatically assigning students to breakout sessions caused different students spread over the classroom to cooperate in breakout session together with remote students.

The use of audience response systems [16] is possible in this setting as is in face-to-face teaching.

This kind of hybrid teaching in our opinion requires much more discipline in repeating questions from the audience. This was already mentioned in [2] and confirmed also by the evaluation, as shown below.

Mayer's principle of *Generative activity* ("People learn better from a video lecture when they are asked to engage in summarizing during learning") cannot only be addressed by technical means but must be considered from a didactic point of view in the future whatsoever.

V. EVALUATION RESULTS

At the end of summer term 2022 we performed an evaluation to gain some insights if our approach using the medium-effort setup is worth the effort – and to find out in which direction the configuration could possibly be improved. A total number of 23 students, which is roughly half of the cohort, participated in this evaluation.

Figure 5 shows the number of lectures in which each individual student participated in classroom or via VCS (zoom in our case). Students are ordered from top to bottom according to their number of attendances in class. We found out that some students participated in classroom and simultaneously in the video conference. Those mixed attendances are only shown once, namely on the left side of the diagram as attendances in classroom.

During the semester we had two lectures per week on two different days of the week. Most students participated in both variants alternately. This was probably caused by the fact that they did not want to come to the university when they also had pure online courses on the same day.

The diagram shows that only one student attended solely in class and one solely online. All others had the opportunity to take both perspectives. The fact that some nine students attended more than half of the lectures in the classroom could be an indication that they really enjoyed to be at the university.

Figure 6 shows how students estimate the importance of several aspects of the hybrid setting. Audio quality and image direction are the most important aspects. Followed by the importance of the transfer from audience's comments to VCS. This is the most important aspect where the setup has to be improved integrating another microphone which is able to capture sound from within the room.

Interesting is how students made use of the recordings that we put online after the lectures as shown in Figure 7. Almost all of them used the recordings to selectively deepen their understanding.

