Student Preparation for and Participation in Virtual Chemical Engineering Practical Classes during a Pandemic

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Description | What was done?

The continued delivery of practical classes during the pandemic was considered according to Bloom's Taxonomy of Educational Objectives (Bloom, 1956). The provision of the practical classes via remote online resources when necessary still need to build up the cognitive levels as described by Bloom. The lowest level (i.e. *Knowing*) can be achieved via some of the questions of a pre-lab assignment as these can focus on recalling facts of the Procedure and Risk Assessment. The highest level (i.e. *Evaluation*) is achieved through the Post-lab assignments which encourages students to consider the procedure, the instrumentation and the data and critically evaluate in terms of expected trends, anomalous results and possible causes of error combined with remedial improvements that could be made. It is therefore necessary that any content that is positioned between Pre- and Post-Lab, whether the traditional in person practical or the alternative remote option with instructional video combined with a live online Q&A session with a teaching assistant, must bring students through the other cognitive levels. Ethical approval for the conducting a survey of the students involved was sought from the Faculty of Engineering and Physical Sciences Ethics Committee.

Motivation and Aims

In the context of replacing the in person Practical Classes with remote alternatives during the Covid-19 pandemic, Fink's taxonomy (Fink, 2013) was also consulted. The alternative provision took on the guise of flipped classroom sessions which had to be designed cognizant of *learning how to learn*, *foundation knowledge*, *application*, and *integration* (Fink, 2013). This format encouraged students to complete their Pre-Lab as normal (after studying Risk Assessment and Procedure) before watching a short instructional/familiarization video (available in Module resources of Canvas) which demonstrated the procedure and the apparatus used. Students were also provided with sample data sets and Post-Lab assignments with detailed specifications which were accompanied with a grading Rubric, which is an important aspect of transparency of assessment (Bennett and Wilson, 2009). Students were expected to engage with these additional resources before joining a live, online, small group tutorial style session led by teaching assistants (which were also observed by the authors). The purpose of these sessions was to be engaging, offering students an opportunity to seek any clarifications while also given the opportunity to direct and interrogate student understanding; this was achieved by TAs asking questions regarding the procedures, theories and wider applications of relevant technologies.

Methodology

For student performance, grade data was extracted from Canvas gradebook and no identifiable data was used. This data was processed to determine average grades and standard deviations.

Student perceptions were also obtained via a voluntary, anonymous survey after the students had completed at least one cycle (i.e. two virtual practical classes). Ethical Approval for this survey was obtained from the Research Ethics Committee of the Engineering and Physical Sciences Faculty at Queen's University Belfast (Ref: EPS 21_83). Predominantly these questions were 5-point Likert scales, though a small number of open ended questions were also employed, allowing students to provide information on what the most useful/enjoyable part was as well as identify areas for improvement. There was also a question which allowed students to identify what content (if any) should be retained to aid their learning in the future when in person Practical Classes could return.

Successes | Challenges | Lessons Learned

The results from the Pre-Lab assignments using the format reporting in Figure 1 (nominally Semester 1) is reported below in Figure 3. The mean score for Semester 1 was 61.39% with a standard deviation of 12.72%.

