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Large interactive touchscreens as an opportunity for synchronous hybrid teaching during COVID-19 pandemic and beyond

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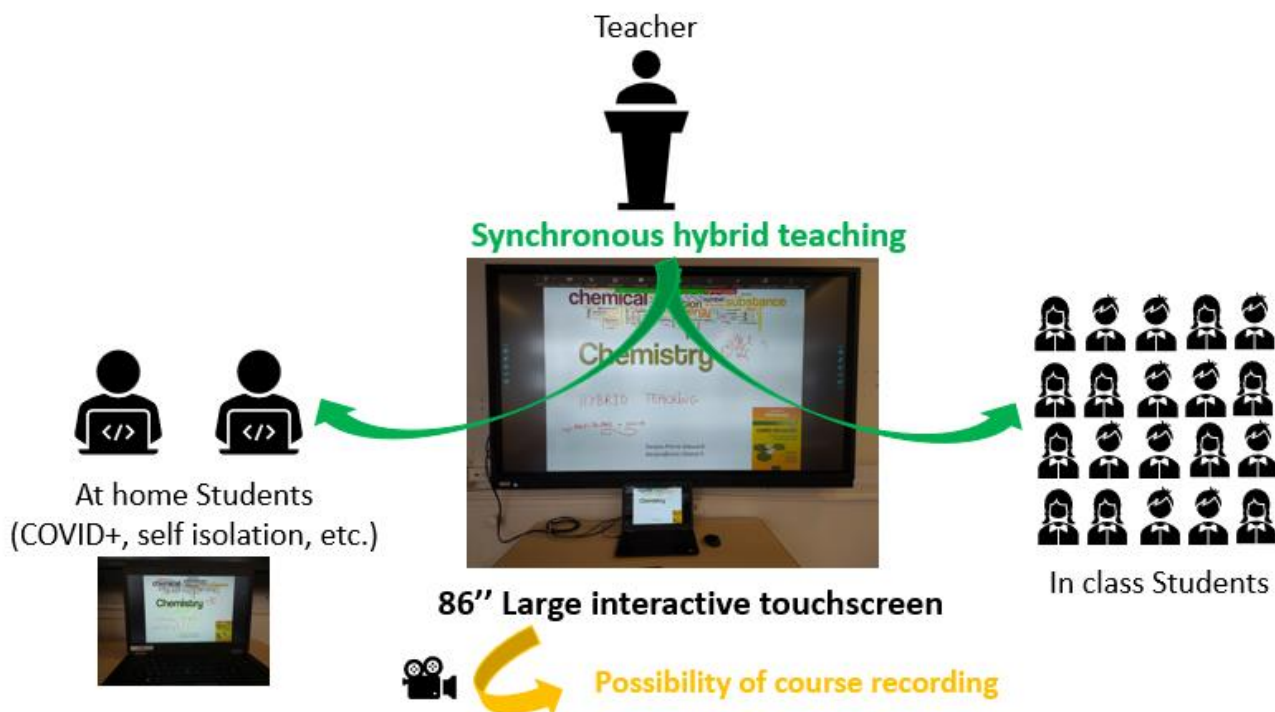
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ABSTRACT

The year 2020 will be remembered as the year of COVID-19 and its subsequent lockdowns. The time to return to face-to-face teaching has arrived, but the shadow of the disease still hangs over teachers, students and society. Disruption in teaching can still occur for students, or even teachers, if they are either diagnosed as COVID-19 positive or as a contact case and forced to self-isolate. In order to limit the impact of self-isolation on learning, synchronous hybrid teaching (i.e. teaching face-to-face to students in a classroom and to students online at the same time) was successfully implemented owing to the combination of a videoconference software and a large interactive touchscreen. The setup presented in this paper allows courses to be broadcasted to students at-home (i.e. voice, visual pedagogic support and, more interestingly, indications handwritten by the teacher) as well as simultaneously teaching to students in the classroom face-to-face. It also allows self-isolated teachers to teach tutorials from their home to students in the classroom. This paper focuses on the use of large interactive touchscreens for synchronous hybrid teaching and its evaluation by students using a questionnaire. The key findings of this study are that students prefer synchronous hybrid teaching rather than missing a course and that synchronous hybrid teaching should only be used in case of absolute necessity.

GRAPHICAL ABSTRACT



KEYWORDS : GENERAL PUBLIC - UPPER-DIVISION UNDERGRADUATE: - GRADUATE EDUCATION / RESEARCH - CHEMICAL EDUCATION RESEARCH - INTERNET / WEB-BASED LEARNING - DISTANCE LEARNING / SELF INSTRUCTION.

