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Delivering remote food engineering labs in COVID-19 time

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Abstract

The impromptu closure of schools and universities and the strict lockdown decided by the French State in March 2020 forced us to find -urgently and without preparation- alternative solutions to conventional face-to-face teaching. Due to their experimental nature, the transposition of labs on pilot plants was particularly challenging. Despite this inherent difficulty, we succeeded in implementing a remote educational device within a few weeks, designed as a viable alternative to conventional food engineering labs for Master level students. Four engineering labs (corresponding to four unit operations widely found in the food industry) were transposed: appertization of cans; concentration in a falling film evaporator; frontal filtration in a plate filter; and spray drying. In the remote labs, hands-on experiments were replaced with various types of virtual tours of the equipment, a detailed description and illustration of its operation, and analysis of real data (previously collected). Evaluation was done via individual quizzes (counting for a small part of the mark, because their aim was above all formative), individual and collective written reports and an individual online oral exam. The teaching team comprised six lecturers, one pedagogical engineer and the person in charge of the technology platform, who also had long experience in distance learning. This experiment took place in the second half of May 2020, with approximately thirty first-year Master students. The effectiveness of the implemented system was evaluated through direct observation and discussions, marks obtained by the students and an anonymous survey. This teaching experiment presents certain flaws induced by the very peculiar conditions of its conception (short time frame, no direct access to the pilot plants). While an “all-digital” approach is not our ultimate aim for these lab sessions, where handling and testing are inherent to the learning process of the student, the educational resources deployed here can be seen as a great incentive to further develop hybrid teaching approaches in food engineering. Moreover, the educational resources and practices implemented in these exceptional circumstances are an opportunity to develop new teaching methods in the future. The present paper reports on this teaching experiment during lockdown due to the COVID-19 pandemic and tries to draw exciting lessons for the future and pitfalls to avoid.

Keywords

Teaching experience; food engineering labs; distance learning; immersive learning; skills; lockdown

1. Introduction

In the context of a global pandemic due to COVID-19, after the closure of all educational institutions on the evening of March 13, 2020, the French population was strictly locked down from March 17. This lockdown was extended several times and was only very gradually lifted after May 11. However, higher education establishments remained closed to students until the end of the academic year.

Faced with this unprecedented situation, teachers reorganized matters to ensure what the French government called “continuité pédagogique” (pedagogical continuity), meaning providing primary and secondary school pupils and students in higher education with 100% distant education for several months. Pedagogical continuity was intended to ensure that the students carried out activities that would allow them to progress. These activities were intended to be a natural follow-up to what had been done in class before lockdown and / or a preparation for what would be done upon return to school. The work that the students were asked to do by their teachers had to be regular, it had to be able to be carried out in a suitable time and explicitly indicated. The proposed work also obviously had to be adapted to the knowledge and maturity of the students. Back then, most teachers had no concrete experience of distance learning, and little or no skill in using the technological devices and appropriate software to provide this distance education. At AgroParisTech (a French public institute specialized in agricultural sciences, food sciences, environmental engineering and forestry), the teachers provided the courses and tutorials remotely for the most part in virtual classrooms (with the web application Blackboard Collaborate). While very convenient and user-friendly, this type of platform induced some obvious drawbacks:

- technical problems: difficult or impossible connection for teachers and students;
- pedagogical issues: difficulty of staying focused on learning for hours on screen; communication and mutual assistance hampered by distance, despite the private practice of social networks. It is indeed well known that these daily private practices are not so easily transferred to education (Endrizzi, 2012).

Unprepared for such an unexpected situation, with a somewhat limited time schedule to entirely “digitize” lab classes, the first option proposed by the teachers in charge was to simply cancel them. While logical, this option however raised a legitimate concern: lab practicals are, for most of the student population concerned (first-year students of the Paris-Saclay Nutrition and Food Science Master), the only class where they are in contact with pilot-scale devices. On April 2, the manager of the technology platform where these labs should have taken place contacted six teachers concerned, proposing to do “something” to replace these labs originally planned for the second half of May 2020. In her previous position, she had practiced distance and

hybrid learning for years (Debacq et al., 2005; Debacq, 2017); however, she had only limited experience of alternative devices to experimental work (Corsyn and Debacq, 2018). During the online meeting of April 14, after a discussion focused on these labs -objectives, profile of the students, the usual syllabus- the teaching team (the six teachers plus the technology platform manager) decided to embark on the adventure and to offer an alternative educational device to the usual four food engineering labs: appertization of cans, concentration in a falling film evaporator, frontal filtration in a plate filter, and spray drying. They decided to keep the original agenda with minimal change, to reduce the possible stress for the students (see full timeline on Fig. 1):

- theoretical courses on May 12 and 13;
- practical work on May 19, 20, 26 and 27;
- report writing session in groups on May 29;
- final oral exam on June 3.

The theoretical courses remained almost unchanged and were delivered through 3h-long virtual classrooms. The four 4h lab sessions were redesigned, following a scenario built by transposing the usual face-to-face organization, in which all the students work on the same unit operation at the same time, to individual work, with the possible support of the teacher(s) concerned connected in a virtual classroom, representing their “virtual office” where they were available to answer students’ questions. The report writing session in groups was planned very close to the usual session, again using a 4h virtual classroom for each group in parallel. Lastly the final oral examination (20 min per student) was carried out by the teachers with the exact same virtual classroom web application.

During the design phase of the pedagogical device and the resources, a pedagogical engineer joined the team to provide support by proofreading some methodological supports and advising on the overall device.

2. Design of the teaching materials and environment

The design of the four 4h lab sessions was based on the educational objectives of these labs:

- Discovering the technological aspects of the unit operations.
- Understanding and analysing the environment in which production equipment is used (sensors, auxiliaries, external characterization tools).
- Linking the theoretical concepts of the courses with the practical applications in labs (mass and energy balances in particular).

The scientific background of the students concerned was biology and nutrition. Food engineering, which involves somewhat different knowledge (physics: flows, heat and mass transfer, thermodynamics; mathematics), could thus be seen as a real challenge for these students. Very few had ever visited a food factory or a technology platform. They needed to update their basic calculation abilities, but would normally

have done so during the exercises included in the course sessions: the calculations to be done during the labs are almost identical to those performed in these exercises. These students are usually serious and involved in their work. There are about thirty students in the class. It is important to mention here that all the students involved had a computer and Internet connection, not always high-speed, but none were without the appropriate devices. Contrariwise, during lockdown some of them lived in very cramped accommodation with sometimes difficult access to sanitary facilities and cooking equipment. Others returned home to their families and enjoyed more comfortable conditions.

Usually these labs take place entirely in person. Students work in groups of 3 to 4 and work successively on each of the four operations under the supervision of a teacher. At the end of each session, the group hands in a summary sheet with the results obtained, the calculations made and sometimes a very brief commentary. When all the groups have completed the four labs, they have to write a full report per group about 1 of the 4 labs (randomly attributed). Finally, each student has an oral and practical exam with a teacher on one of the 3 labs for which he has not written a full report.

During dedicated remote meetings between the teacher(s) in charge of each unit operation and the technology platform manager, the way in which each face-to-face lab usually unfolded was dissected and analyzed. For each step, a form of distance transposition was proposed based on the technology platform manager's experience of distance learning and the ideas or wishes of the teacher(s). The courses of the labs were therefore transposed: they would be delivered remotely, synchronously, by "mimicking" the progress of "normal" labs.

When we decided on the form that these labs would take in a distance learning environment, we were still under strict lockdown and had no idea whether we would be able to access our equipment at the time of the lab sessions. We therefore did not select a "WebLabs" type option, where the students can control and operate the equipment remotely (Klein *et al.*, 2005; Alliet-Gauberta *et al.*, 2012; Leproux *et al.*, 2013). This would have required modifying the pilot plants, which we were unable to do both for financial reasons and for lack of time and access to the platform.

Keeping in mind the four pillars of learning (Dehaene, 2018), namely attention, active commitment, feedback on errors, and consolidation, the scenario of each lab was built. The main principles of the pedagogical device were: content and activities fully written out, instructions specified in detail, format diversification, and tight formatting of presentation and environment. These principles were intended to promote the participation and concentration of each student, which are necessary for their learning and success.

2.1. The remote labs environment

The remote work environment is a LMS (Learning Management System) based on Dokeos, which gives students access to documents (PDF files, images, spreadsheets, etc.) and modules (successions of pages with various resources, and activities such as quizzes or homework to upload to a repository). This LMS also

provides forums for students and teachers, a dedicated description page, a glossary and a survey. It is possible to create groups of students and offer them a private common workspace.

An overview of the home page is visible in the appendix (Fig. A1). As can be seen, the global scenario of the labs is illustrated on this page and direct access to resources and activities is available under this step-by-step progression.

The “Description” page provides details about: skills addressed, audience, assessment, course organization, and schedule. This page was carefully filled in as all this information is very important for students to know the exact “rules of the game”: what they are supposed to do, when, how and for what purpose. The objectives are those mentioned at the beginning of this section. As said earlier, the students are in the first year of the 2-year Paris-Saclay Nutrition and Food Science Master's course. The percentage of the different assessments is: 20% for completion of the five online modules, 40% for the report written by groups and 40% for the final individual oral examination. The organization of the course, including advice and guidance, is explained thanks to an interactive presentation made with the online application Genially: screenshots can be seen in the appendix (Fig. A2); a full presentation (in French) can be accessed from the following link: <https://view.genial.ly/5e9e1e7060e2f20daa515a58/>. The schedule specifies the precise dates and times of the different sessions.

The students also have to complete a follow-up sheet by coloring the empty stars on it as they learn, and return the sheet at the end of the period. This sheet was made with the online application Canva. The sheet (in French) is visible here:

https://www.canva.com/design/DAD6dSTgB70/MCTb0j5YHoHvTuLrVR_pTg/view. Examples of sheets completed by two students are given in the appendix (Fig. A3).

The pedagogical engineer carefully checked the peripherals, since they are the key to distance learning, and made several suggestions to improve them when needed.

