Scenarios, Methods, and Didactics in Teaching Using Video-Conferencing Systems and Interactive Tools

Empirical Investigation on Problems and Good Practices

Khalid, Md Saifuddin; Tretow-Fish, Tobias Alexander Bang; Parveen, Mahmuda

Published in:
Proceedings of the 25th International Conference on Human-Computer, HCII 2023

Link to article, DOI:
10.1007/978-3-031-34411-4_31

Publication date:
2023

Document Version
Peer reviewed version

Acknowledgement: Co-Financed by Erasmus+ Grant Agreement No. : 2021-1-DK01-KA220-HED-000023313, Project Acronym: EdViCon

Scenarios, Methods, and Didactics in Teaching Using Video-Conferencing Systems and Interactive Tools: Empirical Investigation on Problems and Good Practices

Md Saifuddin Khalid[1[0000-0002-3731-2564]] and Tobias Alexander Bang Tretow-Fish[1[0000-0002-2604-0153]] and Mahmuda Parveen[1[0000-0002-3188-2996]]

[1] Department of Applied Mathematics and Computer Science, Technical University of Denmark

Abstract. The restrictions during COVID-19 pandemic resulted in gaining more experience on video conferencing systems (VCS) and continued adoption during post-pandemic teaching scenarios. Designing and installing video conferencing systems in various classroom scenarios are expensive, increase complexity, and reduce interaction opportunities unless the designs for learning activities are well-defined and well-executed. For improving the quality of contact hours, the EdViCon Erasmus+ project's aim is to explore the existing diversity of scenarios of video conferencing systems' use, various methods, and didactics applied for engaging students using various software and VCS features and define and develop two portable VCS toolkits and training. This paper reports the empirical case of Technical University of Denmark by applying phonomyography [1] as the methodology for exploring the VCS use scenarios, methods, and didactics for exploring problems and good practices. Despite increased adoption and number of papers on VCS, the insights on the diversity of the scenarios of use during contact hours has not been sufficiently reported from the viewpoint of HCI researchers. This study applies Shuman's[2] concept of signature pedagogies as the theoretical viewpoint for defining scenarios of the use of VCS in teaching and David Benyon's [3] PACT (people, activities, context, technologies) framework for analysing functionalities, methods, and didactics. The causes and effects of problems with VCS-mediated contact-hour activities were grouped into seven and 12 categories respectively. Seven types of teaching environments, three types of video-conferencing systems (fixed, on-wheels, and mobile), and the various tools used for engaging students were identified.

Keywords: Video conferencing, higher education, student engagement.

1 Introduction

During the COVID-19 pandemic many institutions decided to use video conferencing systems (VCs) as a teaching tool instead of face-to-face teaching. To some educators and students, teaching through a video conferencing system is the future of teaching, to some it is essential for desired learning experience in today's classrooms, and to some it is a technostress. Typically, the video conferencing system that are used in the

classrooms require expensive setup and various hardware components (for example, loudspeaker, wireless microphone, wireless or fixed mics for audiences, control panel for controlling the lights, curtains, projectors, screens, computers, cameras, etc.) Installing the hardware in the various types of classrooms and engaging students during the various types of teaching activities are highly resource intensive. Furthermore, a mapping of the diversity of classroom designs, course activity designs, and the use of digital learning technologies for engaging students during the contact hours cannot be identified in the existing literature. Amidst the pandemic, this study began with the intention of mapping the different scenarios of VCS use during the *contact hours* (when teachers and students are in live interaction), problems and good practices of using VCS technologies and didactical designs, and digital tools for engaging students. The outcomes of this empirical study is expected to contribute with technological and pedagogical aspects for the improvement of teaching-learning activities during contact hours.

As part of the Erasmus+ KA2 project "Portable Video Conferencing Toolkits and Online Applications for Engaging Learning Experience Design in Higher Education Classroom" (EdViCon)[1], this paper reports the empirical investigation conducted at the Technical University of Denmark (DTU). So, the elements of innovation and academic novelty of this paper are:

1. A collection of existing problems and scenarios of using video conferencing systems, which are communicated with graphical and tabular methods. The novelty is the diversity of scenarios and both technological and pedagogical concerns in the uses of video conferencing systems and student engagement.
2. A collection of existing best practices of the methods and didactics for video conferencing-mediated teaching including and student-engagement technologies, which are collected in the form of surveys, interviews, observations, and other methods and communicated visually. The innovation is the explored diversity of best practices in specific scenarios of VCS use integrated with the various online tools for engaging students.

The underlying objective is to find the heterogeneity in the activities of the contact hours, the challenges faced in the process of adopting video conferencing systems, and engaging students. The findings are expected to provide cases of good practices and digital technologies for improving synchronous online and blended teaching.

2 Related works

Existing literature reviewed the use and the comparison of the features of various video conferencing software, which include but not limited to Zoom, Microsoft Teams, Google Meet, WebEx, AdobeConnect, ClickMeeting, and BigBlueButton [4]. The diverse scenarios of the contact hours are not synthesized in the review and not emphasized in the empirical papers included in the review.

[1] https://edvicon.compute.dtu.dk/

The study [5] reports that the first-year pharmacy students were taught the fundamentals in Pharmaceutical Chemistry at the Faculty of Pharmacy, University Technology MARA applying Community of Inquiry approach by participating in online activities through remote video-based laboratories.

In [6], 200 first to fourth year engineering undergraduate students and 30 faculty members from two Engineering institutions in Chennai city and Andhra Pradesh (urban and rural) were asked to share the efficacy of the existing infrastructure facilities for providing online collaborative learning in VC. In [7], 16 graduate students and their instructor participated in a course on discourse and conversation analysis at a public university in the south-eastern United States. The course was conducted in a blended format of physical teaching and online teaching through WebEx. The study tried to analyse turn-taking in single and dual channels of sound and chat as well as repair sequences of turn-taking through the system.