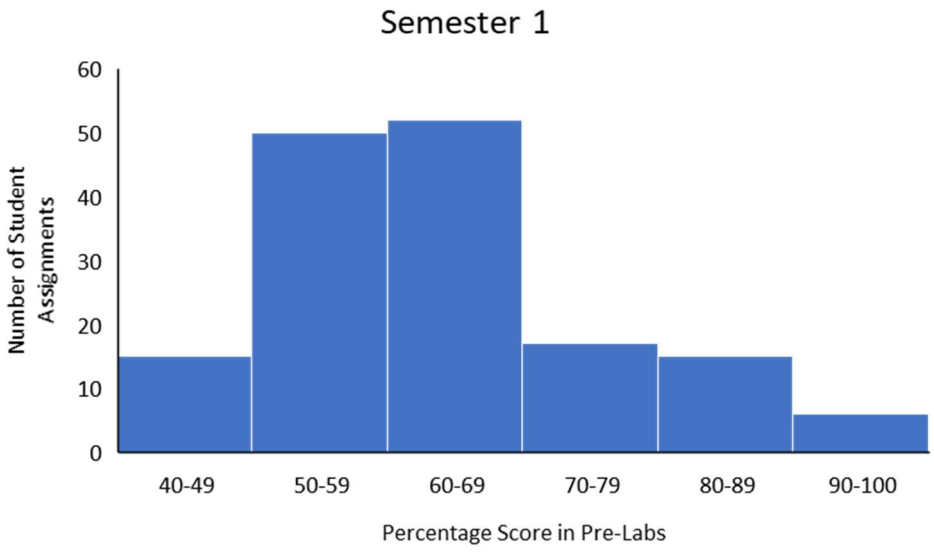

Figure 3: Grades for Pre-Lab Assignments in Semester 1

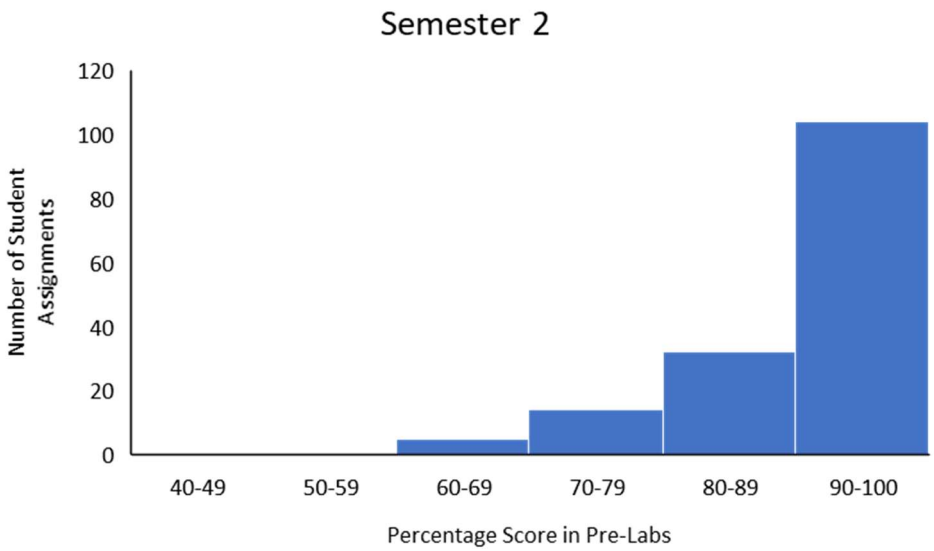

Figure 4: Grades for Pre-Lab Assignments in Semester 2

The grades for the students for pre-lab assignments in Semester 2 are reported in Figure 4. The mean score for Semester 2 was 89.81% with a standard deviation of 12.62%. It is interesting that while the mean score increased from Semester 1, the standard deviation has only decreased slightly (by ~0.1%). This indicates that between both data sets that there is very little difference in the variation of each grade with respect to the mean. This provides some confidence in the robustness of the new assignments in that there is still a similar spread of grades and that there is still an opportunity to differentiate student performance.

The higher grades are a reflection of improved student preparedness for the practical classes. As such, this should then provide the opportunity for students and academics to ask more applied and probing questions during the practical classes and therefore deepen the understanding of the subject matter.

Students were asked to evaluate the new online provision by means of an anonymous survey, with a question directly related to each of the components: pre-lab, instructional video and live Q&A session with a Teaching Assistant (Demonstrator).

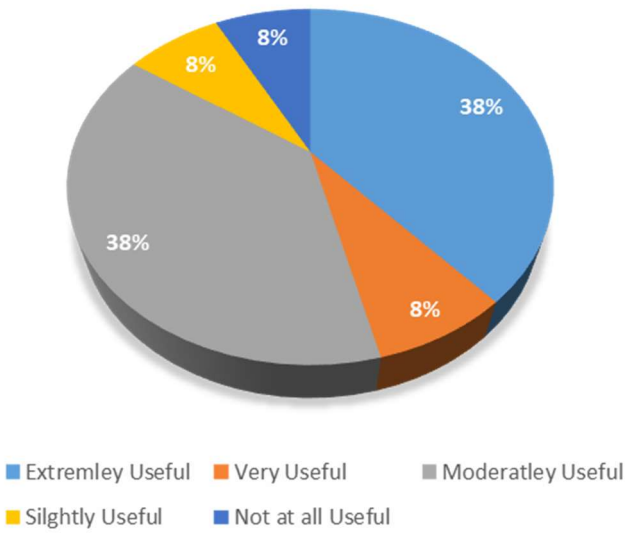

Figure 5: Evaluation of contribution of online pre-labs to student knowledge

Figure 5 reports the responses to the question on the contribution of the pre-lab activity to the student knowledge. From this it is clear that most of the students found the online pre-lab to be at least a moderately useful contribution to their knowledge.

