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| Research Article

A comparison of students' preferences for face-to-face and online laboratory sessions: insights from students' perception of their learning experiences in an immunology course

Chin Wen Png,[1] **Lih Ing Goh,**[1] **Yuanxiang Kenneth Chen,**[1] **Huimin Yeo,**[1] **Haiyan Liu**[1]

AUTHOR AFFILIATION See affiliation list on p. 10.

ABSTRACT The COVID-19 global pandemic has prompted educators in universities to reconsider their teaching methods, mainly due to the social distancing measures imposed within the classroom settings. On the other hand, the growing importance of continuing education opportunities for adult learners after graduation has seen the need to transform traditional teaching modes that primarily depend on face-to-face interaction into virtual modes, which are deemed more time- and cost-efficient. These major shifts in social and economic developments have a significant impact on the evolution of curriculum planning in higher education. Education that has scientific inquiry components inevitably comes into question, as conventional beliefs that experiments should be hands-on and will not be as effective if conducted virtually cast doubts on the move to the online space. This paper discusses the background of an impending shift in a university's approach to more online-based laboratory classes in an immunology course, as well as the exploration of the potential of conducting online laboratory experiments based on student perceptions.

KEYWORDS online laboratory practical, immunology education

The literature discussing the potential of virtual or online laboratory practicals as an educational tool indicates that the effectiveness of hands-on experiments largely depends on the learning objectives. However, conventional beliefs among science, technology, engineering, and mathematics (STEM) educators tend to prioritize practical experiences as vital in ensuring that students develop expertise in their respective fields, particularly in basic and health sciences (1). Based on the report by Corter et al. (1), online practicals or digitally taught materials have the benefits of enhancing conceptual learning, compared to face-to-face (F2F) laboratory sessions. At the same time, user interactions may also increase in the virtual environments. However, pertaining to complex skills and specific hands-on precision, the face-to-face or classroom-based mode would be more advantageous. A study on undergraduate health science students found that sensory awareness and psychomotor skills may best be developed and assessed with supervision in a classroom setting so that immediate feedback could be provided (2).

In fact, the range of contents and skills to be taught or learned is extremely diverse. The target audience may come from different entry levels and have varying prior knowledge of the learning content. Despite the fact that laboratory skills have traditionally been viewed as practical and hands-on, it is possible that fully immersive learning experiences within a physical laboratory environment may not be as crucial or advantageous as one may perceive. For example, a group of researchers classified "conceptual understanding," "laboratory hazards," "procedural complexity," and "sufficiency of resources" as the major factors to gauge improvement in the experimental self-efficacy

Editor Jack Wang, The University of Queensland, Brisbane, Queensland, Australia

Address correspondence to Haiyan Liu, micliuh@nus.edu.sg.

Chin Wen Png and Lih Ing Goh contributed equally to this article. Author order was determined alphabetically.

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of students (3). This explains that distinct knowledge and skills are required in order to effectively carry out experiments, potentially challenging common student perceptions of what laboratory work actually means. Specifically, to be successful in laboratory work may not be so much of the "hands-on" aspects as thought to be and is likely to be a more balanced mix of theoretical and hands-on knowledge and skills. In the study conducted by Corter et al. (1), students perceived higher value in hands-on practicals even though the learning outcomes of conceptual understanding assessed in online practicals turned out to be on par or better than hands-on sessions. There are many factors at play here, and the simulation platforms used in the study could have a part in influencing the satisfaction levels of the students. Findings from the study by Dolan et al. (2) also corroborated the conceptual understanding aspect of the online delivery mode being as good as or better than the classroom setting.

It is, therefore, reasonable to continue exploring online vs F2F laboratory experiences to understand which skills or learning outcomes for specific subjects or disciplines could be planned for virtual or remote teaching. The purpose of this ongoing, iterative exploration is to endeavor to set clearer project scope and objectives for curriculum transformation and logistics planning, such that any instructional program embedded with the online component is developed and executed effectively.