In [8], 49 third-year medical students from 10 different institutions in New Jersey and Pennsylvania participated in a non-credited virtual course. The study examined the conversion of an in-person workshop for orthopaedic trauma basics to a virtual course during emergency teaching due to COVID-19. The virtual course had weekly lectures and virtual interactive small group sessions conducted through WebEx. In a later stage of the study, they assessed the students' perceived value of the class.

In [9], 70 students enrolled at the Computer Science and Cybersecurity course of St. John's University's Division of Computer Science, Math and Science was posed rubrics on learning curve, asynchronous scheduling availability, system response time, student engagement, and overall quality of course delivery experience. The intention was to circumvent the difficulties during COVID-19 restrictions by showcasing the educational journey of engaging in group work through Video conference systems while doing hands-on lab work.

The related work on VCS in the existing literature reports comparison of various VCS software features, cases of various methods (e.g., turn-taking), scenarios (e.g., computer science hands-on lab), and addressed various problems. This paper intends to contribute a holistic overview from one higher educational institution for supporting decision-making and further innovation in making portable video-conferencing toolkits for resource-constraint higher education institutions.

3 Context, Methodology, and Methods

3.1 Context

The context of the study is the Technical University of Denmark (DTU), which is one of the top 2-200 universities, as ranked by various systems. There are about 11200

students and 6000 employees. DTU has four campuses: Lyngby, Ballerup, Risø (which are 10-40 km from Copenhagen), and Sisimiut campus in Greenland. In 2021, DTU had 18 BEng programs (3976 students), 19 BSc Eng. programmes (4065 students), 33 MSc Eng. programs (5373 students), and 17 PhD schools (1527 students)[2]. Students are from 114 countries with 32% enrolled students are women. 54% of faculty are below 50 years of age, 38% of total staff are woman, and with 91 nationalities 12% have an international background. This study covers the teaching facilities in Lyngby campus, which covers a 106-hectare site. All the activities associated with teaching-learning, including but not limited to, the use of video conferencing systems (VCs), classroom environment, use of tools in engaging during the contact hours, are subject to the institutional and national higher education culture of Denmark.

3.2 Methodology and Methods

This sub-section includes the participants, the methods applied for data collection, and the methods for data analysis.

The participants or sources include three target groups (TG): (1) academics and administrative personnel, (2) E-learning consultants, IT support, and Teacher trainers, and (3) Students.

This study conducts the empathize and define activities of the design thinking process [10] by applying Phenomenography [1] as the methodology. Phenomenography [1] covers 'what' and 'how' questions in the phenomenon, where video conferencing mediated interactive contact hours is being investigated.

Data collection includes four methods: in-situ interviews, problem-tree analysis [11, 12] workshops, classroom observation, and one questionnaire survey.

1. In-situ depth interviews [13] are conducted with three audio-visual support roles from the central IT unit, three e-learning (pedagogical) support professionals, and five course instructors from the computer science department (but different signature pedagogies and roles). A semi-structured questionnaire was developed, and analysis of the interviews were conducted by using the PACT (People, Activities, Context, and Technologies) framework [3].
2. Two focus-group discussions are conducted by using problem-tree analysis [12], which shows the causes, effects and a central problem associated with the use of video-conferencing systems and students' engagement during online or hybrid contact hours. During the first workshop, 17 research and administrative personnel from one of the research sections from the computer science department participated in three groups. In the second workshop, 21 graduate students enrolled in an elective course on digital learning technology and entrepreneurship participated in their

[2] https://www.dtu.dk/english/about/facts-and-figures, DTU Facts and Figures 2022, https://issuu.com/dtudk/docs/dtu-facts-and-figures-22?fr=sNDI5MzQ5MzI1MjI

respected course project groups. The students also grouped their courses according to similarities of contact hours and the summarized the use of online tools for engagement or collaborative learning. Applying the concept of signature pedagogies [2], the teaching environments were considered for further observation.

3. Observations of three classrooms, two galleries, two laboratories, and two meeting (supervision and oral exam) rooms are conducted by taking pictures and notes on the use of video conferencing systems. Seven scenarios of contact-hour environments are selected based on the list of all the courses offered by the department of applied mathematics and computer science according to the second focus-group discussion, where the rooms for the enlisted courses are identified and selected the rooms based on the diversity in the courses' signature pedagogies[2].
4. Survey responses from 42 academics regarding their use of digital learning technologies and software they would recommend to their colleagues provide insights on engaging students during contact hours. Although the responses are analysed from the perspective of engaging students during VCS mediated contact hours, but applicable for face-to-face teaching as well.

In the following, the context, the source or participants, and the methods for the data collection and analysis are presented.

3.3 Instruments and protocol

In-depth Interview Protocol

The in-depth interview [13] instrument is inspired by the PACT framework [3]. From this framing, the researchers applied an investigative and explorative approach [14] (Adams, 2015, p. 492-505) to understand the PACT dimensions from the different perspectives of the interview participants. The interviews consisted of two steps:

1. The participant describes how they use VCs from their perspective (either as students, IT-support, or as a teacher). As the participant describes their use of VCs the researchers make the participant elaborate their responses from a PACT framework inspired interview protocol.
2. The participant describes good practice scenarios of using VCs. This is done by putting emphasis on the activities associated with teaching with VCs and if students like them.

The interview protocol includes the following questions (P: People, A: Activities, C: Context, T:Technologies). The survey instrument and data complements the findings from the interviews.