INTRODUCTION

The global pandemic of COVID-19 has profoundly changed the way the entire education community teaches. In France, just as in other countries, students and teachers at universities have been particularly affected, notably by successive lockdowns and the impossibility of face-to-face teaching. However, the education community has been able to react and innovate to switch from face-to-face to distance learning in record time, as evidenced by the richness of the special issue "Insights Gained While Teaching Chemistry in the Time of COVID-19"¹ published in September 2020 in this journal.

All over the world, teachers have embraced digital tools such as Zoom^{2,3}, Teams⁴, Google Classroom⁵, Rain Classroom and WeChat⁶ or even social media like Facebook⁷ or Instagram⁸ to offer students educational continuity with synchronous (teacher and students present at the same time) and/or asynchronous⁹⁻¹¹ (teacher and students are not present at the same times) online courses. Solutions

were also found to allow students to acquire practical skills, normally dispensed in a laboratory, by providing lab kits^{12,13} or designing lab activities with daily products and kitchen utensils^{14–16}. Even if the coronavirus has enabled a dramatic breakthrough in the development of e-learning¹⁷, the time to return to face-to-face teaching has arrived. However, if strict lockdowns seem to be ruled out for the moment, we must adapt to the absence of students (and teachers) when diagnosed COVID-19 positive or as contact cases that are forced to self-isolate for 7 and up to 17 days (in France). So, in these conditions, how can we enable these at-home isolated students to attend classes so that they are not penalized in their learning, without creating an extra workload for the teacher? In this paper, we present a strategy implemented at the chemistry department of the University of Littoral Côte d'Opale (France) with the use of large interactive touchscreens for synchronous hybrid teaching, i.e. teaching face-to-face to students in a classroom and to online self-isolated students simultaneously.

TEACHING APPROACH

With the return of face-to-face teaching and the growing threat of students being absent due to COVID-19, thought was given to how best to ensure educational continuity for students who are affected but able (physically and mentally) to attend classes. Although the possibility of using a simple computer connected to a video-conferencing software (Zoom, Teams, Google Meet etc.) simultaneously broadcasting the course material (mainly PowerPoint or PDF files) in the classroom and online was considered, this solution is not relevant from the point of view of interactivity. Indeed, by this means, it will be possible to discuss the course material, but it will not be possible to provide online students with handwritten notes to the course, nor to teach the tutorials to both face-to-face and online students at the same time. The use of a graphic tablet could complete this task, but this would require the teacher to sit in front of the computer to use it and would break the dynamic of the course. The choice was therefore made to experiment with synchronous hybrid teaching using large interactive touchscreens. This teaching approach was experimented in 2021-22 with 4 promotions of students in chemistry, ranging from second year to master degree (68 students, see Figure S1 in supplementary data). The subject covered during this period (lecture and tutorials) include organic chemistry, analytical

chemistry, inorganic chemistry and toxicology. Students were asked at the end of the academic year to evaluate this teaching approach through a questionnaire.

EQUIPMENT

Following the COVID-19 crisis, three classrooms were equipped with large interactive touchscreens (~3-4 k€ each / 2 different models) in 2020 and 2021 in replacement of traditional video projectors (Figure 1).