Background of study

The Department of Microbiology and Immunology at the National University of Singapore (NUS), Yong Loo Lin School of Medicine, has impending plans to introduce more progressive and advanced online learning programs in the near future. Some of these new programs include online laboratory practical classes.

Life Sciences courses use hands-on practical classes as an integral part of the learning process because students learn laboratory techniques that are employed in laboratory work and research. As a result of safe management measures that are put in place due to the COVID-19 pandemic, F2F laboratory class sizes were capped at 50 students per class. Therefore, there were students who were unable to attend physical classes due to a larger total class size, and online laboratory classes had to be conducted as an alternative.

In view of the irreversible trend of the Institutes of Higher Education opting for online and blended teaching and learning modes due to educational reforms driven and accelerated by the COVID-19 pandemic and post-COVID impacts, specifically on science and medical disciplines (4–9), we aim to investigate how students perceive the effectiveness of online content and technical learning, when compared to F2F, in laboratory practicals.

Additionally, a change in the local higher education landscape has prompted new considerations. A new group of learners has emerged. They are graduates or adult learners taking courses for continuing education and training. This group of learners who have limited time and ability to attend physical sessions influence fundamental changes in content and lesson delivery (10). The educators at the Department of Microbiology and Immunology at NUS noted that online and remote learning are viable solutions to cater to the needs of these learners. Additionally, in other countries, undergraduate learners with disabilities in STEM courses have also been impacted amid the rapid shift to online teaching and learning modes, where their access needs in online lessons may require reassessment in areas of accommodations made available to them (11). As discussed in the study conducted by Gin et al. (11), since the onset of the COVID-19 pandemic, prior accommodations designed or provided for students with disabilities in physical learning contexts have been challenged because where online learning contexts are applicable, accommodations for these students are either non-existent or less than satisfactory. These overseas examples would provide insights into the evolution of the educators' knowledge of how improvement to learners' experiences may be made at the department. In view of the diverse needs of future enrollment of adult learners and learners with disabilities, new dimensions of curriculum planning and logistics requirements are potential areas for transformation, in addition to considerations for traditional enrollment cohorts.

Aims of study

The current study aims to examine student perception of their learning experiences during online and physical F2F laboratory practical classes, identify gaps and key benefits in both practical formats, and propose/discuss improvements that can be made for subsequent online-based practical that targets all learners, including those seeking continuing education. The findings of this study will aid in decision-making when considering whether online laboratory classes are a viable alternative to F2F classes.

In addition, although there is evidence from studies around the world that provide good insights into the relevance of the department's plans to integrate technology and online formats of science labs (12), the department aims to collect specific data to seek areas for continuous improvement to existing programs and modules.

Research questions

1. To what extent do students perceive online content and technical learning as more, less, or equally effective, when compared to F2F, in laboratory practicals?
2. For future planning, what can we learn and apply from the perception of the students for optimal content delivery and learning for both online and physical laboratory classes?

METHODS

Participants and procedure

Students reading (LSM3223) Immunology in Academic Year 2021/2022, Semesters 1 and 2, were required to attend four compulsory laboratory practicals per semester. Those who were interested and successful in their registration were allowed to sign up for the F2F laboratory classes, while the remaining would attend the online classes. Students were free to register for any number of F2F laboratory sessions, or none of them. If the number of students who registered for any F2F laboratory session exceeded the permitted maximum class size of 50, the maximum class size permitted, online slots would be assigned to students. Efforts were made to ensure that all students who expressed interest in attending F2F laboratory sessions would be assured of at least 50% of the total F2F sessions that they signed up for, with priority given to those who had not taken any F2F classes before.

The main difference between the F2F and online laboratory classes was that F2F students performed the experiments physically in the laboratory, whereas online laboratory classes were conducted via Zoom, and online students were shown video recordings of the experiments being performed. Both groups of students attended laboratory briefings given by the lecturers and were guided by teaching assistants (TAs) explaining the details of the experimental procedures and answering questions.