In the qualitative part of the evaluation, we asked our students whether this kind of hybrid teaching should be maintained and further developed in this form. The following feedback is representative; besides some praise it also contains valuable hints for improvement:
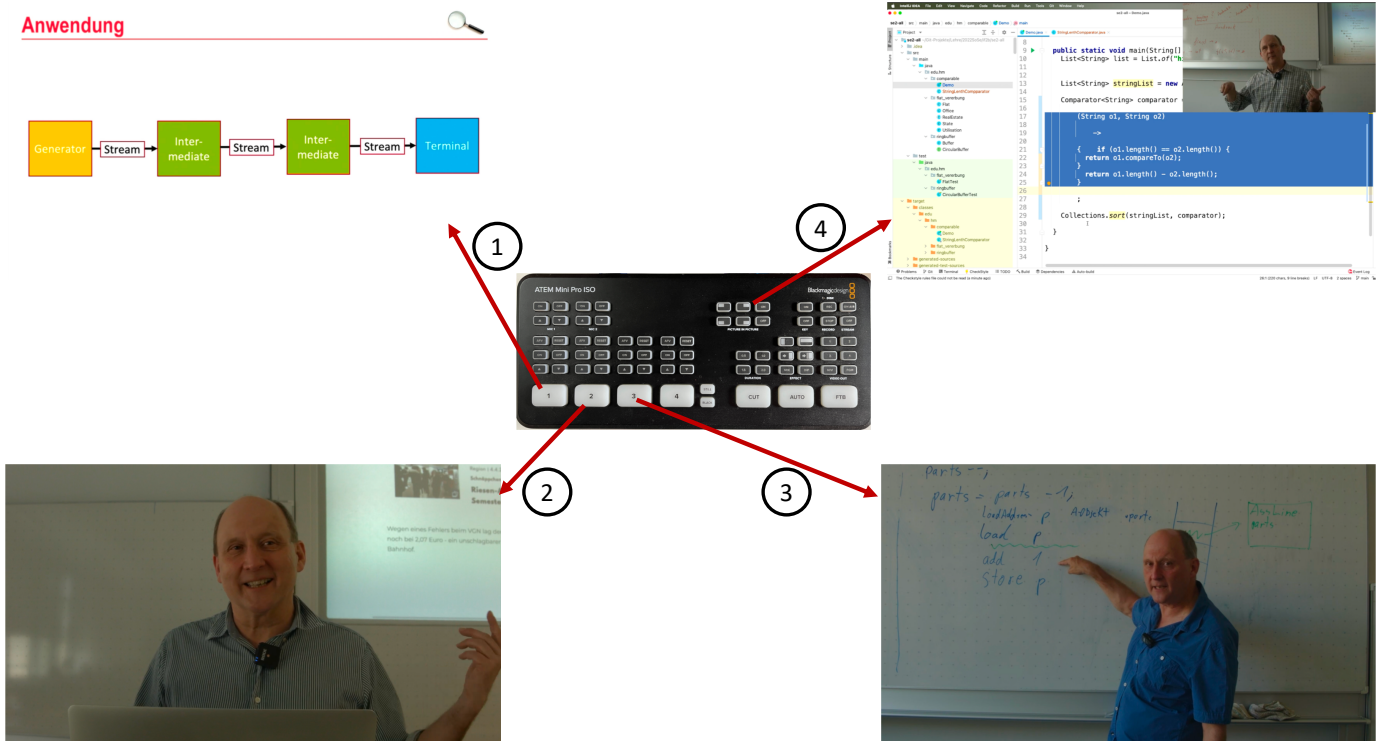
Fig. 3. Image direction using only four keys of the control desk in order to ease operation and to allow switching between four different camera angles/settings. 1: notebook screen directly to output, 2: teacher three quarter shot, 3: teacher drawing on white board, and 4: teacher picture-in-picture (i. e. shots 2 and 1 combined).
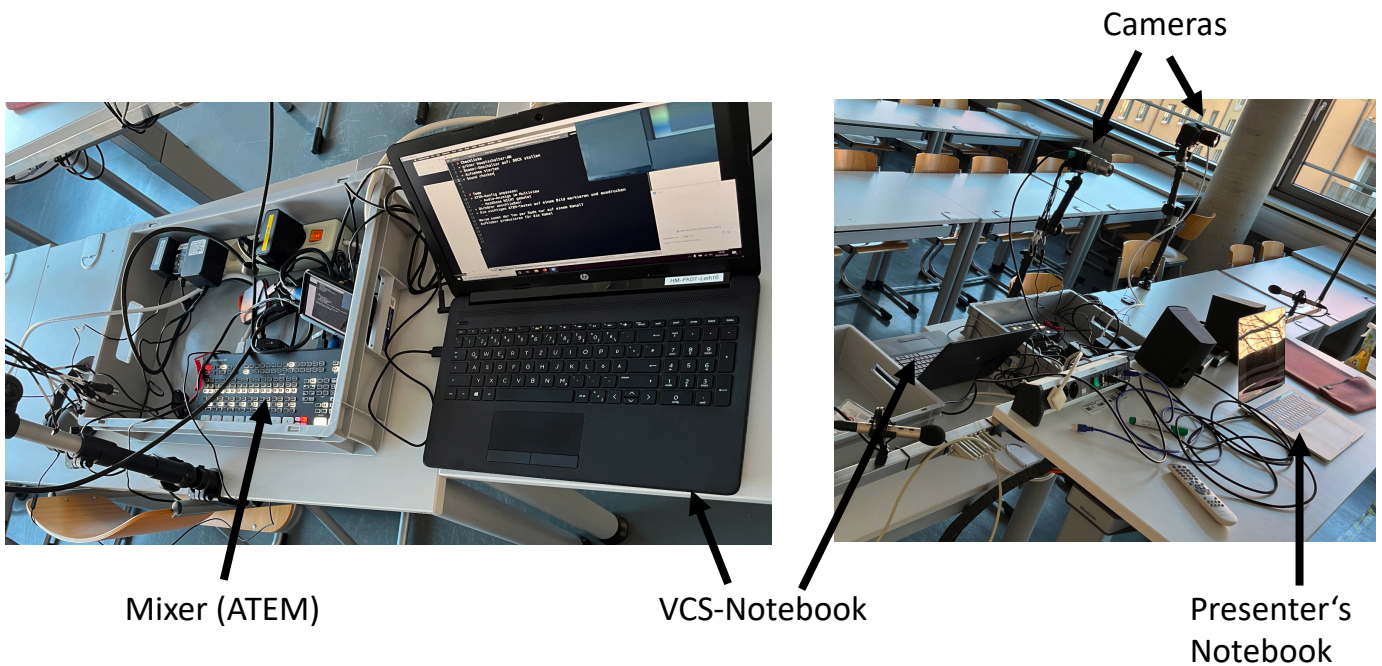