P: What are the roles of the people who you work with? Example: For a teacher it's students and other teachers, teaching assistants, etc. Example: for an e-learning consultant, it's teachers and IT support etc.

A: What are the names of activities that you do in the "contact hours"? What works well and what does not? Example: Lecture, monitoring, meetings, guidance. What didactics and methods do you use? Example: Groupwork in Zoom breakout rooms.

C: 1. How would you define the contact-hour context of your VC experience? 2. What are the core tasks of the unit you work at (e.g., for academic departments, these are

usually teaching and research; for IT-support units, these can be supporting personal computers or other infrastructure)? 3. What are the organizational guidelines that you follow? Example: for teachers, course name, study program, if the students are at home or in the class, what kind of class/lab/studio etc.
T: 1. How various technological features and tools are used during a VC-mediated contact session? 2. What tools do you use for engagement and how? 3. What works well that you would recommend to others? 4. What are some of the main concerns that you would ask other roles/colleagues to address?

Survey
The IT-support team of the university's central IT services has a sub-group responsible for the integration and adoption of digital learning technologies. The team requested for responses from the faculty members of all departments though an online survey questionnaire. The questionnaire includes the following questions: (1) Name of the department, (2) Language (Danish/English), (3) Which digital learning tools have you used in your teaching? (Name as many as possible), (4) Which tool would you recommend to a colleague? (5) What forms of teaching have these tools supported? (Select all that apply) (6) May we contact you regarding your experience with these tools?

Observation

During and after the interviews, the contexts and technologies mentioned by the interviewees are observed while pictures and notes are taken. The observation of experimental setups for VC-mediated teaching are excluded.

Focus-Group Discussion: Problem-Tree Analysis
Problem-tree analysis (PTA) [11, 12, 15] is a flow diagramming technique that enables the researcher to assess stated problems' or later identified problems' causes and effects from the perspective of the participants. By applying this method researchers can illuminate the negative aspects of a situation and represent 'cause-and-effect' relationships between e.g. multiple problems [11]. In this study, the protocol for conducting the problem-tree analysis consists of 7 steps. (1) Participants are divided into groups and are asked to reflect on their experience with VCs. Next, they were asked individually to define, in their perspective, the main problem regarding VCs. Afterwards, the individual problems are brought into the group where they suggest different problems, negotiate, and discuss with each other to produce a single general "problem statement". (2) Each group sits face-to-face (or online) around a table and receives a mind map template with a depiction of a tree. The tree has three major empty spaces to write down: (a) One major problem statement (in the middle of the tree), (b) Multiple causes of the problem (the roots of the tree), (c) Multiple effects of the problem (the branches of the tree). 3. The participants are asked "What causes your problem?" and write as many post-it or notes they could on the tree, each note containing one cause. This was done as an individual task where participants did not need to negotiate or discuss their actions. 4. The participants were then asked, "What are the effects of your problem?" and

write as many post-it or notes as possible, each note containing one effect (positive or negative). This is also done as an individual task like step 3. (5) After the individual notes were placed, the participants were asked to present the causes and effects of the problem to each other in a very brief manner. (6) After the presentations, the participants worked together in grouping similar and related causes and effects together. (7) Next, the participants are asked to draw connecting lines between multiple causes, causes and effects, and multiple effects - this is to highlight their relationship. From these 7 steps a problem-tree analysis is produced, and the researchers collected the physical (or digital) sketches which formed the basis of the data. The authors of the paper facilitated the workshops, further categorized the causes and effects, and excluded the general problem statement as participants had difficulty in agreeing on generalized statement.

The students participated in a second discussion after the PTA. They were asked to think about the video conferencing experience during home-based classes amidst COVID-19 restriction and the subsequent hybrid classroom experience where some students participated from home and others attended face-to-face at the university. The participants were introduced to the concepts of signature pedagogies, teaching styles, learning preferences, and were asked the following: (1) Considering signature pedagogies, what are the different structures of course activities you have? (2) Group the different courses with similar structure and write the structure down in brief terms. (3) Write down which digital tools were used for engaging you during the contact hours of the teaching while considering your experience during the COVID-19 restrictions and later. The participants were facilitated to reflect on the good practices in VC-mediated and other digital tool supported activities during the contact hours.

4 Analysis and findings

The findings from the mixed-method study are presented in two sub-sections, which separately unfold the two problem statements and underlying research questions.

4.1 Existing problems and scenarios of VCS-mediated teaching context

Only one of the groups (students' group four) could agree on a problem statement for the problem-tree analysis: "*The professors are not able to read the room online and need to prepare better for the class and use of technologies*". The participants discussed that if the professor cannot see and/or understand the experience of the students, then both pedagogical and technological preparation is required. The participants discussed that the "read the room" refers to observing facial cues, interactions, feedback, etc. which can be restricted by technology, perception, or pedagogical preferences.

Causes and effects of problems with videoconference-mediated teaching

The authors grouped the causes stated in the PTAs made by the students as categories numbered SC1-4 and the employees (teachers and staff) in categories numbered TC1-4 as shown in Table 3.

Table 3. Causes identified through problem-tree analysis.