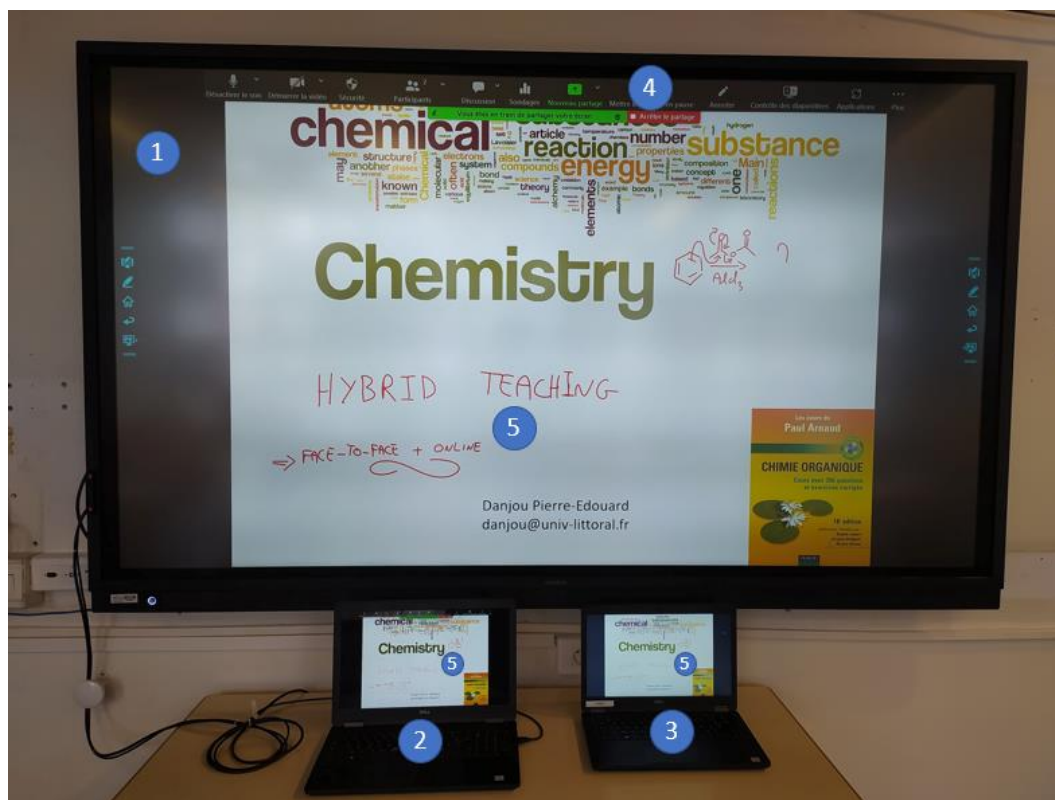


Figure 1: illustration of the synchronous hybrid teaching setup: (1) large interactive touchscreen (2) teacher's computer (3) "at home" student's computer (4) Zoom environment (5) handwritten annotations.

The devices are 86" Interactive 4K LCD Touchscreen that can be used autonomously thanks to an Android environment able to connect to the internet, play videos, read common files such as PDF, word processing, spreadsheet, presentation etc. There is a built-in white board that allows teachers or students to write by hand as you would on a chalkboard, which is particularly useful for tutorials.

More interestingly, the touch screen can be connected to a laptop via HDMI or VGA cables like traditional video projectors. An extra USB cable is required on the laptop to send the "touch" information from the screen to the computer. This feature allows the teacher to use the large interactive touchscreen as a big

graphic tablet and to transmit the handwritten notes directly on the laptop screen. The combination of the large interactive touchscreen with a videoconference software like Zoom is an interesting solution for synchronous hybrid teaching, since it allows students in the classroom as well as at home to see the explanations handwritten directly on the board (Figure 1) which enhances the class' experience.

DISCUSSION

Since 2021 and the return of face-to-face students to the universities, four cases that could lead to difficulties in teaching have been identified and experimented by the teaching team. These cases are listed below.

- Case 1: Teacher and students are face-to-face in the classroom; one or more students are at home (tested positive to COVID-19, contact case, etc.) and able to connect to video conference.
- Case 2: Teacher and students are face-to-face in the classroom; one or more students are at home and unable to connect to video conference.
- Case 3: Teacher is in self-isolation or childcare due to COVID-19 (or injured) at home and able to teach via video conference. Students are in the classroom or online.
- Case 4: Teacher is in isolation due to COVID-19 with symptoms and therefore unable to teach.

Case 1 is a typical case of synchronous hybrid teaching in its simplest definition, i.e. with both a face-to-face and an online audience. In this case, the teacher can teach in the traditional way, except that his computer projecting his documents is connected to a video conference software as well as connected to the large interactive touchscreen. He is therefore able to interact with the group of students in front of him and to provide handwritten clarifications, while allowing remote students to take the courses with the same level of information.

Case 2 can happen when one or more students are ill (COVID or not), injured, or just unable to attend the course (family reason etc.). In this case, the use of a large interactive touchscreen coupled to a videoconference software allowing the recording of the meeting can be of great help since it allows teachers to record the sound and the screen of their lectures or tutorials (including handwritten notes). The recording can then be uploaded to an online platform (YouTube, Moodle, Facebook⁷, Instagram⁸

etc.) in order to be asynchronously accessible to students. This strategy of 24/7 access to course content was previously found to be of great interest for students,⁷ with only a modest increase in workload for the teacher.¹¹ This method could also be interesting for students at home with a bad internet connection limiting the data flow of a live broadcast.

The third case identified is that of the teacher being unable to go to the classroom (COVID, injury, contact case, childcare of contact case child etc.). The latter case has happened to several different members of the teaching team. The presence of the large interactive touchscreen in the classroom allows students to propose solutions to exercises set by the teacher and write those solutions on it. The teacher is able to see from home what the students are writing on the large interactive touchscreen and guide the students either by voice or by interacting directly with the students' writing using the mouse or a graphic tablet.

Regarding case 4, no solution can be proposed since the teacher is an integral part of the teaching.