At the end of the course, a total of 117 students responded to the survey, of which 23 did online only and 7 did F2F practicals only, and these students' responses were excluded from this study. Responses from 87 students who attended both the F2F and online classes were used for analysis based on the assumption that since these students experienced both modes of learning, they were able to better compare and weigh what mattered to their learning needs.

Apparatus

The mode of teaching and learning was designed to accommodate the F2F and online laboratory classes. In each F2F class, one TA was assigned to 10–12 students. In online classes, each session was conducted by two TAs. The TAs involved in the F2F sessions were different from the ones conducting online sessions.

The lesson preparation for the F2F and online classes follows standard course protocols. Handouts including experimental protocols for both online and F2F classes are identical and were provided to the students at least 1 day prior to the class. All video recordings were reviewed and approved by the module coordinators. Videos for the experiments carried out in the practicals were played by the TAs during the online sessions, which were also recorded and made available to the entire class at the end of each practical session. At the end of the semester, students were asked to respond to a survey to obtain their feedback on the F2F and online laboratory classes.

The survey instrument is frequently used in studies to elicit insights in student perception regarding technology use in the classroom. In the study conducted by Radhamani et al. in 2021, survey-based analysis on experiential learning using virtual laboratories and feedback analysis has been employed (7). Another research group developed and validated a questionnaire to analyze the perception of using digital technology among nursing students, and a 5-point Likert Scale was employed for 18 evaluation question items (13).

As shown in Table 1, the survey instrument in the present study consisted of 5-point Likert Scale questions. These questions consisted of 11 sets of questions asking for students' opinions on both the F2F and online classes, i.e., a total of 22 question items. The 5-point scale was labeled against "strongly agree" (5 points), "agree" (4 points), "neutral" (3 points), "disagree" (2 points), and "strongly disagree" (1 point). In addition, one text entry question asking for comments or suggestions was included.

Lessons, materials, and stimuli

Both online and F2F classes were provided with pre-laboratory handouts that included detailed laboratory protocols and tutorial questions. For all sessions, laboratory briefing at the start of each session was carried out in a hybrid format for both groups of students that were physically present in the laboratory and those online. After the briefing, the class would continue the practical in their respective formats (i.e., either online or F2F). For F2F classes, a standard laboratory setup with the required equipment and instruments was provided in the session. Online classes operated remotely via Zoom concurrently with F2F classes in a separate room. The online teaching sessions were led by two TAs who showed pre-recorded videos of the experiments before facilitating small group discussions and tutorials after the completion of each pre-recorded video screening. The professor in charge of the practical was present physically onsite with the students at the F2F session and was available to join the discussions and answer questions from the online session at the same time.

Both groups shared similar learning objectives. It is noted that the learning objectives for the laboratory classes concerning the actual handling of experiments would not apply to students attending the online sessions. It is deemed more important for the students to understand the experimental approaches and link them to the concepts learned in the lectures. With regard to the calculations related to the experimental work, students' understanding of these calculations should not be impacted regardless of the delivery format.

In addition, the TAs in both F2F and online classes served as mediums of knowledge transfer and facilitation and supported the social–emotional needs of the students in their learning process through interactions and immediate feedback. It is important to note that the TAs in the online and F2F sessions were different. The students from different groups in the F2F session would also have different TAs assisting them with their learning. It is important to note that all the TAs attended the same practical briefings and were equally trained to handle the classes. This helps to maintain consistency in the content taught to all the students.

Data analysis

In the present study, survey responses to a 5-point Likert Scale were collected for 22 question items. The data were divided into two groups (online or F2F) and five categories

TABLE 1 Summary of survey responses[b,c,d]