Category	Causes/Groups	S1	S2	S3	S4	S5	E1	E2	E3
SC1: Inter-personal and social interaction issues	Experiencing difficulties with intrinsic motivation			X					
	No opportunities for socialising	X	X	X		X			
	A lack of and a need for physical presence	X	X						
	Non-anonymous chat/questioning requirements by some professors				X				
	Lack of familiarity with the VCs (fx. muted and un-muted complications)			X	X				
SC2: Issues related to students' perception & preferences	VCs teaching is not engaging or motivating	X		X					
	Difficult to get help or support over VCs from teacher or fellow students (fx. coding)	X		X					
	Changed structuring of lectures causes problems (fx. No breaks or few of them, long talks without interaction)					X			
	The surroundings of my home does not engage me in teaching			X		X			
SC3: Technological troubles	Communication barriers due to technical circumstances of VCs (fx. one way of communication, lack of body language)		X						
	Technical issues regarding VCs interrupts the flow of communication (fx. late/long response time while speaking, updating software issues, network and bandwidth issues, video and audio issues)		X		X	X			
	VCs technology needs improvement (fx. digitalizing of "reading the room" skill)				X				
	VCs has limitations on time and participants				X				
SC4: Unsorted	Access to different tools				X				
	VCs enables multitasking					X			
	Lack of interaction while editing online board		X						
	Can't participate all the time		X						

TC1: Technical issues	Lack of features in VC (no tool for zooming, indication for student questions, not intelligent enough, blackboard alternatives, limitations of VC etc.)						X	X	X
	Technical issues related to VC (Connection, audio, and video problems, etc.)							X	X
TC2: Pedagogical-behavioural	Online students are de-prioritized in teaching context (inattention, turning off webcam, lack of a connection with students etc.)							X	X
	Two different modes of teaching simultaneously (guidelines for teachers' actions, attention, different context, etc.)						X	X	X
TC3: Resources	Lack of resources (time, training, quality LMS etc.)						X	X	X
TC4: Unsorted	Question answer sessions not equal							X	
	The system isn't ready for teachers, technicians, or students. Everyone needs to be better prepared							X	
	Independent training by teachers							X	
	Large numbers of students								X

The similarities between the categories of causes perceived by students and teachers are: 'SC1: Interpersonal and social issues' & TC2: Pedagogical-behavioural. Students focused on the problems and limitations of interacting with each other and only in a limited way interacting with the teacher. The teachers emphasized on the behavioural factors in the phenomenon and the pedagogical implications. Students and teachers shared the category of 'SC3& TC1: technical issues' as they engage with the technical aspects from different perspectives. Students focus on issues related to communicating through and with technology whereas teachers focus on lack of features and connectivity.

Unique for the students' category is 'SC2: Issues related to learning' touching upon the experienced problems of engaging with the software, support issues, and problematic organisational and physical circumstances participating in VC teaching. A unique category for teachers is the 'TC3: lack of resources' where resources is understood as time, training, quality of LMS e.g., Lastly, both students and teachers have an 'SC4&TC4: unsorted' category containing elements of lack of access to different tools, limitations of participation, functionalities of the VC, critique of the system, and organisational issues related to the application of the VC.

The authors also grouped the *effects* stated in the PTAs made by the students as categories numbered SE1-6 and the employees (teachers and staff) in categories numbered TE1-6 as shown in Table 4.

Table 4. Effects identified through problem-tree analysis.

Category	Effects/Groups	S1	S2	S3	S4	S5	E1	E2	E3
SE1: Improving teaching	Improvement to teaching reasons being VC features (Microphone, Blackboard access, etc.)	X		X					
	Improvement to learning preferences (Own pace learning etc.)			X					
SE2: Worsening teaching	Worsening to learning preferences (Slower understanding, less personalized, group work difficult, difficult to engage in class, fear of asking questions etc.)	X	X		X				
	Worsening to teaching reasons being VC features (Can't hear other students' questions and answers etc.)		X						
SE3: Interpersonal and socially related.	Lack intrinsic motivation (feeling ignored, distracted, annoyed, loneliness etc.)	X			X	X			
	Difficult to socialize over VCs with teacher or students (Asking questions, getting help or support, no interactions etc.)		X			X			
SE4: Rules and behaviour	Online learning norms (web camera on, muting when not on etc.)			X					
SE5: Technicalities	Online Learning materials (Reading improvement, etc.)	X							
SE6: Unsorted	Working from home autonomy (Rest opportunities, food etc.)			X					
	Harder to event to invite student participation			X		X			
	Easy to skip class					X			
TE1: Improvement of teaching context	Opportunities for students to choose their learning preferences.							X	
	Improved flexibility for teachers and students							X	X
TE2: Differences between physical and online students	Difference in attentiveness (online versus physical students.)						X	X	
	Larger difference between good and bad students (Learning, independence)							X	

TE3: Worsening of teachers' conditions	VC teaching is a less satisfying way of teaching							X	
	VC teaching results in lower quality of the course and heavier workload								X
TE4: Worsening of teaching context	Less opportunity for collaboration							X	
	Lack of feedback in interactions between students and teacher						X	X	X
	Lack of familiarity of students' knowledge, skills, and competences from online activity							X	X
	Decrease in student activity in lecture and with content.						X		
TE5: Organizational benefits	Increased capacity of courses								X
TE6: Technicalities	Issues with IT support							X	
	Problems with VC features (cumbersome to navigate)						X		X

The following similarities between students' and teachers' effect categories were shared. Students' 'SE1: Improving teaching' and teachers' 'TE1: improvement of teaching context' were teachers focus on the positive effects of VC being flexibility and customization for teachers and students. Students also emphasises customization as well as technological features of the VC. Another similar category is students' 'SE2: worsening teaching' and teachers' 'TE4: worsening of teachers' conditions' and 'TE5: worsening of teaching context'. Students focus on the exact opposite of students' improving teaching category whereas teachers mention less motivation with teaching VC, lower quality of teaching quality, less collaboration, less opportunity for feedback, and less activity from students. Last of the categories sharing similarities is students' and teachers' 'SE5&TE6: technicalities. Students appreciate the new learning materials whereas teachers experience issues with IT support as well as VC features.