The experience gained between 2020 and 2022 in synchronous hybrid teaching with large interactive touchscreens allows the teaching team to assess this system through the following SWOT matrix (Table 1)

Table 1 : SWOT analysis of using an interactive touchscreen for synchronous hybrid teaching

<p style="text-align: center;">Strengths</p> <ul style="list-style-type: none"> ● Continuity of teaching despite the health crisis (synchronous hybrid teaching) ● Few constraints for the teacher ● Autonomy ● Use of the teacher's PC or Mac computer (software, courses) 	<p style="text-align: center;">Weaknesses</p> <ul style="list-style-type: none"> ● Different ergonomics between the boards ● The size of the screen is not compatible with large amphitheater. ● Quality of computer sound recording
<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> ● Non-pandemic: Take distance learning courses, take/give courses in other universities ● Opportunity to attend classes in case of injury/illness ● Offer asynchronous content easily (recording) ● Enable continuous learning (asynchronous courses for workers) 	<ul style="list-style-type: none"> ● Threats Lack of digital competency of teachers ● Unwilling teachers ● Student access to a computer ● Price of interactive TVs limiting their deployment. ● Stability of the internet connection (in class + remote; proximity of Wi-Fi terminals)

The system described and the associated synchronous hybrid or asynchronous teaching practices represent a real asset for educational continuity, whether in times of health crisis as we have experienced, or in the face of individual student difficulties. One of the major strengths of this device is that it does not drastically alter the teacher's way of teaching or the students' way of receiving the course, leaving both parties in their comfort zone. This device works similarly to a video projector (see supplementary data) and does not require additional staff to connect remote students with participants in the classroom, thus offering great autonomy to the teacher.

Among the weaknesses identified are the difference in ergonomics between the different large interactive touch screens from different suppliers. This can easily be solved by using the teacher's personal computer, which will use the large interactive touchscreen as a screen. This use of the computer allows for easy connection to video conferencing software, but also to the teacher's own software for demonstrations. What transpired from our experience is that this instrument was not the most suitable for teaching in front of a large student audience in a lecture theater for example. However, the interactive nature of the screen means that it is mainly intended for use in smaller rooms with a capacity of around 40 students. During our tests, especially when uploading videos recorded with this set up to YouTube, we realized that the sound captured by the computer could be of uneven quality, as regularly reported in the literature¹⁸, this is why an external microphone was used to record courses. Nevertheless, the sound quality is sufficient to catch up on a lesson that would otherwise have been lost to the student. Threats to this educational practice have also been identified. One of the biggest obstacle to the development of this kind of synchronous hybrid teaching, apart from the price of the device, is the lack of digital competency of teachers and / or their unwillingness to broadcast their course content live over the internet even with restricted access. This may be due to the fear of judgment by peers or the desire not to distribute freely a course that has taken years of work. This issue can only be resolved through with the goodwill of teachers and a change in mentality. The other threats are technological ones. Indeed, the pandemic has taught us that students are unequal in terms of access to a laptop or a reliable internet connection³.

Regarding the opportunities offered by large interactive touchscreens, they can allow us to improve our pedagogical practices, notably by facilitating access to courses given in other universities, whether synchronous or asynchronous. Another opportunity for teachers could be to teach a course to students enrolled in a foreign university, such as in the case of joint degrees between several universities. Synchronous hybrid teaching will also ensure that students do not sustain breaks in their learning in the unfortunate event of an injury, illness or any other event that prevents them from coming to the classroom. We also hope to have the opportunity to use this set up to provide courses to practicing

workers (continuing teaching) who wish to take up a university course and validate their professional experience with a degree while continuing to be employed.

Following this 2-year test, a questionnaire was sent to the 68 students of the 2021-22 classes. The anonymized responses (65% response rate, see supplementary data) were compiled in Table 2 using a 5-point Likert scale. Students were also asked to write freely about the positive points and areas of improvement of synchronous hybrid teaching with large interactive touchscreens.