S/N	Themes	Questions	Modes	% strongly agree (5 points)	% agree (4 points)	% neutral (3 points)	% disagree (2 points)	% strongly disagree (1 point)	Chi-square test *P*-values	Cramer's *V*
1	Aims of practical	F2F or online laboratory classes have helped me understand the aims of the practicals.	F2F[a]	52	45	2	1	0	0.085605	0.21550
			Online	33	55	8	3	0		
2	Mode of instruction 1	I am satisfied with the conduct and format of the F2F or online laboratory classes.	F2F	43	45	10	2	0	0.61901	0.12250
			Online	32	48	16	3	0		
3	Mode of instruction 2	The F2F or online laboratory classes allowed me to approach the lecturers and teaching assistants for consultation.	F2F[a]	59	38	2	0	0	<0.00001	0.51880
			Online	18	40	30	12	0		
4	Mode of instruction 3	The F2F or online laboratory classes allowed peer-assisted learning through interactions with fellow classmates.	F2F[a]	43	49	8	0	0	<0.00001	0.71860
			Online	11	8	35	34	12		
5	Mode of instruction 4	The F2F or online laboratory classes encourage students to be active in the learning process.	F2F[a]	52	38	8	1	0	<0.00001	0.56880
			Online	13	25	36	22	4		
6	Lab techniques & protocols 1	The F2F or online laboratory classes have helped me understand how to apply knowledge learned in lectures to laboratory situation.	F2F[a]	45	50	3	1	0	0.000036	0.38580
			Online	19	50	22	8	1		
7	Lab techniques & protocols 2	The F2F or online laboratory classes have helped me understand the experimental techniques/protocols used.	F2F[a]	55	44	1	0	0	0.000225	0.35250
			Online	29	48	17	6	0		
8	Lab techniques & protocols 3	The F2F or online laboratory classes have enabled me to perform the experimental techniques and to carry out the protocols confidently.	F2F[a]	44	52	3	0	0	<0.00001	0.66150
			Online	9	22	26	34	9		
9	Concepts	The F2F or online laboratory classes have helped me understand the concepts involved in the practicals.	F2F	41	49	8	1	0	0.903532	0.07710
			Online	35	53	9	2	0		
10	Tutorials	The F2F or online tutorials are helpful in my revision of the knowledge learned in lectures.	F2F	35	49	12	4	0	0.950652	0.10000
			Online	35	53	8	3	0		
11	Overall effectiveness	The F2F or online laboratory classes are effective.	F2F[a]	51	45	2	1	0	0.000039	0.60340
			Online	22	51	22	5	0		

[a]Modes with higher overall points.
[b]Note: $N = 87$.
[c]A Chi-square test is used to test whether a mode of teaching is preferred over the other. $^{**}P < 0.01$. $^{***}P < 0.001$.
[d]Cramer's *V* is used to measure the effect size (ES) for the Chi-square test. ES ≤ 0.25 = weak; 0.25 < ES ≤ 0.6 = moderate; ES > 0.6 = strong.

(responses from the Likert Scale ranging from “strongly agree” to “strongly disagree”), in the format of a 2 × 5 contingency table. The number of responses for each category (categorical data) was then entered for the two groups and analyzed using Chi-square calculation. These responses were analyzed using the Chi-square test of independence as it allows the measurement of differences of dichotomous independent variables (14). *P*-values of <0.05 are considered statistically significant. Cramer’s *V* was employed to measure the effect size for the Chi-square test, where degree of freedom =4 and Cramer’s *V* >0.25 are considered moderate to strong effects.

In addition, Bayesian analysis was carried out to support the evidence provided by Chi-square and Cramer’s *V* analysis. Bayesian probability was calculated using a prior probability of 0.2 [i.e., 1/5 (representative of 5-point Likert Scale) × 100%]. The Bayes factor between 10 and 30 is considered moderate evidence, and >30 is considered strong evidence (15).

In a study on 84 adolescents’ perception of health-related quality of life, the mixed methods design was employed (16). This provided the basis for the current study’s approach for analysis, as the 5-point Likert Scale questionnaire was also used for the investigation of perception and the sample size was similar (*N* = 87). Similarly, the current study analyzed text-based qualitative data using content analysis, as part of the mixed methods design.