2.2. The lab scenarios

As explained by Villiot-Leclercq (2020), it is the scenario that ensures the quality of the “learner’s experience”.

Between April 15 and 27, the technology platform manager self-trained to be operational with LMS (based on Dokeos), tested other tools (Genially and Canva) and gathered all the requisite materials from the teachers: course supports, operating procedures (if created), existing photos and videos. She provided the teachers with one scenario for each lab, so that they could prepare some explanations on the operation of the pilot plant and questions, answers and feedback for the quizzes. It should be noted that, due to her recent arrival on the technology platform, she had not yet had the opportunity to operate or see operating 2 of the 4 pilot plants used for these labs.

On April 28, special permission was obtained for her to go to the platform to take pictures and shoot some movies, necessary for the remote labs.

With all these materials, she implemented the five modules following the scenarios defined in the LMS from April 29 to May 18 for the first two remote labs and until May 25 for the last two. During this period, the teachers proofread, checked and supplemented the resources developed.

As the students were not familiar with pilot plants or industrial environments, an additional short module was developed so that they could virtually visit the technology platform and acquire knowledge of good safety practices in such an environment. This module consisted of: a virtual visit of the platform developed with the online application Uptale, an immersive learning platform; a video (prepared with VideoScribe) presenting the safety rules; and two quizzes to verify that the students had assimilated the information.

The main steps of each of the four lab scenarios were as follows:

1. presentation of the equipment with: photos, videos, diagrams, explanatory texts, sometimes detailed instructions and procedures; intermediate quizzes with feedback; focus on sensors, characterization tools and auxiliaries;
2. presentation of the experiments (illustrated explanations or videos), recovery of “raw data” (generally in the form of a datasheet), sometimes a few quiz questions to ensure that the most complex manipulations have been understood;
3. guided realization of the calculations: all the stages are “dissected” and teachers are available in the virtual classroom to answer students' questions;
4. individual rendering in the form of one or more files to be submitted as homework in the online repository.

The 5 scenarios can be seen in detail in the appendix (Fig. A4).

A synthesis of the different types of “pages” is given in Table 1. As can be observed in this table, the modules provide numerous pages containing instructions; this is crucial for distance learning, because students must be able to understand unambiguously what they are expected to learn and produce. For Watrelot (2010), reflection on work instructions allows teachers to “put into words” what is not often formulated (metacognition) and to compare their ways of doing things with those of other teachers. As it is known that multimedia information highly promotes distance learning compared to single medium teaching, emphasis was put on providing clear and detailed instruction combining several media. This table also reveals the variety of resources and activities proposed in each module:

- The content pages and instructions were created directly in the LMS as HTML pages; Dokeos offers page patterns ready to complete without the need to code in HTML. Examples of these pages are available in the appendix (Fig. A5 and A6).

- The virtual visits were developed with Uptale: spherical pictures (360°) are implemented in the online application as “scenes” and enriched with texts, illustrative flat images, even quizzes or videos. It is possible to mimic moving from one place to another in the platform or around a pilot plant *via* “doors”, allowing access to another “scene” based on another 360° picture. A full visit of the technology platform (in French) is accessible (after free registration) here: <https://my.uptale.io/Experience/Launch?id=Od1dI50yEEViTKLsyhQnw>. A screenshot of the visit of an evaporator is given in the appendix (Fig. A7).
- The enriched technical documentation was produced using the Dokieli model in the Scenari environment. The full manual of the spray drying pilot plant can be seen (in French) here: <https://mol12.agroparistech.fr/halle/atomiseur3/> and a screenshot can be seen in the appendix (Fig. A8). Scenari is an open source editorial chain that enables the collaborative production of high-quality media in various formats (PDF and web in particular) from the same content in a few clicks. The contents are highly structured and abundantly illustrated. Writing in the Scenari environment is based on the WYSIWYM principle (what you see is what you mean) and differs from conventional office software, where “what you see is what you get” (WYSIWYG).
- The videos were shot with a smartphone, post produced with Camtasia software and hosted either on YouTube or on our Seafile server (an open source, self-hosted file sync and share solution). Some of the videos used were filmed 15 years ago and edited for the purposes of the present remote labs. Others were taken on the fly during training in the use of one of the pilot plants and were not intended to be used for teaching, only as a record of procedures; they were scripted and edited to be used for our remote labs. The last types of videos used were recorded during an afternoon of lockdown, by a person having limited knowledge of the pilot plant back then; audio comments and drawings were then added by a teacher to convert them into pedagogical videos. A few videos not produced by the pedagogical team, but publicly available on YouTube, were also used to illustrate some concepts or technologies.
- Most of the PDF files were fragments of the lab supports, previously used for the face-to-face labs and were therefore produced with Microsoft Office. Data sheets were also produced thanks to Microsoft Office Excel.
- The numerous images (photographs taken with a smartphone and old scanned process diagrams) were reworked with the open source software Gimp.
- A “fake” training simulator of the appertizer control panel was made with Genially. Unlike a true simulator, its behavior is not the result of calculations from a model; rather, different messages are simply displayed depending on the student's actions: for example if he clicks to open a valve while at

this moment of the operation he should choose a temperature setpoint, an error message is displayed inviting him to try again. Due to lack of time to develop it further, this “fake” simulator does not offer feedback allowing students to understand their errors and giving them clues to correct their procedure; this will be an interesting improvement in the future. The full interactive resource can be tested (in French) here: <https://view.genial.ly/5ecaa30931834c0d95f4a4eb/> and a screenshot is given in the appendix (Fig. A9).

- The glossary, a tool available on the LMS, provides definitions, sometimes illustrated, of some technical terms widely used in food or chemical engineering: glove finger, potting, relative pressure, purge, steady state, P&ID, auxiliary, drain.

2.3. The quizzes

Table 2 gives the numbers of each type of question available in Dokeos used in each module. We did not use the picture type questions, despite their great educational interest, because of working issues on some computers spotted during the preliminary test trials.

In the LMS, only a small number of question types are available to make quizzes. Hence, we used open-ended questions, which have the disadvantage of not being corrected automatically: this generates additional work for teachers and deprives students of immediate feedback. UCQs and MCQs (unique or multiple choice questions) are relatively easy to design but quickly become boring; we therefore tried to alternate them with close-ended and pairing type questions.

The quizzes are implemented within the module and used primarily for formative (rather than summative) assessment, even if the scores obtained by the students did, among other things, make it possible to build their marks for the 20% “completion of the online modules” part.

As these quizzes concerned the understanding of how pilot plants work, the questions were very often illustrated with diagrams and photos.

2.4. The support provided by teachers

Because it is sometimes difficult for online learners to understand what is expected from them (Limperos *et al.*, 2014), great care was taken in writing the instructions, which are very detailed at each stage of the modules. As can be seen in Table 1, they represent a large proportion of the total number of pages in each module.

Forums and wikis were available for students, but they did not use them at all. The use of email for question purposes was strictly forbidden (to ensure that the answers would benefit everyone) but this rule raised no concerns or specific issues.

The virtual classrooms, made available to students with the Blackboard Collaborate tool, were used: during the morning lab sessions (+ some afternoons for additional sessions dedicated to calculations); for writing the report in groups; for the individual final exam. During each session, most of the students were connected

in the virtual classroom where they could ask their questions either orally or by writing *via* the chat tool available in Collaborate.

2.5. What is Yoda doing in these labs?

Gamification is well known to have interesting virtues in education in general (Alvarez *et al.*, 2016; Azizan *et al.*, 2018; Bodnar *et al.*, 2016). The principle of gamification during laboratory experiments was used for example by Burkey *et al.* (2013) to promote the interest and engagement of students and to address soft skills beside technical and scientific skills. In their study, gamification got the students to do optional tasks that they do not usually do.

In our pedagogical device, one-off references to the Star Wars universe appear in the resources and accessories on the training platform:

- master Yoda gives recommendations for remote and autonomous work;
- Lego Star Wars minifigures appear on some photos of the pilot plants;
- quotes from the saga and other motivating messages appear from time to time;
- finally, excerpts from John WILLIAMS' score are sometimes played as background music (which can be turned off if the student wishes, to improve concentration).

These appearances are intended to bring de-dramatization, motivation, and even recreation to the training sessions. They also create a common thread between the activities offered. This common thread is, pedagogically speaking, of great use as it underlines the topic underlying all these labs, namely food process engineering. Their number is limited so as not to disturb the students (generally 2 appearances per module + sometimes a last one on the final page of the module). While interesting, this pedagogical bias can lead to rejection and a lack of credibility of the work if not well introduced. Also, referencing is double-edged in that if the references used are quite obscure, some students can be negatively impacted if they did not understand it. This was not the case in this experiment, as we will see in section 4.

After having completed all the modules, the students were asked to return to the interactive presentation at the beginning, to discover a hidden page where they had to type in a secret code (the digits of the code come from the modules: for example, the number (single digit) of filter plates calculated for operation on the pilot plant in module #1, the sum of the digits constituting the number of sensors on the evaporation pilot plant of module #3, etc.). If the secret code is correct, the student gets their "Jedi of Food Engineering" badge (Fig. A10); if it is incorrect, the Darth Vader theme will sound and the student may "try again".

2.6. The final survey

An essential element of any educational device - especially if it is new - is the final survey, aiming to collect learners' initial impressions. Our survey did not adopt a standardized format. It consisted of 20 questions (UCQ, MCQ, scale or free answer) listed in the Appendix. The students answered them anonymously. The questions concerned: whether the learning modules had been completed or not; overall satisfaction on

various aspects (organization, content, duration, support, educational form offered); any technical difficulties encountered; the time spent; skills acquired and usefulness for future studies and working life; references to Star Wars; and finally open-ended questions about what they liked most, what they hated most and what surprised them most. Our survey did not specifically focus on the acceptance of the technology, as the context of the Covid pandemic did not allow students any other choice. 25 out of 29 students responded to the final survey, i.e. 86%, from June 1 to 15.

We were able to supplement this anonymous survey by direct exchanges with the students in a virtual debriefing. The results of the survey and informal discussion will be discussed in section 4.