Table 2. Distribution of Students' Responses to the Questionnaire ($N = 44$) in Percentages

Entry	Affirmation	Totally agree	Somewhat agree	No opinion	Rather disagree	Totally disagree	mean
1	It would have been better not to set up hybrid teaching	6,8	15,9	13,6	40,9	22,7	2,43
2	The introduction of hybrid teaching has enabled you not to fall behind in your lessons	27,3	36,4	27,3	9,1	0,0	3,82
3	It is more interesting to take the courses remotely than to catch up on it alone.	56,8	31,8	4,5	2,3	4,5	4,34
4	Hybrid courses are of the same quality as 100% face-to-face courses	2,3	6,8	13,6	38,6	38,6	1,95
5	The possibility of conducting hybrid courses should allow the teacher to choose whether or not to come to the university in person	4,5	9,1	11,4	29,5	45,5	1,98
6	The possibility of conducting hybrid courses should allow students to choose whether or not to come to the university in person	6,8	18,2	2,3	29,5	43,2	2,16
7	The image quality was good	25,0	54,5	15,9	4,5	0,0	4,00
8	The sound quality was good	18,2	59,1	9,1	13,6	0,0	3,82
9	When take the courses remotely, it is important to see the presentation that the teacher projects	95	5	0	0	0	4,95
10	When take the courses remotely, it is important to hear the teacher's explanations	98	2	0	0	0	4,98
11	When take the courses remotely, it is important to see what the teacher writes	91	9	0	0	0	4,91
12	When take the courses remotely, it is important to see the teacher	25	18	34	20	2	3,43
13	It would have been interesting to record the lectures and make them available to students via YouTube for example.	43,2	29,5	6,8	18,2	2,3	3,93

It is interesting to note that about 23% of students would have preferred not to follow synchronous hybrid teaching (entry 1) but only 9% of them disagree that this teaching approach allows them not to fall behind in their lessons (entry 2) and 7% of them seems to prefer catching up on course on their own

rather than following them remotely (entry 3). These results are in favor of the implementation of synchronous hybrid teaching, but are tempered by the answers to questions 4, 5 and 6. Indeed, three quarters of the students found the courses to be of lower quality than face-to-face courses. Some explain these responses by the lack of training of teachers, who sometimes struggle to solve connection problems and juggle the different windows in Zoom. These elements tend to slow down the course and alter its fluidity. With the increasing experience of teachers, the quality of synchronous hybrid courses should improve in the very near future. Students are also in favor of deploying synchronous hybrid teaching only when it is absolutely necessary (illness, injury, etc.) and not of making it a personal choice to come to the university at the discretion of students or teachers (entry 5, 6). This idea was frequently encountered in the students' free responses part of the questionnaire. These answers are consistent with the students' need of social interactions^{19,20} among themselves and with teachers. This reluctance to choose voluntary distance learning could also be explained by the "Zoom fatigue"²¹ phenomenon that students may have encountered during the previous years. From a technical point of view, the students judged the image and the sound to be of good quality (entry 7, 8), although the mean score for the sound was slightly lower than for the images. These responses tend to show the effectiveness of the system for synchronous hybrid teaching, allowing online students to benefit from the same visual and audio quality as their face-to-face peers. Some students wrote that this system allows them to not miss any content, explanations or debates. Regarding what is important to consider when following a distance learning course, all students agree that it is important to see the teacher's media, to hear the teacher's explanations and to be able to see the teacher's handwritten indications (entry 9, 10, 11, mean >4.90). On the other hand, although seeing the teacher seems relatively important (entry 12, mean 3.40) it appears to be much less important than the previous points. Without surprise, most of the students found attractive the possibility to record the lectures (entry 13, mean 3.93) to make it available asynchronously to students via YouTube. This point is under progress, but it mainly depends on the goodwill of teachers. All the above points support the idea that the integration of large interactive touchscreens in classrooms represents an opportunity to support the learning of students with difficulties in coming to the university.

CONCLUSION

In conclusion, the chemistry department of the Université du Littoral Côte d'Opale (France) experimented between September 2020 and June 2022 with the use of large interactive touchscreens to ensure pedagogical continuity in the face of the health crisis that causes disruption in teaching. What transpired from this synchronous hybrid teaching experience is that the combined use of videoconference software and large interactive touchscreens could allow for pedagogical continuity by enabling synchronous hybrid teaching. This strategy was employed in the following identified cases: i. if a student is able to attend class, but must stay at home ii. if a student is not able to attend class iii. if the teacher is able to teach the class but is unable to come to the university. Evaluation of this synchronous hybrid teaching approach by students allows us to conclude that they prefer synchronous teaching, even if they are at home, rather than catching up on a course alone at a latter time (asynchronous learning). It also transpires from the questionnaire that synchronous hybrid teaching must only be used in case of absolute necessity and should not be a choice given to students or teachers, probably due to the need for social interactions between students. This study also points out that the quality of synchronous hybrid courses is not the same as traditional ones probably because teachers are not sufficiently experienced with this new tool, but we believe that the implementation of this approach will increase the teachers' skills through practice and thus also improve courses quality. Future work will be dedicated to the exploitation of large interactive touchscreen in the post-COVID era to provide better accessibility to university courses.

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NOTES

The authors declare no competing financial interest.

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