Likert Scale survey responses

The Chi-square test *P*-values would reveal whether online or F2F was the preferred mode for each question taking into account all the different response categories (i.e., strongly agree, agree, neutral, disagree, and strongly disagree were designated 5, 4, 3, 2, and 1 point, respectively). Therefore, the higher the point, the greater the preference for the particular mode of practical.

Text analysis from survey responses

In understanding the dynamics and complexity of participants’ experiences and the nuances behind these experiences, the qualitative data provide lengthy descriptions of the experiences and valuable information on how effective a particular program is, alongside statistical analysis of quantitative data (17).

The qualitative data in the current study were open-ended responses submitted in the survey, e.g., feedback/information in text form. These underwent a coding process of content analysis (18). Depending on the construct to be measured and the emerging themes from the content, there could be a need to achieve inter-rater reliability. An excellent agreement of 0.8 between two raters was expected and required mediation for such an agreement to be achieved. In the current study, both raters have largely agreed on the themes in the first round, with minor naming convention edits, and did not require further negotiation for agreement.

During content analysis, the content, i.e., the text entries in the survey, was coded using the content analysis coding technique by determining the unit for analysis (19), after which MS Excel was used to explore and arrange the data for meaningful interpretation. Lines of text were chosen to be the units for analysis instead of the number of participants, to avoid certain sentiments to be viewed as more significant simply by individual participants who contributed more content than others. The counts or frequency of the coded theme mentioned were tabulated, and the percentages were analyzed and interpreted as trends.

After the text entries with “N/A” were omitted, there was a total of 34 entries of text responses by students. This means 34 out of 87 students (39.08%) entered their comments or suggestions. Of these text responses, a total of 76 lines of text were separated and coded.

RESULTS

In our study, F2F practicals were preferred over online practicals in overall effectiveness as shown in Table 1. There was also a clear preference, for F2F sessions, regarding performing experimental techniques and carrying out protocols confidently. In fact, as far as knowledge and skills directly related to conducting experiments are concerned, particularly for conceptual understanding and application of experimental techniques and skills, F2F sessions were preferred over online sessions.

F2F sessions were also preferred over online sessions in areas of active learning, interactions with the TAs and peers, and teaching and facilitation by TAs. There was, however, no significant difference in the satisfaction level regarding the mode of instruction (Table 1, S/N #2). Similarly, there was no perceived preference for F2F over online classes in the understanding of the aims of the practicals (Table 1, S/N #1).

While the students valued human interactions and active learning in F2F classes, there was no significant difference in the survey results pertaining to the students' conceptual understanding (Table 1, S/N #9) and their revision (Table 1, S/N #10). This suggests that neither mode of teaching had a clear advantage over the other in the perceived benefits of enhanced learning. Enhanced learning refers to having a better understanding of the concepts and benefiting from the F2F or online laboratory classes or the tutorials on the revision of the knowledge learned in lectures.

As illustrated in Fig. 1, the sentiment analysis showed that students appreciated the structure and organization of online classes, compared to the F2F classes, mainly due to the long duration of F2F classes (7.89%, $n = 6$ of total mentions). However, students also mentioned that they tended to lose focus or listen blindly during online lessons (6.58%, $n = 5$ of total mentions), compared to having the opportunity to clarify their doubts with TAs in F2F scenarios (5.26%, $n = 4$ of total mentions) and enhancing their understanding through hands-on practice (3.95%, $n = 3$ of total mentions).

DISCUSSION

This study aims to investigate and compare how students perceive their learning experiences in their participation in laboratory practicals conducted both online and F2F in person. Through this analysis, the aim is to identify the key benefits and shortcomings of both approaches, with the ultimate goal of proposing improvements to future online practicals that cater to all types of learners.