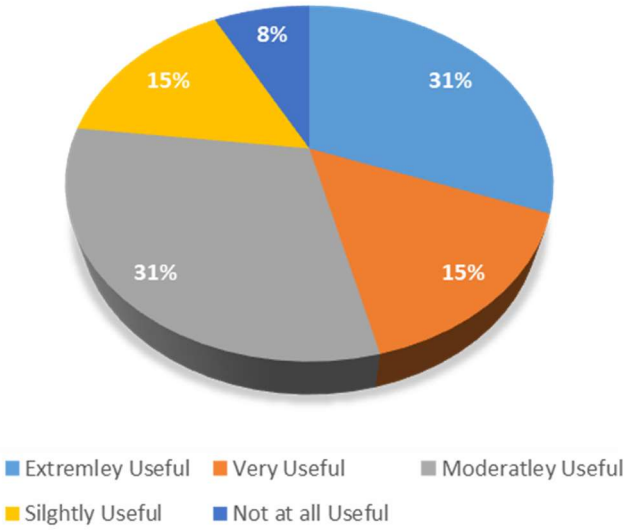

Figure 6: Evaluation of contribution of instructional videos to student knowledge

Figure 6 reports the responses to the question on the contribution of the instructional videos to the student knowledge. From this most of the students found the instructional video to be at least a moderately useful contribution to their knowledge and overall the contribution is somewhat similar to that of the pre-lab activities.

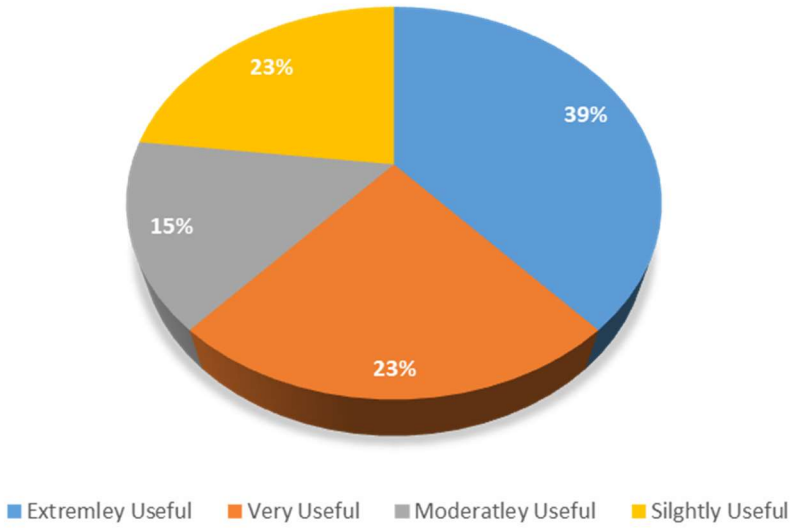

Figure 7: Evaluation of contribution of instructional videos to student knowledge

Figure 7 reports the responses to the question on the contribution of the online synchronous Q&A sessions with a Teaching Assistant (Demonstrator) to the student knowledge. From this most of the students found the instructional video to be at least a very useful contribution to

their knowledge and overall the contribution of this provision is evaluated as higher than that of the other two components.