Fig. 4. Installed setup in a lecture room. The hardware can be stored for transportation in the two gray carrier boxes. Assembly and tear-down takes approximately five minutes.
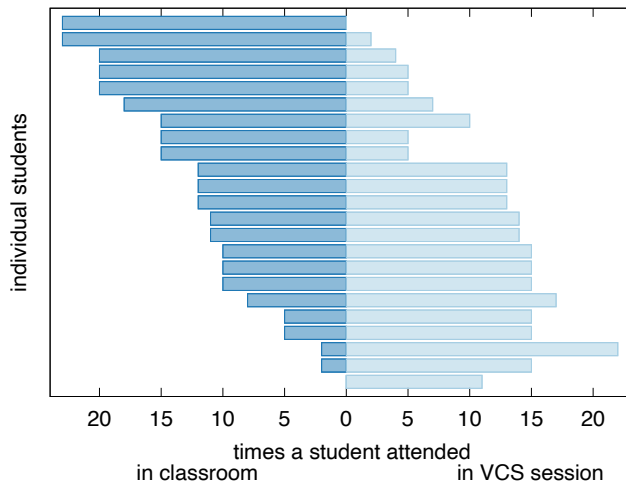
Fig. 5. This diagram shows for each individual student on the ordinate axis how many times she or he participated online or in the classroom.
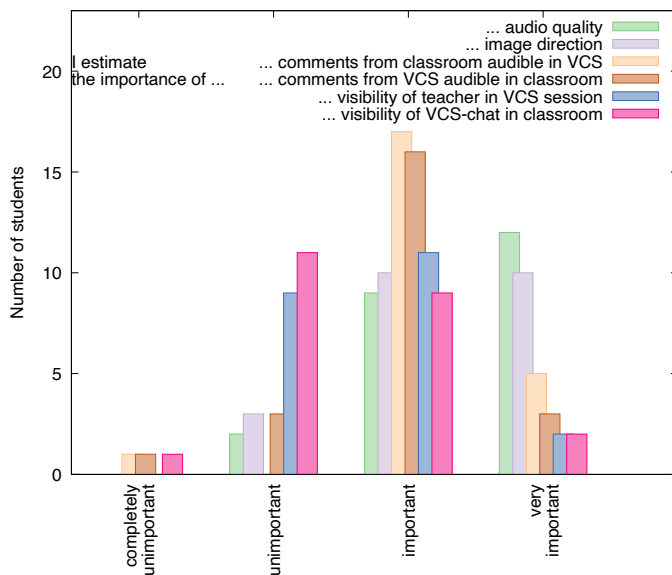

Fig. 6. Students estimation of several aspects of an hybrid setting.

Fig. 7. How students used the recordings (multiple answers were allowed).