Students and teachers also have uniquely represented categories such as students' category of 'SE3: interpersonal and socially related'. In this category students describe the lack of motivation and socialization they experience. Another unique category for students is 'SE4: rules and behaviour' which deals with how to navigate the online environment. Lastly, students have an 'SE6: unsorted' category emphasising the benefits of working from home, problems of engaging with other students, and how easy it is to skip classes. Teachers' unique categories are 'TE2: differences between physical and online students' underlining differences between online and physical students related to attentiveness and students' academic levels. The final unique category for teachers is the 'TE5: organisational benefits' related to the possibility of increased student capacity in classes.

While some of the technological issues can be supported by the IT roles (SC3, TC1, TC4, and TE6), a lot of the issues can be addressed by pedagogical strategies and practices by the teachers or small organizational changes (elements of SC1, SC2, TC1, TC2, TC3, TC4, SE2, SE3, SE4, SE6, TE2, TE3, and TE4.) Other issues are conditional to

the signature pedagogy of VC-mediated teaching (elements of SC2, SC3, TC1, TC2, SE3, SE4, TE2, TE3). This implication of signature pedagogies in the contact hours and learning process need to be communicated to students and teachers by introducing the *concepts of surface, implicit and deep structure of the profession* [2] influencing teaching style.

Analysis of Interviews and Observations of videoconferencing setups and toolkits

The activities conducted during the contact hours with the professors are typically defined and stated as: 1) lecture 2) supervision 3) exam. For each of the three activities in contact hours, the scenarios of the VCS use differ due to further differences in people and context. For example, the context differs when lectures are given in auditorium, design studio, laboratory, and home or office space. People differences can be, for example, supervision or oral exam of students individually or in group. Moreover, the technologies (VCS and other resources) in the location of the activities influence the scenarios. For example, a lecture in an auditorium is streamed to one or more auditoriums or online, may involve writing on a touchscreen or pen tablet or through Remarkable2™.

From observations and from the interviews three broad categories of VCS have been identified: (1) fixed installations in the rooms, (2) mobile setup on tables/wheels, and (3) portable bags containing equipment.

The teaching contexts of a teacher using the three types of VCS have seven different types of contexts, which have different surface structures from the perspective of signature pedagogies. (a) *Galleries/auditorium*, elevated seats facing towards the teacher with a high capacity of students (Fig. 3). The camera is placed in the back of the room capturing the teachers' movement at the blackboards and at the desk. This enables the teacher to move around in the room and use multiple blackboards and/or whiteboards. Camera and screen-sharing are streamed to digital and physical attending students. (b) *Studio* for group-wise seating, tables arranged around the room with a possibility for rearranging the setup and to move around the room (Fig. 4). Screen-sharing is streamed to digital and physical attending students. (c) *Traditional classroom*: Teacher-faced rows with less capacity than the auditorium (Fig. 5). Screen-sharing is streamed to physical attending students (d-e) *Laboratories* with hardware installed or tables where hardware can be installed to work on it individually or in groups. Cameras installed at the tables can showcase teacher experiment activity as well as screen-sharing is streamed to physical attending students (Fig. 7 & 8) (f) *Supervision:* Teachers' table for online lecture or supervision involving laptop camera, external webcam, mobile stand & camera, pen tablet & remarkable, and a white board behind or beside the seat (Fig. 6). (g) *Meeting rooms* of three types but mainly for supervisions and thesis defence (fixed, mobile, and portable versions of setup), which are shown in Fig. 9 & 10.

Fig. 3. Auditorium - signature pedagogy (a)

Fig. 4. Studio - signature pedagogy of (b)

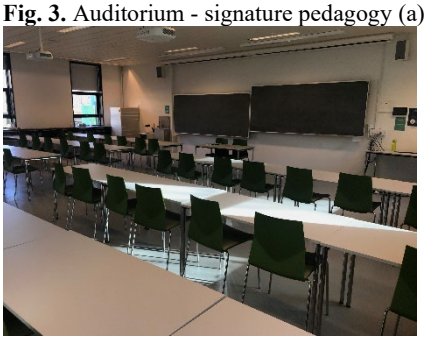

Fig. 5. Traditional class - signature pedagogy (c)

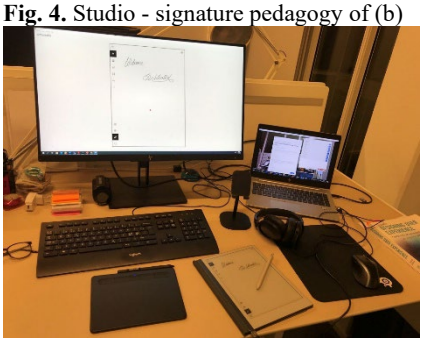

Fig. 6. VCS-mediated *supervision* & can simulate signature pedagogies (a, b, c & f)

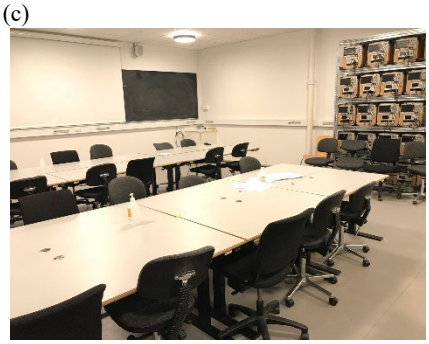

Fig. 7. Laboratory cum traditional classroom - Signature pedagogy (d)