In all, the findings showed students' preference for F2F classes mainly due to the opportunities to learn new experimental skills or lab techniques through hands-on activities, and the human interactions and close proximity to immediate support from TAs. As illustrated in Fig. 1, the sentiment analysis on the text responses in the comment section of the survey, the online classes, however, were perceived to be more effective in teaching concepts and knowledge and sometimes through better facilitation (organization) and structure, compared to the F2F classes (5.26%, $n = 4$ of total mentions). This corroborates with the findings in the study conducted by van der Merwe and Levigne-Lang (8). Specifically, students in our study commented that the online laboratory lessons were more efficient and jam-packed with information and aided in learning the concepts behind what each lab was focused on, while F2F classes involved longer waiting time and felt "draggy." Despite the negative connotation, students held a tolerant attitude toward the waiting time during F2F classes, stating that it was inevitable and that it allowed interaction with peers.

When asked about the satisfaction of both modes of teaching, there was no statistical difference. The perception toward the two modes of teaching may be attributed to different factors that do not have bearings over each other. Kolil et al. studied the factors that influence students' self-efficacy in chemistry experiments, including conceptual understanding and procedural complexity, which are distinct in nature (3). They classified factors that influence experimental self-efficacy in the laboratory environment into two categories, namely, cognitive laboratory activities and physical laboratory activities.