3. Unfolding of the “remote labs” experiment

This training session went well overall, without any major technical difficulties. The main dysfunction observed concerned the time devoted by students to each module; we will come back to this in section 4.

The “Description” section and module #0 (Visit and safety) were put online for the students on the evening of May 13, just after the two days devoted to courses on the four unit operations. The instruction was that this “Description” must have been read and the module completed before May 19. On May 14 in the middle of the day, a problem with access to the virtual tour arose: this problem had not occurred during the preliminary tests carried out before, but was resolved quite quickly thanks to a few exchanges between a student, a teacher and the head of the technological platform. On the evening of May 14, 3 students had finished reading the description and completed module #0. On the evening of Saturday May 16, 6 additional students had finished. By Monday morning, May 18, 20 students out of 29 had finished, 2 had consulted the resources but had not yet completed the quizzes, 7 had not yet consulted anything. By the evening of May 18, the 29 students had finished everything.

The four “remote labs” were scheduled in the mornings from 8:30 am to half past twelve; each time the students had the following afternoon free. In order to give them more flexibility and absorb any connection difficulties or other technical delays, we decided to give them until 5:00 pm to upload their homework. The instructions on these assignments were that they were not full reports at all, but simply, depending on the case, involved uploading a diagram, a graph, or some results of calculations with a brief comment.

Throughout the morning of May 19, the remote lab session on frontal filtration took place (in autonomy but with a virtual classroom open for questions, as well as a forum). Some students had difficulty connecting to the training platform, but all were gradually connected. For the first 2.5 hours, few questions were asked and focused only on technical aspects: how the platform and quizzes worked, etc. During the last hour and a half of the session, questions were asked about the calculation part of the labs, with some diversity in the issues encountered: many students did not know how to make a graphical integration by the trapezoid method; some were surprised about the order of magnitude of the specific resistance of the cake obtained

graphically. The forum was not used at all by the students; they asked their questions orally in the virtual classroom or *via* the chat available in the same virtual classroom. At the end of the session, the teacher agreed to send some additional recommendations by email to all the students at the very beginning of the afternoon, which she did. The students had until 5:00 pm to upload their homework: the first was uploaded at 3:31 pm; the last at 5:19 pm; 4 out of 29 were returned a few minutes late.

The other three mornings of “remote labs” were carried out in a similar way: very few -if any- questions during the first 2 to 3 hours; questions about calculations during the last hour. Taking into account the first experiment and the initial feedback from the students on the fact that they lacked time to complete the requested work in four hours, the teachers of the other 3 labs proposed an additional virtual class of approximately one hour in the afternoon for questions related to calculations; the instructions concerning the homework to be returned were recalled, as well as the fact that the deadline to upload them was 5:00 pm.

On the 3rd “remote lab”, concentration by evaporation, a difficulty -that we had not anticipated at all- was encountered in producing the P&ID diagram: a blank diagram with the equipment and pipes was provided, and the students had to position the different instruments on it. For this, a page of instructions in module #3 explained how to draw a standard P&ID representation and many forms of description of the pilot plants with photos, videos and virtual tour allowed the students to find which instruments were present on the installation and where. The students encountered unexpected difficulties in retrieving the blank diagram (depending on their browser or if they were using a Mac) and then completing it on a computer (most of them not having a printer): some had no idea how to complete the diagram (*via* an image processing software such as Gimp or presentation software such as PowerPoint for example), nor the reflex to simply ask the question in the virtual classroom.

The 4h session for writing the final group report went very well: each group had to write a report on one of the four labs, chosen randomly. The teacher responsible for these labs explained to them what was expected of them, if necessary providing them with other experimental results to analyze and compare with those used during the “remote labs” session. All the groups were able to work together remotely and upload their report on time.

The individual oral exams took place in a virtual classroom, without any technical difficulty or disaster in terms of ability to answer teachers' questions (except in one case, for a student who had serious difficulties due to the lockdown, being alone with a young child to look after).

4. Results and discussion

4.1. Quantitative results from the survey, marks and learning analytics

Student involvement: Both the completion rates of the modules (first line in Table 3) and the responses to the survey show that all the students completed the five modules almost entirely. 72% of students who responded to the final survey declared having completed all the modules offered in full; 28% “more or less” (question 1). In another survey question, 61% said they had consulted more than 90% of the resources offered, 78% more than 80% of the resources (question 7). 40% of those who did not complete all of the modules said it was for lack of understanding / discouragement, and 12% because of external constraints (technical, family, etc.) (question 2).

Technical issues: 9% said they encountered technical difficulties “often”, 35% “occasionally”, 35% “rarely” and 22% “never” (question 5). In the free comment following this question, they stated that the difficulties were mainly related to the slowness of their computer and/or their Internet connection during the 360° virtual tours. Overall Internet connection difficulties were also mentioned. No issues were raised about acceptance of the technology, perhaps simply because students were aware that in these exceptional circumstances, there was no other choice. Apart from the difficulties related to old computers or a slow Internet connection mentioned above, the students had no difficulty with the platform and no preliminary training or assistance was necessary.

Time spent: The statistics of time spent per module in the LMS (second line in Table 3) show that the 40 min planned for module #0 were achieved overall. For modules #1 to 3, the scheduled time (4h) was significantly exceeded. Finally, for module #4, the average connection time was a little less than the four hours planned. This is consistent with the responses to the final survey (question 10): 78% said the pace was too fast, for 22% the pace was adequate, and none found the pace too slow; in another survey question, 88% said they spent “much more than what was planned”, 8% “about what was planned” and only one student said he/she spent “significantly less” time than scheduled. This dissatisfaction with the time spent on each part is also found in the graph in Fig.2. Students specified in the free comments that only the 4th “remote labs” was feasible in a reasonable time; indeed, the first assignment was handed in at 12:28 pm. During the informal debriefing, the students complained a lot about the time spent doing the labs. They had already brought up this difficulty before the end of the “remote labs” and indicated that this put them in a great state of stress.

The emotional state of the students: Despite the reminder about what was expected in the homework assignments and the reassuring messages from the teachers, a certain number of students were stressed by these “remote labs”, to the point of panic for some of them. The students of this Master's degree are usually subject to stress, have a great desire to do well, absolutely want to complete/succeed in all the disciplines and put pressure on themselves even in regular working conditions. We believe that the circumstances (lockdown due to COVID-19) in which these “remote labs” took place aggravated their natural inclination to stress: it was the first time that they had been confronted with this type of teaching (100% remote and work essentially in autonomy); in addition, the material conditions for some of them during lockdown were poor

(insufficient computer equipment and Internet connection; very cramped accommodation and severe limitations on movements due to health regulations). Despite teachers' efforts to explain, reassure, and offer extra support in the afternoons, we were unable to reduce this feeling of stress to an adequate level for learning. It wasn't until the end of the period that the students realized that the work requested was pedagogically in line with what can legitimately be expected from a Master student and fully consistent with their scientific background. For their part, the teachers noted that a lot of the individual homework assignments returned at the end of the "remote lab" day were almost already full reports, which was not required at this stage.

Given the emergency conditions in which the system had to be put in place and many other matters to manage in parallel, we had not taken the time to review literature. However, Josceanu et al. (2009) already warned about stress related to limited time and recommended flexibility and asynchronous learning. In the light of the experience of distance learning set up in the emergency due to lockdown, Villiot-Leclercq (2020) also warned about cognitive overload for students, who experience a strange distance face-to-face during the day, and the disappearance of working temporalities conducive to students' responsibility and autonomy. Caron (2020) underlined the difficulty of bringing together and managing to reconcile the teaching and learning processes on the one hand, and the learner's freedom and autonomy on the other hand, in a private and open environment.

Educational level and overall student satisfaction: 86% of the students who answered the final survey said the level of education was appropriate, 14% found it was too high, and none considered it too low (question 9).

Fig. 2 shows the overall satisfaction of the students on various aspects: apart from the issue of duration already discussed, the rate of satisfaction was around 50% for the pedagogical form, support and organization items; the satisfaction rate was over 70% with regard to the content (question 4).

Learning outcomes, skills and performance: The overall high scores obtained for quizzes (last line in Table 3) show that students carefully read/viewed the educational resources provided. Their assessment scores for the whole subject (course + labs) are higher (by 1.0 point out of 20) than in previous years (Fig. 3), which is more than the standard deviation in assessment scores through the four previous years. This difference is hardly visible on the lab scores, which are usually already high. The minimum and maximum marks are higher than usual but remain within the limit of the standard deviation over the previous four years. The same was observed on the marks for the individual oral examination, which were on average 1.6 points higher (out of 20) compared to previous years. This is consistent with the teachers' impression: they found that the students overall answered their questions well during the oral exam and had indeed understood a lot; they took advantage of this oral presentation to re-explain some points that had been misunderstood. For their

part, the students, who were very worried before the oral exam, said during the debriefing that they appreciated it too.

Fig. 4 shows how the students assessed their own skills. They considered their acquired skills (in the immediate + long term): 70% for the discovery of processes in their technological aspect, 65% for the application of concepts and tools seen in courses, 48% for everything “around the process”, 83% for remote teamwork and 78% for autonomous work (question 12). They are therefore fully aware of having acquired new soft skills during these “remote labs”. We note that they have little confidence in the sustainability of the skills acquired in terms of instrumentation, utilities, characterization tools. 74% of respondents believe that what they learned during these labs will be useful for their future studies and 71% useful for their future professional practice (question 13). There was no such survey in the past, so it is not possible to compare these results with those of previous years. Given the context, however, we consider them more than satisfactory. It will obviously be interesting to re-examine these skills next year to see if the students’ self-assessment was correct.

Finally in terms of gamification: 71% of respondents found the references to Star Wars “fun and enjoyable”, 25% had a neutral opinion, none had a negative opinion, only one student claimed that she/he disliked Star Wars (question 14). When they answered the survey, 54% had obtained their “Jedi of Food Engineering” badge (Fig. A10), 25% had not obtained it, 21% did not know it existed but were planning to go and collect it, only one declared not to be interested in this badge (question 15). The Star Wars common thread therefore turned out to be quite a good pedagogical idea and apparently quite well balanced. Any comparison with the work of Burkey *et al.* (2013) is limited, as in our case no optional tasks were proposed. However, we note an enthusiasm among our students similar to what they observed with theirs.