- "thank you for the effort! For me, the best variant of hybrid teaching in my whole degree program so far :)"
- "The flexibility to have both options was a real enrichment during this semester."
- "I've seen most of the lectures at least twice, I probably wouldn't have gotten along without the recordings."
- "I think it would be more efficient to write directly into the pdf instead of filming the board."
- "It was very worthwhile because it made learning a lot easier and the motivation to participate and stick with it was significantly higher than in online events with mere screen transmission and poor sound quality" (*see section IV on didactic aspects*)
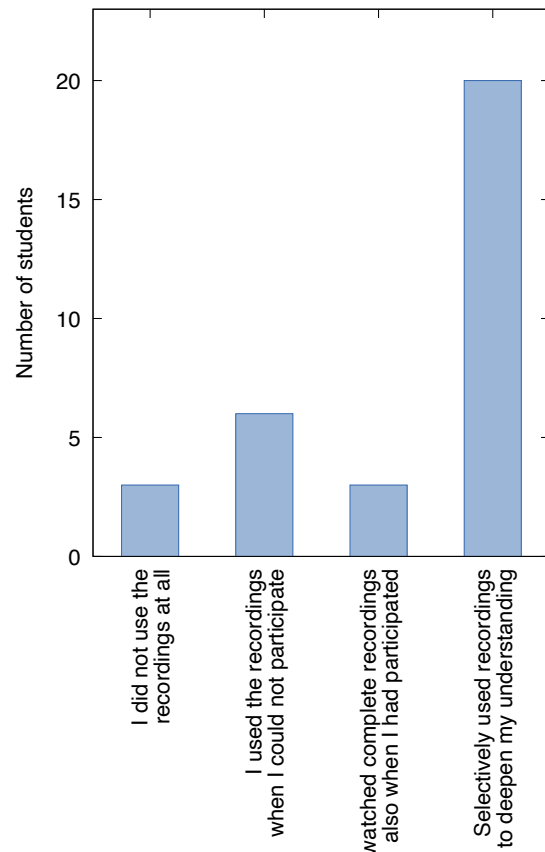- "I think this is a great idea. It gives the students the

opportunity to decide what is good for them and it also allows for a better allocation of time. For example, I divided it into two parts, once a week from classroom and once from home, so I could balance everything better with work without wasting time on travel, and once I always came to classroom because it was still important for me to see fellow students and to hear and participate in lectures live." This conforms to the conclusions drawn from Figure 5 above. It is promising insofar as students are still motivated to attend in the lecture hall.
- "A room microphone is not essential, but then the professor must consistently repeat the questions in the room for the online participants." This important aspect is also mentioned in [2] and must be incorporated by the teaching persons.
- "You could use more polling tools that are good to use for all participants such as EduVote" This statement is definitely correct. Becoming more and more familiar with operation of the technical setup brings more possibilities to activate students.
- "Remote participants could be more involved" (*see section IV on didactic aspects*)

VI. Conclusions and further work

In this paper we presented a setting for hybrid (synchronous) teaching and evaluated students' perception to some extent. From the teacher's point of view the most important feature of this setup is the separation of video conferencing and presentation to separate computers thus reducing mental load significantly.

Furthermore, adding some capabilities of image direction brings us closer in accordance with good practices of video-based learning.

The setup presented could be extended in several ways yet all leading to more complexity and might require operation by a dedicated directing person:

- Display chat messages to the audience in the lecture hall, e. g. by splitting the chat window to separate monitors that can be seen by the audience a swell as by the teacher.
- Add more camera angles and introducing the larger ATEM mini extreme pro providing much more flexibility in terms of highly configurable split screens and multi-box layouts.
- Improve sound from lecture hall to VCS by a dedicated and separately controlled room microphone.

One of the next steps would naturally be an analysis of the effectiveness in terms of students' grades and academic performance in general. This, however, is still difficult to evaluate and compare with the pre-pandemic situation since many parameters have changed.

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