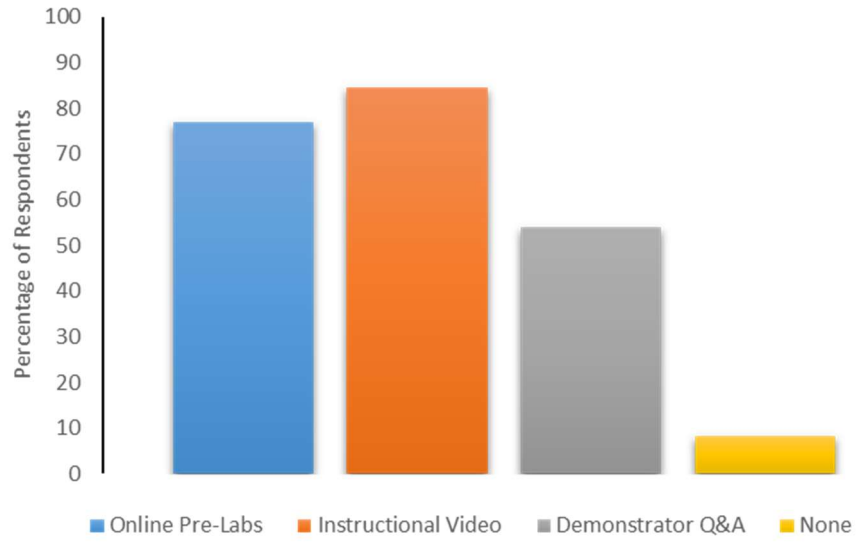

Figure 8: Retention of online resources once Face to Face Teaching Returns

Students were also asked to evaluate which of these components (if any) they would like to see retained, even once face-to-face undergraduate laboratory classes would return, and the results of this are reported in Figure 8. It was observed that the students are largely in favour of the retention of each of these components, albeit to varying degrees. The outcomes of this will be maintaining an updating the current online pre-lab activities while also retaining the online instructional videos to enable familiarization with apparatus and techniques prior to use.

The students also had an opportunity to respond to two open ended questions; one on concerning what was most useful and one on what improvements can be made. The responses to these can be found below. Largely these comments were favorable and there is certainly some useful comment; though some of the perennial issues of timetabling out of sync with the teaching content; this occurs in normal years due to limited equipment meaning that experiments are done on rotation and so some students may not have had lectures on the theory, though they are provided with sufficient background material to still complete the experiment. It is of note that some of the positive comments also contradict the negative ones but this is understandable since the process is always subjective and students' personal experience and interpretation of content will always vary. Unfortunately there seems some disconnect from intended outcomes in that some students expect more in terms of "practical" skills or more use of equipment; given many chemical engineering experiments are modifying settings and observing readings there is not often much more to it than that and so the major focus is data handling, interpretation/analysis and communication. It is possible this has originated with Level 1 students still so far unfamiliar with that distinction between Chemical Engineering Experiments and those in Chemistry (which are by nature much more hands on). It is still good that such concerns are raised as it indicates that those outcomes need to be spelled out more. It is also an indication that other, more hands on experiments/practical skills content be considered such as the ability to change oil and seals of a simple pump or the leak detection in a compressed air system. These were already

considerations prior to the pandemic but the nature of these comments reinforces the need to improve the student perception of practical skills.

Reponses to "What did you find most useful or enjoyable about the virtual practical classes?"

They can be done at home
The online q&a
I feel all the elements of the virtual practicals work well
The teams sessions with the demonstrator were very useful. The demonstrators went into more detail in these online sessions than they sometimes did in person. This helped my understanding of the experiments greatly.
none
I think the instructional videos were very informative in being able to picture what is happening, especially when we cannot carry out the lab in person. Although if this is continued I feel they will still be very helpful as they aid in understanding the lab manual before carrying out the lab.
The instructional videos were useful for referring back to when completing the post-lab report. I believe they would be useful on canvas whenever in person practical classes return.
I found them lacking compared to physical practical classes in both understanding the topic the practical wants to reinforce, and the ability to talk to tutors face to face and query them is a much superior option.
The discussion in the q & a sessions made the postlabs much easier as I knew exactly what I needed to do

Reponses to "What could be improved about the virtual practical classes?"

The preparateory videos could be more detailed
Providing a more detailed description of the analysis that should be included in the post lab. Given that a post lab could be submitted before learning information about that topic in class time not discussing everything to be analysed is handicapping students who submit work early.

It would be very helpful to see the experiment taking place. In the instructional videos the equipment is explained well but at no point can we see how the experiment actually looks. It can be difficult to visualise what is happening without seeing the experiment take place.
Actually demonstrate the experiment, not just read the instructions at us. Ensure all lecturers know that no mark is awarded for the Q&a section
nothing
Recording the Q&A session with the demonstrator would be useful but it is understandable that it is not done.
Have the lab done by the instructors
Better opportunities for the student to interact and have a chance to gain a semblance of practical knowledge. Having to work with a couple of pre-set values for calculations doesn't do much for practical knowledge, Maybe longer video of said demonstration if we're not physically allowed to do it?
Perhaps a longer video of the whole process of each practical, although I would hope that once covid restrictions are lifted we would gain practical experience through in person sessions rather than virtual.

References

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