4.2. Qualitative results

Some quantitative results of the final survey may appear negative (Fig. 2 for example); they are balanced by the responses to open questions. Authors read through all the responses and then identified recurring themes that are shared below. The selection for excerpts included in the text was made collectively and meant to share recurring elements:

- To the question “What did you like the most (and why)?” (question 16), the students mentioned: the work carried out by the teaching team to offer this alternative to practical work, their pedagogy and their enthusiasm; videos and interactive teaching resources were mentioned very often; the oral examination and the group work for the final report were mentioned by two students; several also mentioned references to Star Wars.
- To the question “What did you hate the most (and why)?” (question 17), many of the answers concerned their stress and the time spent, which was much longer than what was planned; some also mentioned the feeling of not having really understood (because it is necessary to “move forward” to

upload the homework on time), which is consistent with the answers they gave to the question about the sustainability of the skills acquired (Fig. 4); fatigue related to prolonged screen work was also mentioned; as well as the difficulty of managing many documents open at the same time on their computer (few students had a printer) and about where to find the data needed for calculations; most of these points also emerged during the informal debriefing.

- To the question “What surprised you the most?” (question 18), the students mentioned: references to Star Wars; the quality of the teaching materials and the remote learning environment, as well as their very rapid implementation by the teaching team; the fact that we had videos (even old or a little blurry) already shot and that we managed to put them together for this unexpected educational use.
- In response to the last question about suggestions concerning these labs, but also during the informal debriefing, the students proposed: quite logically, to shorten the labs, or to provide more clues and help to carry them out in the allotted time, or to split the sessions into two parts (one to discover the equipment and complete the quizzes, then one devoted to the calculations, leaving time between the two parts to take a step back); the idea of leaving more time between the course and the labs was also proposed, if possible providing tools to help the assimilation of the courses before the labs; providing paper support before starting the labs was also suggested; only one student asked for further clarification of the expectations for homework, although this seemed important to improve from teaching team’s point of view (does this mean that everything was already explained rather well?).

During the informal debriefing with the students, in addition to the problems of time and stress already discussed above, the students mentioned their fatigue and obsolete computers as difficulties. They also mentioned as positive points: the format of these “remote labs”, the fact that they learned and what they learned interested them and aroused their curiosity.

The very special conditions of these labs thus seemed to have generated some unexpected communication issues, to our mind related to the amount of pressure the students felt to be under. It has also to be mentioned that they never saw the teachers face-to-face as the whole module started right after the lockdown. Maybe this lack of direct communication somehow “robotized” the teachers for some of the students, turning them into a voice behind a screen, thus making the reassuring words have less impact than if they had been uttered face-to-face. Aware of this bias, the teachers always put their camera on, when the Internet speed allowed it, to keep a visual link, although this obviously did not replace standard communication. Also, the fact that the students were most of the time asked not to put their camera on, again because of Internet speed issues, might have reinforced a feeling of isolation for the most sensitive students, thus increasing stress. According to a new survey reported by Johnson (2020), 78% of households with a high school or college student have experienced disruptions stemming from COVID-19. A worrisome

side effect of these disruptions has been the impact on student mental health. Among students impacted by COVID-19, an overwhelming majority (81%) somewhat or strongly agreed they were experiencing increased stress. Golberstein et al. (2020) came to similar conclusions of strong impact of COVID-19 and mental health impacts on children and adolescents.

Here are the main points that emerged from the pedagogical team's final discussion:

- The student learned and retained knowledge (notably visible during the oral exam). This is probably the result of the students' individual commitment to their learning: they clearly worked more and alone (which they also complained about), but this additional work, despite stress, is reflected in their results and in the skills acquired. The teachers noted that many individual homework assignments were far more extensive than in previous years; many students submitted an almost complete report. They also noted the discrepancy between the stress deplored by the students and the quality of their renderings. Moreover, the students also recognized afterwards that "it was not so awful".
- The quantity of work assigned per lab requires review and/or instructions need to be more explicit and/or the labs should be organized differently, for example by dividing the sessions into several shorter sequences, the simplest ones carried out autonomously and asynchronously, and others provided with more interaction and support from teachers. According to Mayer (2008) the key elements of teaching' science are: the reduction of unnecessary cognitive processing which does not support the educational objective (confused instructional design); managing the cognitive processing required to mentally represent the incoming material and its complexity; and support for cognitive processing aimed at making sense of the incoming material, including its organization and integration with prior knowledge. Budel (2020) offers an operational remediation in the form of infographics and a very useful table summarizing Mayer's principles.
- For their part, students must know how to limit themselves. When they get stuck on a part, they need to decide to move on. It must also be recognized that it is easier to let one's attention be distracted when working alone: during face-to-face labs the teacher is also the "timekeeper" and forces students to move on so as to have time to do everything in 4 hours.
- There are still points to improve in the interpretation of experimental results and calculation errors to be avoided: discussions between the group of students and the teacher next to the equipment or with the first calculation results in hand were certainly lacking.
- It is more difficult to establish a relationship based on trust with distance-learning students (at the time of lockdown, the teachers had not yet met the students). In addition, these students already tend to put a lot of pressure on themselves, as they know that the Master's course they are following

is highly selective (30 admitted out of around 400 applications) and that admittance to their first choice second-year Master specialty depends on their first-year grades.

- Points remain to be improved, but given the conditions under which this teaching experiment was conducted, the results are very positive and the experience was very enriching for the pedagogical team.

We will end this discussion by going back to the four pillars of learning (Dehaene, 2018), namely attention, active commitment, feedback on errors, and consolidation:

1. Even if it was by a negative reaction, the students' attention seems to have been effectively captured, since several of them said they skipped lunch on lab days so as to concentrate on the homework. If such a device had to be put in place again, we would invent more positive ways to keep students' attention focused. Gamification could then be a lead.
2. Active commitment was also mobilized: this is visible in the exhaustive consultation of resources, the high scores obtained for quizzes, the fact that all the students returned all homework assignments and finally in the exam results.
3. Feedback on errors was partly provided by the self-correcting quizzes during discovery of the equipment. It will remain necessary to imagine a way to have -if possible- instant feedback on calculation errors. One way could be the use of "calculated questions" in our new LMS based Moodle. A more interactive synchronous session with teachers, perhaps in small groups, could also help to address this third pillar.
4. Consolidation was partly the subject of the report written in groups and individual oral examination, and was also an opportunity for the teacher to make remedial action on points that had been mis- or poorly understood. Here again, a synchronous session with teachers in small groups should help.

5. Conclusions and perspectives

The lockdown and closure of universities during spring 2020 imposed due to the COVID-19 pandemic led us to develop an educational device as an alternative to practical work. None of us would like such a situation to happen again, but the resources and practices developed on this occasion represent in our eyes an opportunity to develop new teaching methods in the future. In the sense of the editorial by Glassey and Magalhães (2020), we believe that sharing our perfectible experience can give ideas to the teaching community.

It is very difficult to assess the time spent by the teaching team to prepare these "remote labs". However, it was undoubtedly considerable, which suggests that various forms of pooling should be envisaged: pooling of the methods and development tools for other types of labs, either fully or partially distance taught; pooling between different courses when labs use the same equipment (lab scenarios should be reviewed for each

course regarding its objectives and students' characteristics, but some resources can be used across the board).

In the event that these educational resources are reused in a totally remote format, depending on the evolution of the health situation, we plan to:

- carry out these labs in two parts: a first part asynchronous and in total autonomy (with an open forum for questions, but without a virtual classroom), this first part being devoted to discovering the equipment and its peripherals, with formative quizzes; a second tutored part, for calculations, perhaps in smaller groups; if a face-to-face part is possible, it would be shorter and devoted to experiments, counting on the fact that as the students had discovered the installation upstream, they would be more efficient on site; it would probably also be necessary to allow slightly different formats from one lab to another, their objectives and difficulties being different;
- review the breakdown between individual and group work to promote the co-construction of knowledge; most web conferencing tools allow working groups to be created within a virtual classroom and the teacher can “navigate” between groups to give guidance and help;
- without going so far as to mollycoddle students, we need to demonstrate more the attention we pay to them, while maintaining a high level of demand with respect to learning outcomes; for this, the drafting of a vade-mecum focused on the learning methodology should be considered and could be shared on a much larger scale than the teaching subject of this paper;
- in order to both enhance the learning process and to handle the abovementioned emotional aspects, live exchange times with teachers should be organized, distinct from periods devoted to individual work;
- if these labs were to be done completely remotely again, we will need to find a way to transmit clues on how to interpret the experimental results and avoid calculation errors: one way could be a pedagogical game format, forcing students to think of accessing clues, rather than giving them directly;
- additional resources to explain or review some “mathematical” tools (integration method by trapezoids, determination of a portion of curve's slope, etc.) will be added.

A final perspective, which will require financial investment in the pilot plants, concerns the development of online laboratories (so called “WebLabs” or “iLabs”) to allow students to “practice” remotely with direct feedback on the result of their actions. Originating in microelectronics, these Web- or iLabs are experimental setups that can be controlled through the Internet from a simple web browser. Some applications in chemical engineering have been reported (Klein et al., 2005; Alliet-Gauberta et al., 2012). A hybrid approach (Domingues et al., 2010), which does not delete the experimental part but prepares and enriches it with

online work, seems to us the most relevant approach to develop in the case of pilot plants in the future. However, this presupposes equipping pilot plants with suitable sensors and acquisition systems and must be examined carefully from the safety point of view.

The resources developed in an emergency for the realization of these “remote labs” and the new skills acquired by the teaching team will be invaluable in the future: for example, in the event of deterioration of the health situation in the coming months and of partial re-lockdown; or at the time of the relocation of our institute (the four Ile-de-France sites of AgroParisTech will soon move to Palaiseau and be grouped on a new campus, closer to Paris-Saclay University); or for other training courses without practical work. Moreover, by the end of August 2020, engineering students will be strongly encouraged to practice three of our “remote labs” for revision or upgrades on unit operations before starting their third year in a food process engineering specialty.