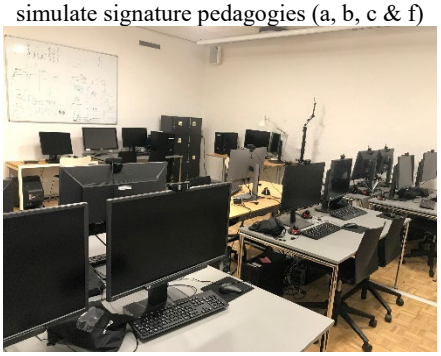

Fig. 8. Dedicated Laboratory - Signature pedagogy (e)

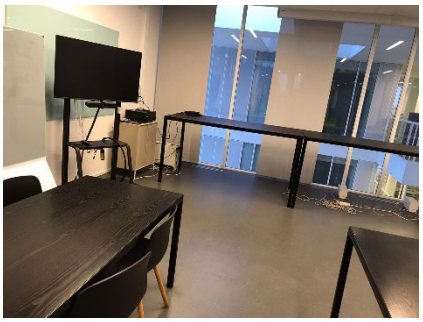

Fig. 9. VC system setup for a meeting room

Fig. 10. VC system setup for a meeting room

at DTU corresponding to the signature pedagogy of (g) for a mobile or portable setup.

at DTU corresponding to the signature pedagogy of (g) with a fixed setup.

The mobile version of VCS is similar to the hardware components of fixed installations and some of the components are fixed, for example, projector, automated screen, wall-mounted configuration buttons etc. There are two different versions of the portable VCS bags, where the bags are expensive as those are designed to be borrowed from the IT unit, audio-visual unit, or library. The Portable bags were designed and assembled by the audio-visual team of the university. Two portable VCS setups contained the following items presented in Fig. 11-16 showcasing the five items of the portable kit and the portable kit itself. Each of the bags contain single-page instructions for setup, which is laminated and securely tried inside the bag.

Fig. 11. Owl Labs Meeting Owl 3: Camera, microphone, and speaker system in portable kit

Fig. 12. Jabra 750: Microphone and speaker system in portable kit

Fig. 13. Camera tripod in portable kit

Fig. 14. USB charger in portable kit

Fig. 15. USB extension cable in portable kit

Fig. 16. An example of the portable kit.

4.2 Existing methods, didactics, and practices for engaging teaching

This section includes the findings from the second workshop with students, survey responses from teachers, and interviews with the teachers and other roles.

Student Engagement Tools: Faculty Survey Responses

From the survey distributed to teaching staff at DTU (n=42), employees were asked which tools they adopted in their teaching, which of these tools they would recommend to their colleagues, and which teaching forms of teaching the tools support. Analysing

the text of the survey responses, the frequency distribution of the tools mentioned more than once are shown in Figure 17. The video conferencing software mentioned in the survey are Zoom, Teams, and Adobe Connect. The software used for streaming recorded videos is video.dtu.dk which is now replaced by Panopto.

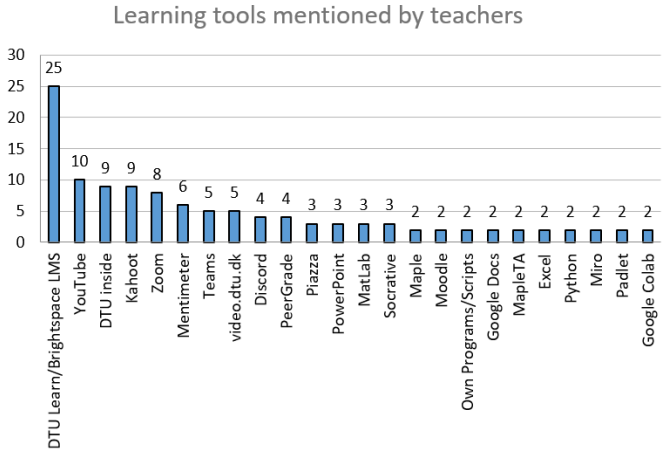

Fig. 17. Software used by the teachers during contact hours.

The tools adopted for engaging students during contact hours, whether VC-mediated teaching or face-to-face are Kahoot, Socrative, Polleverywhere, Mentimeter, Piazza, Miro, Padlet, Wooclap, and Google collab. For facilitating discussion during and beyond the contact hours, the adopted tools are Discord, Piazza, Zoom channel, and Microsoft Teams. Although Teams, Zoom channel, Slack, and Discord were mentioned by the teachers, they did not recommend those for supporting engagement during contact hours.

The responses include scenarios of good practices of tools, which include videoconference mediated teaching using customized setup designed by the teachers for laboratory context:

"PowerPoint presentation on PC where I need at least 2 for the YouTube videos. A camera on three leg-stand connected to the PC to show off the experimental setups as a lot of students needs to see it. Camera + PC + Zoom enables the experimental setups projected onto the screen and to students' PCs." was a survey comment from a teacher. The comment shows that the teacher considers online and physical students in the planning of teaching a typically lab experiment.

Another teacher presents how teaching is conducted through podcasts and video as well as how this is applied in teaching:

"Podcasts - Video-recorded lectures, including the option to start recordings yourself in the auditorium (permanent installation with audio/clip microphones). Video-recorded lectures from walk-in study at DTU Library (a help yourself system, but it was fine). Electronic whiteboard (rarely works though/I can't figure it out with the limited time I've invested in it). Electronic projector. One that has a white plate on the catheter, which (live) photographs the plate so that it can be projected onto the wall behind.

There was one like that in one of the auditoriums, but it disappeared, and Kahoot." as a teacher describe the teaching practice using digital tools for VCS-mediation, recording, and student engagement.

These comments showcase that teachers at the university uses a variety of different tools and have a reflective practice as they engage students during the contact hours and conduct VC-mediated teaching. The scenarios of good practices mentioned by the teachers can also be validated by the scenarios documented during the focus-group discussions with the students.