We presented our experience at the school's annual pedagogical seminar (Debacq et al., 2020). On this occasion, colleagues asked how to build such a device from scratch. We took the liberty of giving some general recommendations: work in thematic groups of teachers; call on the assistance of a pedagogical engineer or, failing that, a teacher experienced in distance education; start from learning outcomes and targeted skills. The most important element is of course the educational scenario, but it is obviously useful to benefit from the advice of people who are familiar with digital tools and who can train teachers in their use.

Acknowledgements

We would like to thank the 29 students who participated in this educational experiment in spring 2020 for their enthusiasm, their comments, suggestions and encouragement; we would like to apologize for the stress these labs sometimes generated. We also thank Thierry KOSCIELNIAK and Cnam for the allowing us to use their immersive learning platform Uptale free of charge. Lastly, we would like to thank Benjamin BAATARD for his assistance in using the learning management system <https://tice.agroparistech.fr/coursenligne/>

Appendix

The following figures give examples and details about the learning environment and the modules developed as substitutes for labs.

List of Abbreviations

COVID-19: COronaVirus Disease 2019

HTML: HyperText Markup Language

LMS: Learning Management System

MCQ: Multiple Choice Question

PDF: Portable Document Format

P&ID: Piping and Instrumentation Diagram

UCQ: Unique Choice Question

WYSIWYG: What You See Is What You Get

WYSIWYM: What You See Is What You Mean

Glossary of software and tools

Camtasia: Software suite for creating video tutorials and presentations directly via screencast, with Easy-To-Use post-production tools <https://www.techsmith.com/video-editor.html>

Canva: online graphics studio that allows you to easily create a whole series of documents of all kinds (banner, poster, newspaper, illustrated quote, ...) <https://www.canva.com/>

Collaborate: Simple and reliable virtual classroom solution to power online teaching and web conferencing needs <https://www.blackboard.com/teaching-learning/collaboration-web-conferencing/blackboard-collaborate>

Dokeos: LMS & e-learning suite, provides online training tools and can manage certifications <https://www.dokeos.com/>

Genially: Easy-To-Use online software devoted to creating stunning interactive presentations <https://www.genial.ly/>

Gimp: Open source image editor for graphic designers, photographers, illustrators, scientists <https://www.gimp.org/>

Scenari: Open source software solutions aimed at different business users, having in common the creation, design and modelling of documents in areas such as: training, documentation writing, document management <https://doc.scenari.software/en/>

Seafile: Open source, self-hosted file sync and share solution, which allows collaboration across devices and teams <https://www.seafile.com/en/home/>

Uptale: Immersive learning platform designed to create, share and track training modules in 360° and virtual reality. <https://www.uptale.io/en/home/>

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Figures

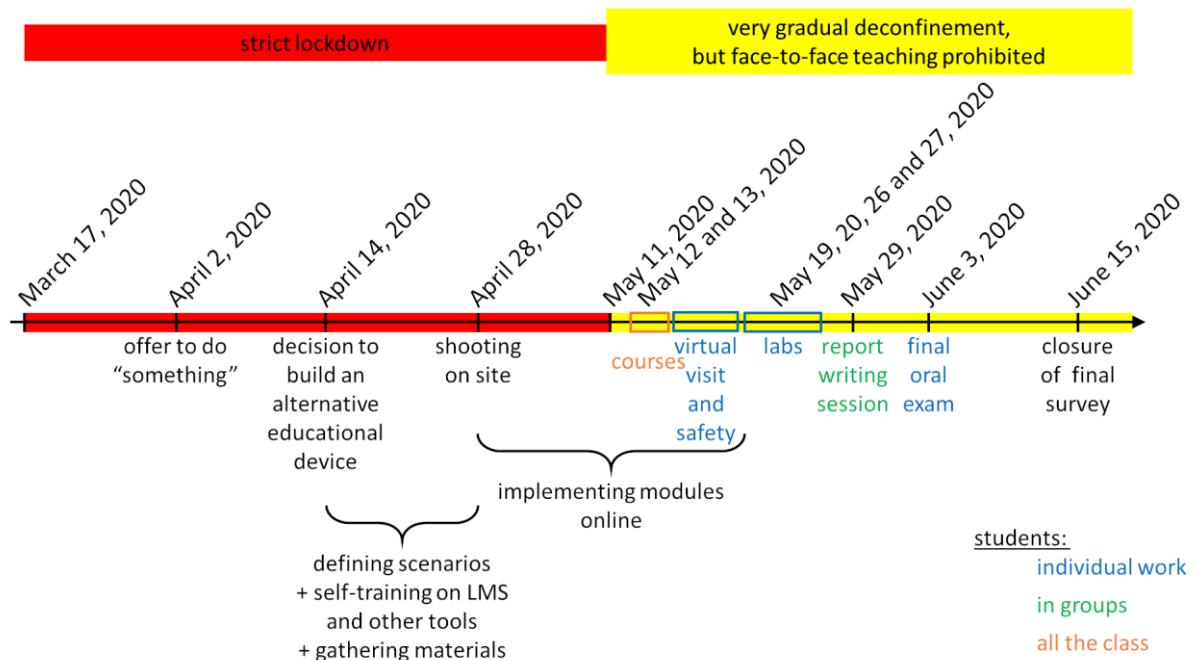


Fig. 1. Timeline of the food engineering "remote labs".

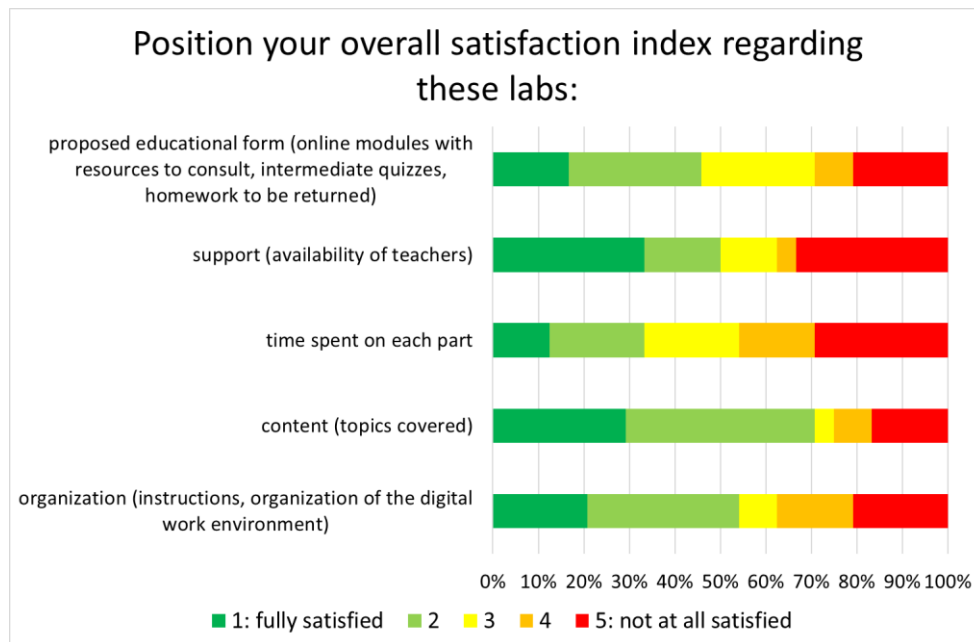


Fig. 2. Overall students' satisfaction.

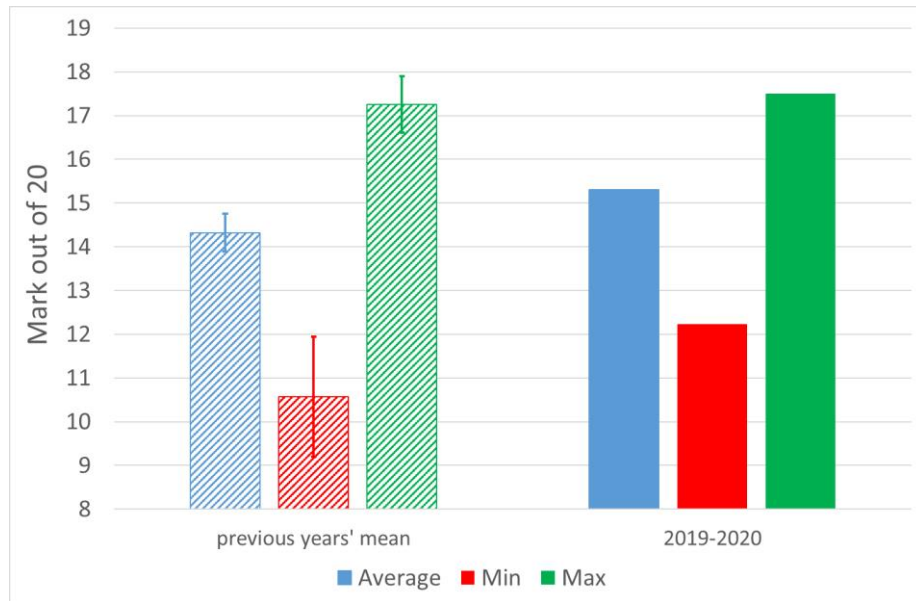


Fig. 3. Assessment scores over years for the whole subject (course + labs). Previous years run from 2015-2016 to 2018-2019.

Evaluate the skills you have acquired:

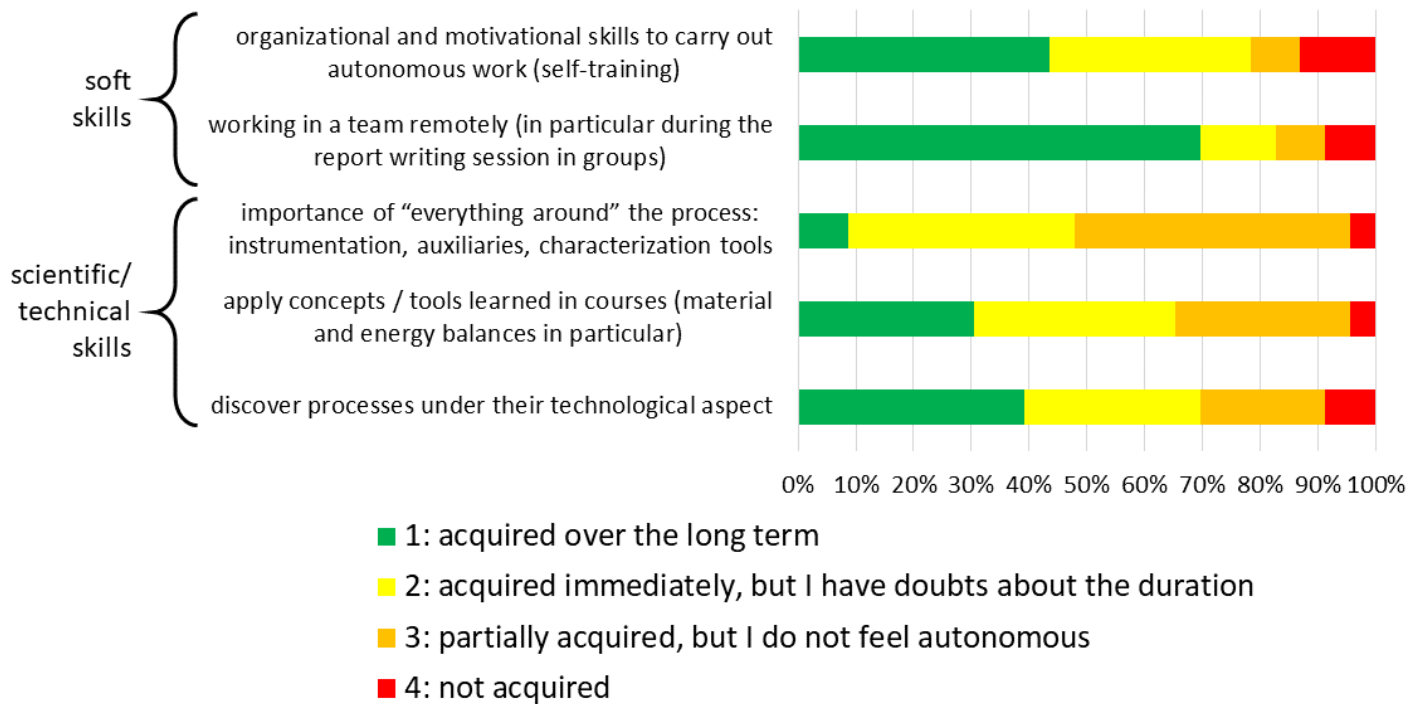


Fig. 4. Self-evaluation of acquired skills.

Appendix

We provide here many illustrations and additional documents allowing the reader to better understand the nature of the resources and activities offered to students for these remote labs.

The list of survey questions is also provided.

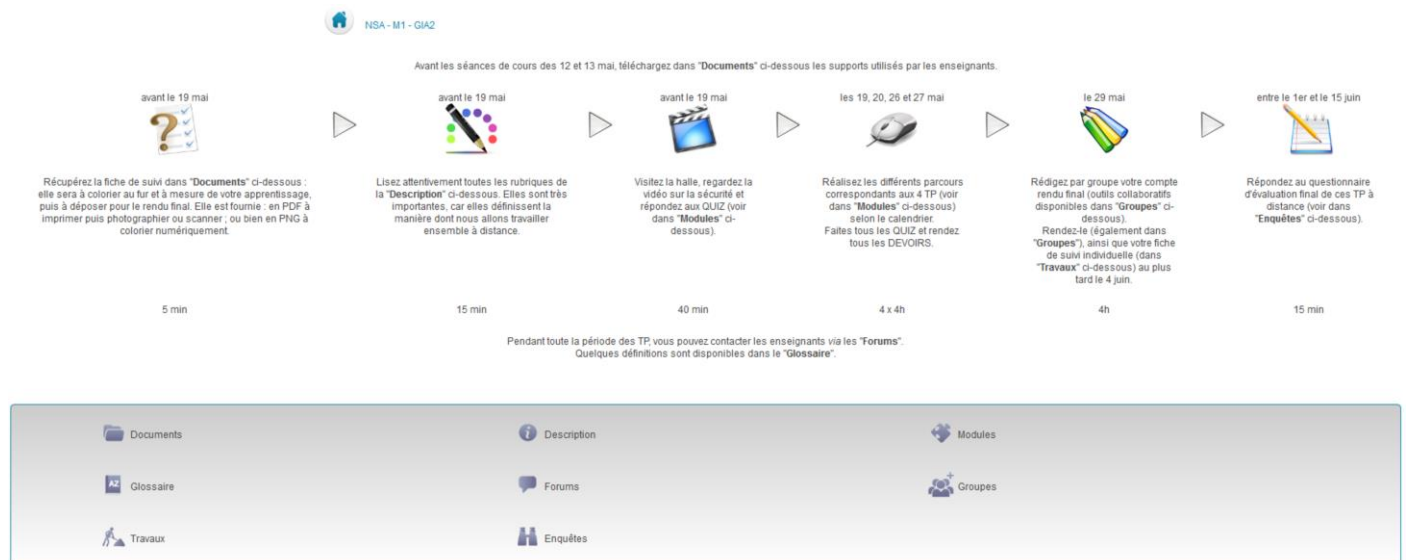


Fig. A1. Overview of the home page in the LMS (learning management system).

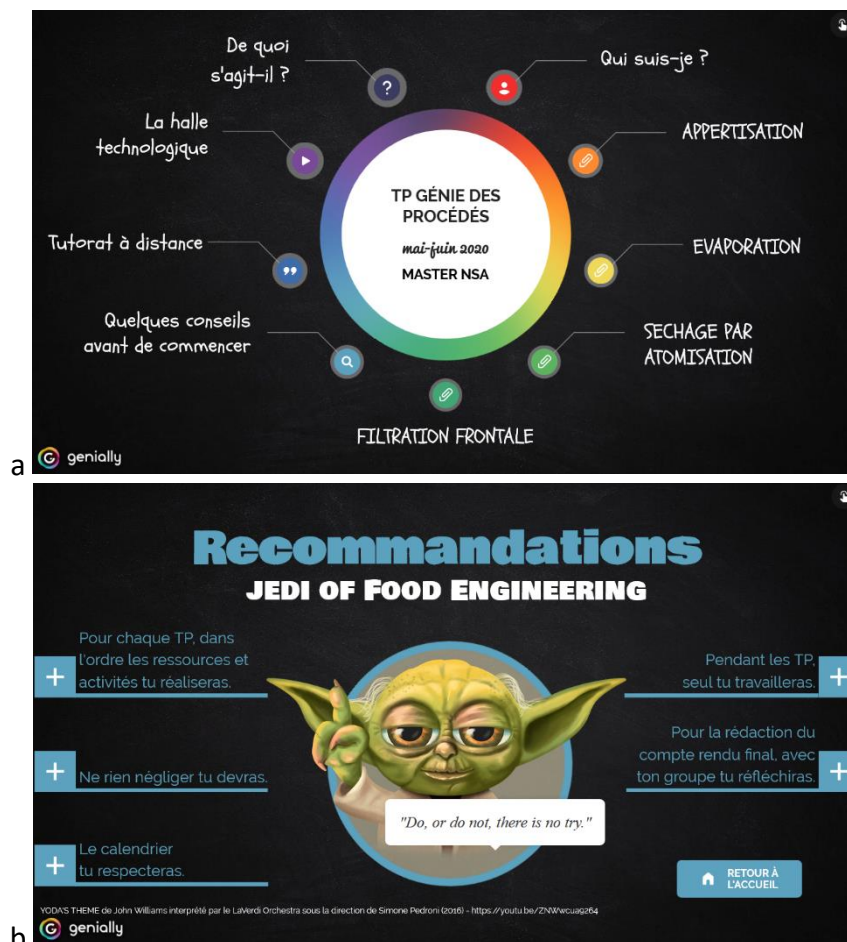


Fig. A2. Screenshots (a) of the first page of the preliminary interactive presentation and (b) of the recommendations page.

TP génie des procédés à distance

NSA-GIA2-..... indiquez ici votre nom

20 mai à 8h30
4h TP ATOMISATION

26 mai à 8h30
4h TP ÉVAPORATION

27 mai à 8h30
4h TP APPERTISATION

40 min AVANT le 19 mai
VISITE DE LA HALLE

Visite virtuelle
Visitez l'ensemble de la halle : il y a plusieurs étoiles à récolter...

QUIZ halle
Répondez aux questions : pour la deuxième, écrivez 3 phrases résumant vos premières impressions.

Vidéo
Regardez la vidéo présentant les règles générales de sécurité dans la halle.

QUIZ sécurité
Faites le test sécurité.

**19 mai à 8h30
4h TP FILTRATION**

Introduction
Lisez les consignes.

Partie 1 + Quiz 1
Consultez les diverses ressources et répondez au premier quiz.

Partie 2
Étudiez les ressources et exploitez les mesures à l'échelle laboratoire.

Partie 3
Calculez la surface de filtration sur le pilote.

Partie 4 + Quiz 2
Réalisez une filtration.

Partie 5
Exploitez les mesures sur le pilote.

Devoir
Rendez vos calculs, analyses et commentaires.

**20 mai à 8h30
4h TP ATOMISATION**

Introduction
Lisez les consignes.

Partie 1 + Quiz 1
Consultez les diverses ressources et répondez au premier quiz.

Partie 2 + Quiz 2
Définissez la procédure de démarrage, préparez la solution de lait et commencez l'expérience.

Partie 3
Recueillez les mesures.

Partie 4 + Quiz 3
Arrêtez l'installation en toute sécurité.

Partie 5
Faites les calculs, les bilans et placez les points sur le diagramme de Mollier.