One constructive criticism of digital learning technologies stated by a teacher: *"Becoming Europe's best engineering education does not come through using digital learning tools - Menti, for example, is as much entertainment as it is a functional tool - but through being able to engage and motivate the students, whose everyday lives are already largely distanced by digital tools. Reflection and independent thinking do not come from using digital learning tools, any more than you get good architecture from using a nail gun instead of a hammer."*

Didactics and Methods of VCS-mediate Teaching: FGD with students

At workshop two with the students, scenarios on the different teaching and learning practices were shared by the students (see Table 5). The different categories of VC systems use and the use of various tools for engaging teaching during contact hours are grouped into multiple themes.

"Online individual work - Learning through the screen"

Students shared which tools were used to support the work during lectures, exercises, group work, and hand-ins etc. These tools were either used synchronously or in parallel with the VC lecture (e.g., note taking in OneNote), to support the VC lecture (e.g., Quizzes with Kahoot), or to conduct the VC lecture with (e.g., Zoom). Other tools were used to facilitate exercise work when the VC lecture was completed such as Miro, Overleaf, Google drive and Colab etc.

In synthesizing the students' responses three specific scenarios were identified.
Scenario 1: Video lectures and student collaborative work on online documents,
Scenario 2: Synchronous video lectures and laboratory work or physical group work,
Scenario 3: Pre-recorded video lectures, exercises, TA support, and hand-in of reports.

These three scenarios share similarities with the categories of "Traditional classes - Learning by listening" and "Theory framed group work - Learning through exercises" while not having a lot in common with either "Project- and group-work - Learning through deliveries" or "One to one teaching or supervision - Learning through relation".

Table 5. Analysis of Scenarios found in the student workshop 2.

Scenarios	Tools	Individual activities/Tags	Groups					
			1	2	3	4	5	6
Traditional classes - Learning by listening	Traditional blackboard, Mobius, Piazza, PowerPoint, Discord, Tandem, Coursera, Google Classroom, Zoom, Moodle, Teams, Slack, GitHub, Codejudge, Peergrade, OneNote, Theme cords, Ankyl flashcards, DTU Media lab, Facebook, Overleaf, Brightspace LMS, Zotero, Discord.	Students only listen to a lecture in auditoriums or smaller classes.		X		X		X
		Students listen & invited to ask questions. Teacher initiates discussions and issues breaks.	X	X	X	X	X	
		Teacher presents theory and provides exercise examples. After the presentation students are meant to do calculation exercises and laboratory work. To get help from TAs students raise their hands.	X	X	X	X	X	
		Hand-ins on a daily, weekly, monthly basis is in focus of the lectures & exercises.		X		X	X	
Online individual work - Learning through the screen	Zoom, Slack, Miro, Overleaf, Google docs, Kahoot, Pollev, Google colab, recorded lecture, OneNote, Theme cords, Ankyl flashcards, Colab, Deep note, IDE´s/coding environment, GitHub, DTU learn (Forum), Google drive	Video lectures and collaborative work on online documents such as Deep learning coding in an online auditorium setting	X	X		X	X	X
		Synchronous video lectures and laboratory work or physical group work.	X	X			X	X
		Pre-recorded video lectures, exercises, TA support, and hand-in of reports.	X			X		
Theory framed group work - Learning through exercises	Piazza, Slack, GitHub, Miro, Figma, Google drive	Some theory from a teacher but with the intention of working on simulation of practical application such as laboratory work, programming, or soldering circuit boards. Teacher shows a method, and we apply it to our case right away in a back-and-forth method.	X	X	X			X
		Lectures from people from industry presenting topics or tools to situate exercises.				X		
Project- and group-work - Learning through deliveries.	Miro, Figma, Google drive, Overleaf, Cloud based servers, Peergrade, Metaverse VR, Trello, Zoom,	Identifying a problem and investigating it to solve it. e.g., through staging co-creation workshops, interviews.			X	X		X
		Hands On experience from internship with accompanying field work			X		X	

	Overleaf, Grammarly, Google translate, ResearchGate, DTU find-it (Library search), DTU Learn Forum (Brightspace LMS), Microsoft Teams, GitHub, Canva	Supervision structure for the project work with presentation of work to other students.			X		X	
		Hand-in as the basis of the project work such as bachelor thesis				X		
		Group Work presentation as the delivery and group activities as the method such as discussions, project development process.				X		
One to one teaching or supervision - Learning through relation		Supervision sections with teachers		X				

5 Discussion and Conclusion

Learning experience during the contact hours is influenced by the video conferencing systems (VCS), other digital and non-digital resources associated with the learning activities. This study involved students, teachers, and IT roles from the Computer Science department of the Technical University of Denmark in exploring the problems underlying the VCS use, the use contexts or pedagogical scenarios of contact hours, and the technological and pedagogical good practices in engaging students during the contact hours. Despite the national, institutional, and individual level of technological competencies, some of the participants agreed on the problem statement: "*The professors are not able to read the room online and need to prepare better for the class and use of technologies".* The authors interpret that the challenges are not technological but rather pedagogical and technological-pedagogical [16, 17]. Every class is a multi-channel user experience (UX) context, where the professor's physical movement, the slides and its content, the writings on a board or tablet, and use of other tools like Kahoot (including audio) provide the desired interaction experience. The interaction experience through these multiple channels is, however, only part of the learning experience. The live interaction, whether face-to-face or VCS-mediated involves the art of theatrical engagement, coming from the profession and involving the resources in the teaching context. The causes of the problem are grouped into different categories from students' viewpoints and teachers' and staffs' perspective. The lack of inter-personal, social interaction and behavioural aspects of the contact hours are some of the central causes that are not associated with the individual differences in teaching or learning preferences. The negative effects of the VCS-mediated teaching can be focused on the social and engagement dimensions.