Devoir
Rendez vos calculs, analyses et commentaires.

**26 mai à 8h30
4h TP ÉVAPORATION**

Introduction
Lisez les consignes.

Partie 1
Consultez les diverses ressources de présentation de l'équipement.

Partie 2 + Quiz
Démarrez l'installation.

Partie 3
Recueillez les mesures sur le pilote.

Partie 4
Mesurez les taux de sucre.

Partie 5
Faites les bilans et calculs.

Devoir
Rendez vos calculs, analyses et commentaires.

**27 mai à 8h30
4h TP APPERTISATION**

Introduction
Lisez les consignes.

Partie 1
Consultez les diverses ressources de présentation de l'équipement.

Partie 2 + Quiz
Faites un essai à vide pour prendre en main l'installation.

Partie 3
Préparez les boîtes.

Partie 4
Réalisez une production.

Partie 5
Faites les calculs.

Devoir
Rendez vos calculs, analyses et commentaires.

**29 mai après-midi
4h TP**

Tirage au sort
Participez au tirage au sort avec votre groupe.

Compte rendu
Rédigez collectivement le compte rendu sur ce TP et déposez-le.

Les étoiles tu dois colorier (au fur et à mesure que les tâches sont réalisées...).

Marie DEBACQ - mai 2020

TP génie des procédés à distance

NSA-GIA2-..... indiquez ici votre nom

20 mai à 8h30
4h TP ATOMISATION

26 mai à 8h30
4h TP ÉVAPORATION

27 mai à 8h30
4h TP APPERTISATION

40 min AVANT le 19 mai
VISITE DE LA HALLE

Visite virtuelle
Visitez l'ensemble de la halle : il y a plusieurs étoiles à récolter...

QUIZ halle
Répondez aux questions : pour la deuxième, écrivez 3 phrases résumant vos premières impressions.

Vidéo
Regardez la vidéo présentant les règles générales de sécurité dans la halle.

QUIZ sécurité
Faites le test sécurité.

**19 mai à 8h30
4h TP FILTRATION**

Introduction
Lisez les consignes.

Partie 1 + Quiz 1
Consultez les diverses ressources et répondez au premier quiz.

Partie 2
Étudiez les ressources et exploitez les mesures à l'échelle laboratoire.

Partie 3
Calculez la surface de filtration sur le pilote.

Partie 4 + Quiz 2
Réalisez une filtration.

Partie 5
Exploitez les mesures sur le pilote.

Devoir
Rendez vos calculs, analyses et commentaires.

**20 mai à 8h30
4h TP ATOMISATION**

Introduction
Lisez les consignes.

Partie 1 + Quiz 1
Consultez les diverses ressources et répondez au premier quiz.

Partie 2 + Quiz 2
Définissez la procédure de démarrage, préparez la solution de lait et commencez l'expérience.

Partie 3
Recueillez les mesures.

Partie 4 + Quiz 3
Arrêtez l'installation en toute sécurité.

Partie 5
Faites les calculs, les bilans et placez les points sur le diagramme de Mollier.

Devoir
Rendez vos calculs, analyses et commentaires.

**26 mai à 8h30
4h TP ÉVAPORATION**

Introduction
Lisez les consignes.

Partie 1
Consultez les diverses ressources de présentation de l'équipement.

Partie 2 + Quiz
Démarrez l'installation.

Partie 3
Recueillez les mesures sur le pilote.

Partie 4
Mesurez les taux de sucre.

Partie 5
Faites les bilans et calculs.

Devoir
Rendez vos calculs, analyses et commentaires.

**27 mai à 8h30
4h TP APPERTISATION**

Introduction
Lisez les consignes.

Partie 1
Consultez les diverses ressources de présentation de l'équipement.

Partie 2 + Quiz
Faites un essai à vide pour prendre en main l'installation.

Partie 3
Préparez les boîtes.

Partie 4
Réalisez une production.

Partie 5
Faites les calculs.

Devoir
Rendez vos calculs, analyses et commentaires.

**29 mai après-midi
4h TP**

Tirage au sort
Participez au tirage au sort avec votre groupe.

Compte rendu
Rédigez collectivement le compte rendu sur ce TP et déposez-le.

Les étoiles tu dois colorier (au fur et à mesure que les tâches sont réalisées...).

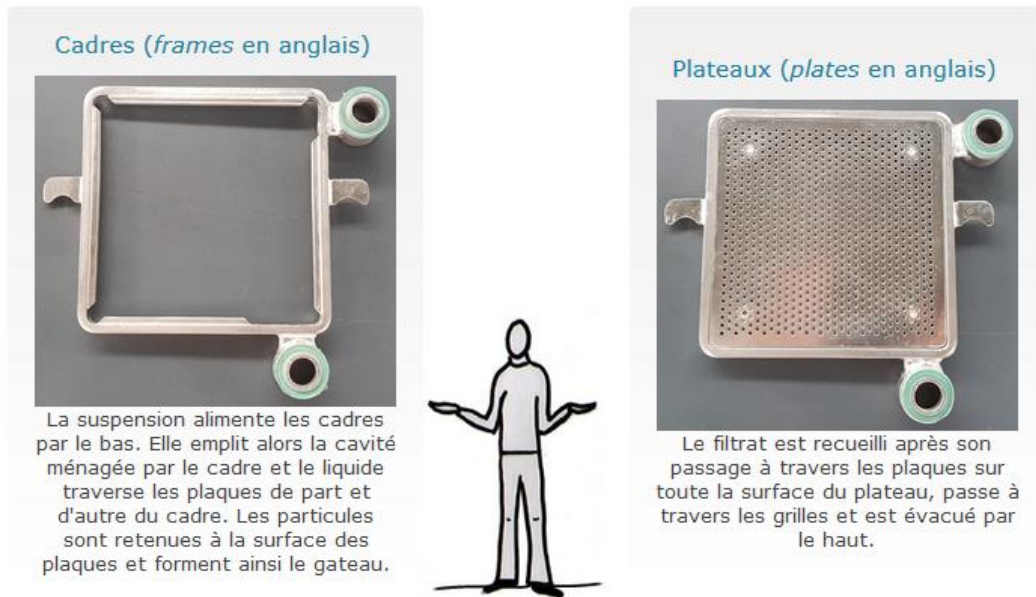
Marie DEBACQ - mai 2020

Fig. A3. Monitoring sheets completed by two students (they had to color the stars as they completed the work): (a) directly on the computer or (b) by hand after printing the sheet (on which the student added a sandtrooper sticker).



Fig. A4. Scenarios of the preliminary module and the labs: (a) Module #0: Visit and safety; (b) Module #1: Frontal filtration in a plate filter; (c) Module #2: Spray drying; (d) Module #3: Concentration in a falling film evaporator; (e) Module #4: Appertization of cans

Cadres, plateaux et plaques



Les cadres et plateaux sont positionnés alternativement sur le filtre et on place entre chacun une plaque (ici de cellulose). Aux extrémités du filtre sont positionnés un cadre et un plateau d'extrémité.

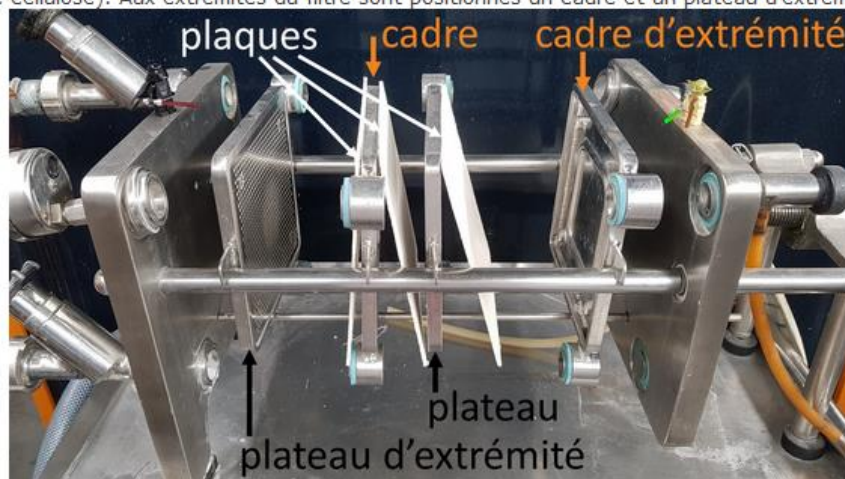


Fig. A5. Example of a content page (module #1) produced directly on the Dokeos platform. Note the Lego Star Wars minifigures placed on the ends of the filter.

module 1 - TP filtration frontale

Liste des modules
 Contenu
 Scénario

Déroulement du TP filtration frontale à distance

1/ prendre connaissance des documents et découvrir les équipements

2/ manip labo pour déterminer la résistance spécifique du gâteau

3/ calcul de la surface de filtration nécessaire

4/ manip pilote à débit constant puis pression constante


5/ analyse des résultats

CONSIGNES

Les parties 1 et 4 comportent diverses ressources (documents, images, vidéos) à consulter + un quiz à réaliser dans chaque partie. Les parties 2, 3 et 5 comportent peu de ressources, mais vous aurez des calculs à faire, à analyser/commenter et à rendre à la fin du module.

Notez que les QUIZ ont surtout vocation à vous amener à réfléchir sur ce que vous avez vu ou lu et à le restituer sous une forme guidée ; ils n'entrent que pour une très faible part dans votre évaluation. Ne les négligez pas pour autant, car ils vous permettent de vérifier que vous avez bien compris le fonctionnement du pilote. La correction automatique propose à chaque fois une remédiation des explications antérieures (sauf pour les questions ouvertes, qui seront corrigées manuellement ultérieurement par les enseignants). Ceci sera vrai pour tous les modules de "TP à distance".

Lisez attentivement toutes les recommandations ; réalisez toutes les étapes, dans l'ordre ; rendez bien tout ce qui est demandé.



Pendant toute la durée de la séance de TP (mardi 19 mai de 8h30 à 12h30), vous pouvez vous rendre dans la [classe virtuelle](#) pour poser des questions à Marie-Laure LAMELOISE. Un peu comme si vous étiez dans la halle et que vous alliez frapper à la porte de son bureau... Comme elle pourra être occupée à autre chose quand vous arriverez dans son "bureau virtuel", vous devez faire un "toc-toc virtuel" en levant la main ou bien en allumant votre micro et en parlant : "Bonjour, j'aurais une question s'il vous plaît ?". Marie DEBACQ, dont le bureau se trouve "pour de vrai" juste à côté de celui de Marie-Laure LAMELOISE, sera également connectée et pourra aider si besoin ; en particulier pour les problèmes techniques liés à la plateforme et au module.

Vous pouvez également poser des questions sur le [forum dédié au TP filtration](#). Choisissez un titre explicite lorsque vous créez un fil de discussion ; vérifiez qu'il n'existe pas déjà un fil de discussion sur le même sujet, avant d'en créer un nouveau. Nous nous efforcerons de répondre rapidement, mais selon l'affluence dans le "bureau virtuel" et sur le forum, le délai pourra être plus ou moins long...

PRENEZ LE TEMPS DE RÉFLÉCHIR AVANT DE POSER UNE QUESTION !

Nous vous recommandons de cliquer sur ces deux liens pour ouvrir la classe virtuelle et le forum dans 2 onglets séparés de votre navigateur Internet ; ainsi vous pourrez facilement vous y rendre à tout moment pendant la matinée.

Le "dépôt de devoir", pour rendre vos calculs et commentaires à la fin du module, reste ouvert jusqu'à 17h ; mais le tutorat n'est assuré que pendant la matinée. En revanche le forum restera ouvert et rien ne vous empêche d'y échanger entre vous pendant l'après-midi.

Il ne sera répondu à aucune sollicitation par mail.

Bon "TP à distance" !

N'hésitez pas à **enregistrer les fichiers PDF et XLSX** incrustés dans ce module, ils pourraient vous resservir dans la suite du module...

Si vous le souhaitez, vous pourrez récupérer le support de TP de l'an dernier, à partir duquel a été bâti ce module, dans "Documents" via la page d'accueil de "NSA - M1 - GIA2" ; il y sera disponible en fin de matinée.

Fig. A6. First page of instructions for module #1 on the Dokeos platform.



Fig. A7 Example of virtual visit (module #3: falling film evaporator) developed with the online application

Uptale.



Fig. A8. Example of interactive technical manual (module #2: spray drying) made with the open source

editorial chain Scenari.

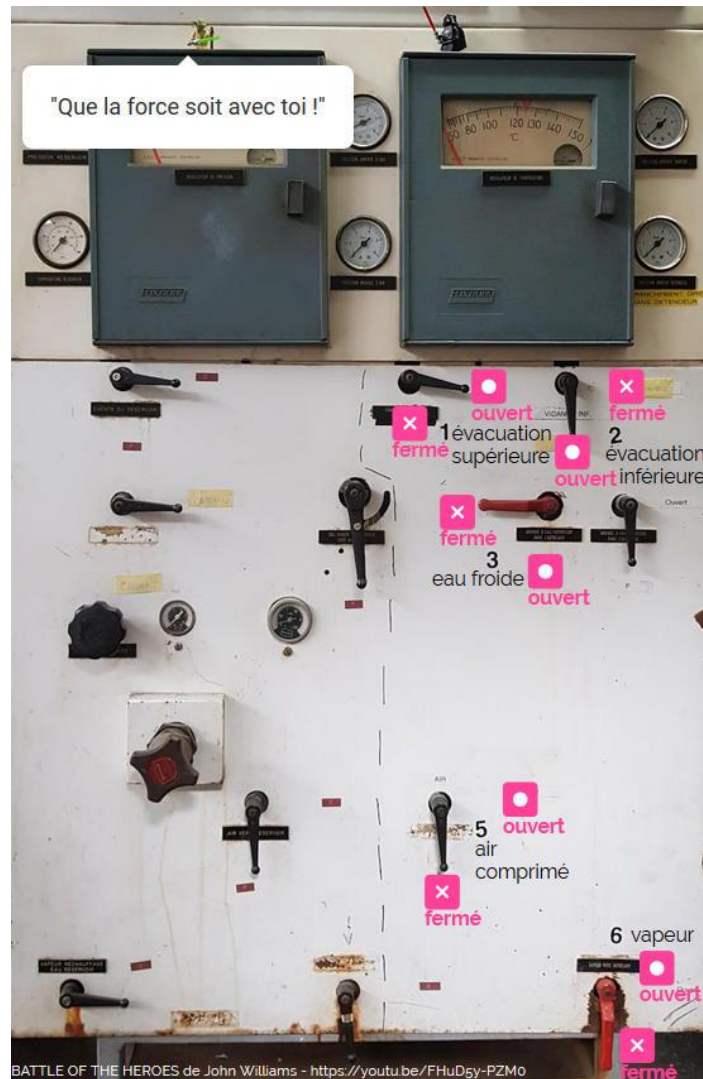


Fig. A9. The fake simulator (module #4: appertization of cans) set up with the online application Genially.

Jedi of Food Engineering



Fig. A10. Badge obtained at the end of the period thanks to a secret code: each of the 5 digits comes from a module. [Jedi symbol from <https://fr.wikipedia.org/wiki/Jedi>]

Survey questions:

1. Did you do all the proposed modules in full?

- ☐ yes
- ☐ no
- ☐ more or less

2. If not, is it:

- ☐ because of external constraints (technical, family, etc.)
- ☐ for lack of understanding / discouragement
- ☐ other
- ☐ I did them all.

3. If you checked "other", please explain:

open ended question

4. Position your overall satisfaction index regarding these labs (from 1: fully satisfied to 5: not at all satisfied):

organization (instructions, organization of the digital work environment)

content (topics covered)

time spent on each part

support (availability of teachers)

proposed educational form (online modules with resources to consult, intermediate quizzes, homework to be returned)

5. Did you have technical difficulties to follow these labs remotely? connection problem, difficulty viewing certain resources, problems submitting homework, etc.

- ☐ often
- ☐ occasionally
- ☐ rarely
- ☐ never

6. Specify any technical difficulties encountered:

open ended question

7. What percentage of the resources available did you read / view?

NB : We refer here only to resources (texts to read, videos to watch, virtual environment to explore, etc.), not activities (quizzes, homework).

% scale

8. What exchange tools did you use with the teachers?

- ☐ forum
- ☐ virtual classrooms

- ☐ None, I didn't need it.
- ☐ None because I was completely overwhelmed / lost.

9. What did you think about the level and pace of the teaching? (1: too fast/high; 2: suitable; 3: too slow/low)

Rhythm

Level

10. How much time do you estimate you spent on these remote labs?

- ☐ significantly less than planned
- ☐ about what was planned
- ☐ much more than what was planned

11. If applicable, specify on which part(s) you spent more time than planned.

open ended question

12. Evaluate the skills you have acquired (1: acquired over the long term; 2: acquired immediately, but I have doubts about the duration; 3: partially acquired, but I do not feel autonomous; 4: not acquired)

discovering the technological aspects of processes

applying concepts / tools learned in courses (material and energy balances in particular)

importance of “everything around” the process: instrumentation, auxiliaries, characterization tools

working in a team remotely (in particular during the report writing session in groups)

organizational and motivational skills to carry out autonomous work (self-training)

13. Do you think that what you learned during these remote labs will be:

- ☐ useful for your future studies
- ☐ useful for your future professional practice
- ☐ useless for your future studies
- ☐ useless for your future professional practice
- ☐ I already knew everything that was seen during these labs.

14. Did you obtain your “Jedi of Food Engineering” badge?

- ☐ Yes
- ☐ No
- ☐ I did not know it existed, but I plan to go and collect it now!
- ☐ Not interested.

15. What did you think about the references to Star Wars?

- ☐ fun and enjoyable
- ☐ neutral
- ☐ disturbing and off topic
- ☐ I hate Star Wars.

16. What did you like the most (and why)?

open ended question

17. What did you hate the most (and why)?

open ended question

18. What surprised you the most?

open ended question

19. Your final remarks / suggestions about these remote food engineering labs:

open ended question

20. Would you be willing to share your experience with these "remote labs" in the context of a workshop for teachers and pedagogical engineers?

open ended question

Tables

Table 1. Different types of “pages” and rich media in the several modules.
Colored symbols and icons correspond to Fig. A4.












number of	module #0 Visit and safety	module #1 Frontal filtration	module #2 Spray drying	module #3 Concentration in evaporator	module #4 Appertization of cans
parts	2	5	5	5	5
“pages”	6	35	39	42	19
content 	0	13	8	13	1
instruction 	2	10	13	12	9
forum or virtual classroom 	0	2	2	2	2
homework repository 	0	1	1	1	1
virtual visit 	1	0	1 (included in interactive manuals)	1	0
technical manual 	0	0	2	0	2
video 	1	2	0	8 (on 3 pages)	19 (included in interactive manuals)
PDF file 	0	3	6	3	2
XLSX, DOCX or JPG file 	0	2	1	4	1
fake simulator 	0	0	0	0	1 (linked on an instruction page)
quiz 	2	2	6	3	1

Table 2. Different types of questions in quizzes.

	module #0	module #1	module #2	module #3	module #4
total number of questions	13	10	23	7	7
UCQ (unique choice questions)	7	5	5	3	2
MCQ (multiple choice questions)	3	1	1	1	2
cloze	1	0	0	0	0
pairing	0	2	4	2	3
open response	2	2	13	1	0

Table 3. LMS statistics.

	module #0	module #1	module #2	module #3	module #4
mean completion rate	98%	99%	97%	99%	98%
mean time spent	44:45	5:37:25	4:55:21	6:00:59	3:29:45
first homework assignment returned at	not relevant	03:31 pm	02:17 pm	03:58 pm	12:28 am
last homework assignment returned at	not relevant	05:19 pm	05:32 pm	06:06 pm	07:13 pm
number of homework assignments returned late	not relevant	4	3	5	2
mean quiz scores	85%	68%	55%	61%	74%