Applying the concept of signature pedagogies and PACT analysis, seven contexts of contact-hour environments are identified: auditorium, studio, traditional classroom, laboratories (fixed installation and portable equipment), teacher's table, and meeting or group rooms.

Five best practice scenarios were identified for teaching, and of these five three scenarios were associated with VCS-mediated teaching: (1) video lectures and student collaborative work on online documents, (2) synchronous video lectures and laboratory work or physical group work, and (3) pre-recorded video lectures, exercises, TA support, and hand-in of reports. Furthermore, Piazza is recently institutionally adopted and the tool allows anonymous questions addressing fear factor. Kahoot and Socrative allows gamified quizzes, which have become popular engagement tools for increased social interaction. Panopto is adopted for allowing video recording and flipped-teaching approach. From the students' perspective, motivating the students to engage through fun and reflection using Menti improves the learning experience.

The portable video conferencing tools and the student engagement tools adopted and recommended by the students and professors is expected improve the learning experience for VCS-mediated or supported classrooms.

Future case studies can inform specific signature pedagogies of different professions with particular scenarios involving the VCS, engagement tools, and the multi-channel interaction including their evaluations. Considering each of the scenarios (associated with signature pedagogies), the VCS problems identified, and engagement tools recommended by professors, the two video conferencing toolkits and student engagement tools will be further ideated and tested.

References

1. Åkerlind, G.S.: Variation and commonality in phenomenographic research methods. Higher Education Research & Development. 31, 115–127 (2012). https://doi.org/10.1080/07294360.2011.642845.
2. Shulman, L.S.: Signature pedagogies in the professions. Daedalus. 134, 52–59 (2005). https://doi.org/10.1162/0011526054622015.
3. Benyon, D.: Chapter 2. PACT: A framework for designing UX. In: Designing User Experience: A guide to HCI, UX and interaction design. pp. 27–48. Addison Wesley, Harlow, England ; N.Y (2019).
4. Cavus, N., Sekyere-Asiedu, D.: A comparison of online video conference platforms: Their contributions to education during COVID-19 pandemic. WJET. 13, 1180–1191 (2021). https://doi.org/10.18844/wjet.v13i4.6329.
5. Abdul Rahim, A.S.: Mirror Mirror on the Wall: Escape a Remote Virtual Stereochemistry Lab Together. J. Chem. Educ. 99, 2160–2167 (2022). https://doi.org/10.1021/acs.jchemed.2c00050.
6. Akkara, S., Mallampalli, M.S.: Online Teaching and Learning in India During Lockdown and Its Impact on Teaching Practices. In: Auer, M.E. and Centea, D. (eds.) Visions and Concepts for Education 4.0. pp. 151–158. Springer International Publishing, Cham (2021). https://doi.org/10.1007/978-3-030-67209-6_17.
7. Earnshaw, Y.: Navigating Turn-Taking and Conversational Repair in an Online Synchronous Course. OLJ. 21, (2017). https://doi.org/10.24059/olj.v21i4.1029.
8. Morley, M., Kellish, A.S., Fleischer, L., Clements, D., Freeland, E., Ramirez, R., Fedorka, C., Gutowski, C., Pollard, M., Kim, T.W., Kleiner, M.T.: A Virtual Curriculum to Prepare

Medical Students to Achieve Accreditation Council for Graduate Medical Education Level-1 Milestones in Orthopaedic Surgery. JBJS Open Access. 6, (2021). https://doi.org/10.2106/JBJS.OA.20.00117.
9. Troja, E., DeBello, J.E., Roman, N.: Teaching Efficient Computer Science and Cybersecurity Courses Amidst the COVID-19 Pandemic. In: 2021 IEEE Global Engineering Education Conference (EDUCON). pp. 510–520. IEEE, Vienna, Austria (2021). https://doi.org/10.1109/EDUCON46332.2021.9454150.
10. Gibbons, S.: Design Thinking 101, https://www.nngroup.com/articles/design-thinking/, last accessed 2018/11/03.
11. Khalid, Md.S., Nyvang, T.: Application of Participatory Learning and Action Methods in Educational Technology Research A Rural Bangladeshi Case. In: Georgsen, M. and Zander, P.-O.M. (eds.) Changing education through ICT in developing countries. pp. 107–130. Aalborg University Press, Aalborg (2013).
12. Narayanasamy, N.: Participatory rural appraisal: principles, methods and application. SAGE Publications, Los Angeles (2009).
13. Polaine, A., Løvlie, L., Reason, B.: Service design: from insight to implementation. Rosenfeld Media, Brooklyn, NY (2013).
14. Adams, W.C.: Conducting Semi-Structured Interviews. In: Handbook of Practical Program Evaluation. pp. 492–505. John Wiley & Sons, Ltd (2015). https://doi.org/10.1002/9781119171386.ch19.
15. Khalid, Md.S., Nyvang, T.: A change agent's facilitation process for overcoming the barriers of ICT adoption for educational administration – A case of rural-Bangladesh vocational Institution. AJET. 30, 547–561 (2014).
16. Ling Koh, J.H., Chai, C.S., Tay, L.Y.: TPACK-in-Action: Unpacking the contextual influences of teachers' construction of technological pedagogical content knowledge (TPACK). Computers & Education. 78, 20–29 (2014). https://doi.org/10.1016/j.compedu.2014.04.022.
17. Koehler, M.J., Mishra, P.: What is TPACK. Contemporary Issues in Technology and Teacher Education. Vol. 9, s. 60-70 (2009).