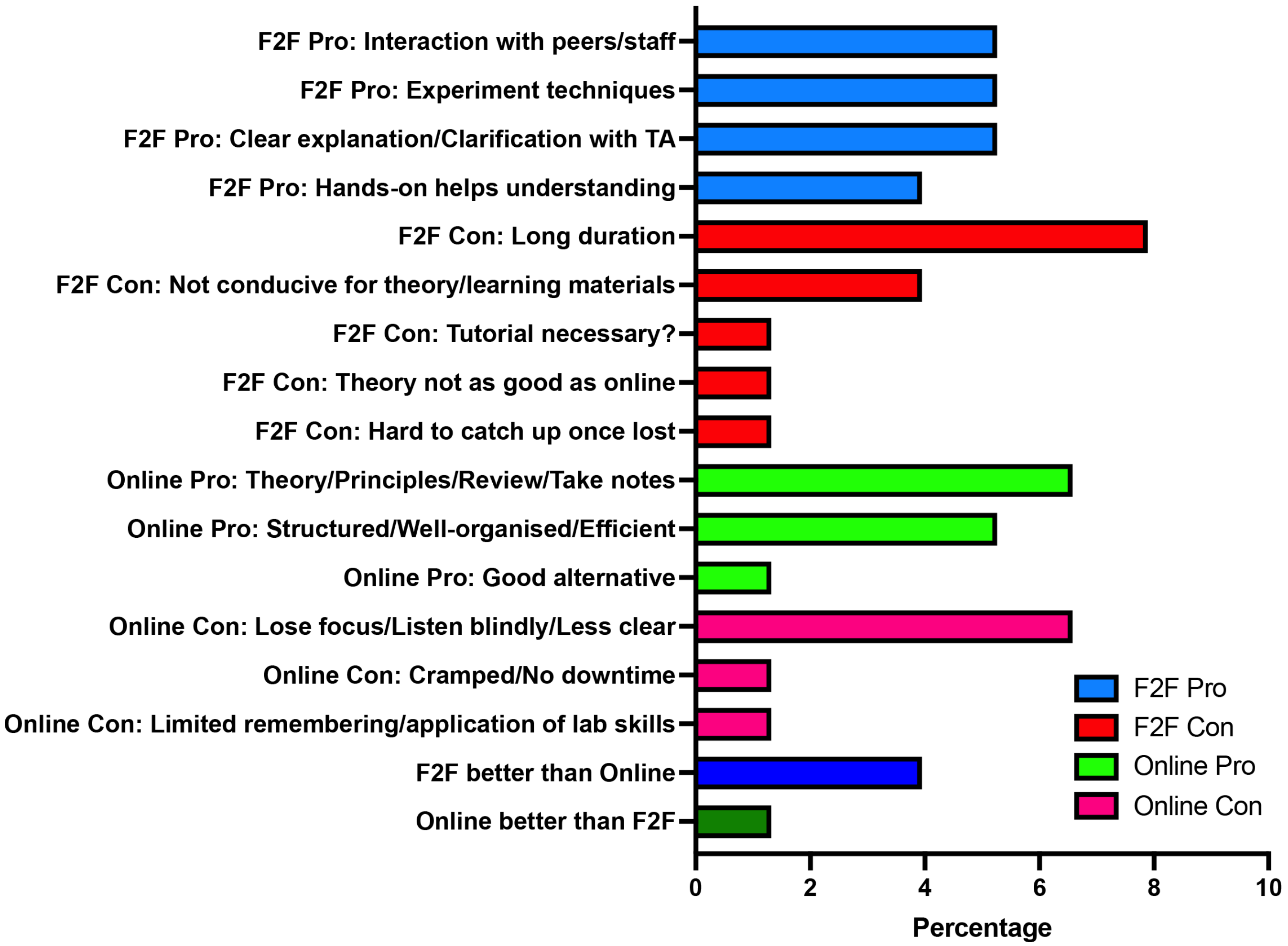

FIG 1 Sentiment analysis. The bar chart shows the percentage of each sentiment mentioned in the comment section of the survey. "Pro" and "Con" denote positive and negative sentiments, respectively.

There were two factors under each of these two categories, i.e., conceptual understanding and procedural complexity under cognitive laboratory activities and laboratory hazards and lack of sufficient resources under physical laboratory activities. These factors were found to be the top anxiety-causing factors in students through an open-ended online survey that was administered as part of their study. This suggests that experiments could mean different things at different times or instances to students, depending on the nature of the experiments and the contexts of conducting such experiments. Kolil et al. (3) also designed virtual experiments as their intervention for students. They analyzed pre- and post-results of students in the control group and experimental group and reported substantial improvements in conceptual understanding and procedural complexity, as well as reducing anxiety caused by laboratory hazards and lack of sufficient resources. As our study investigated student perception of F2F and online instructional programs involving experiments, the study conducted by Kolil et al. provided insightful perspectives for meaningful interpretation of our data.

The importance of practicals to students lies in the nature of hands-on experiences to fully grasp the concepts being taught. To them, practicals that include hands-on activities are essential in enabling them to truly understand and retain what they are learning. Whether this significance is grounded in evidence or facts depends on which knowledge and skills were being assessed in practicals. Hence, in this study, student perception of the advantages and disadvantages of F2F and online practicals was consistent with literature, where perception and reality do not necessarily align with the course expectations (1, 20). In a study on student motivation toward laboratory work in physiology teaching, the researchers also noted that specific beliefs shaped by the students' learning experiences in the laboratory do not necessarily reflect their actual learning in the course (21).

It is highly probable that the misalignment between student experiences and beliefs and course expectations underpins the preferences indicated in the survey responses in the current study. The students may not be aware that the experimental techniques were not the primary learning objectives for their course. Instead, it was the understanding of the concepts and knowledge, such as "seeing is believing" that the course objectives were about. The laboratory techniques that F2F students picked up during the hands-on practicals, which were perceived by students to be core learning points, would be highly beneficial only if they progress to future research laboratory projects. At their current level, these would be considered "good-to-have" traits. A possible improvement would be having the TAs remind students of the learning objectives during or at the final briefing, in addition to the usual summarizing of the results, linking back to the laboratory work.

In this study, online classes did not appeal to the students sometimes due to logistical and curriculum constraints. It appears that the advantage of teaching and providing materials in a virtual environment could become a disadvantage if there was a lack of "personal touch." In fact, the study conducted by van der Merwe and Levigne-Lang noted that higher education students could benefit from active communication and ongoing support from their instructors during the remote learning mode (8). Hence, deliberate efforts to equip TAs with the skills and mindset to conduct online classes in a manner that emulates F2F classes, especially in the presence of an able facilitator of learning, may be beneficial. If the quality of teaching facilitation is controlled in future iterations, certain elements of the current survey may produce different insights.

On reflection, we found out that the waiting time during F2F sessions could be the actual waiting time for the results of experiments to show or any developments to take place. That would be the time when students had nothing to do. Since the study has concluded, we have implemented some changes to improve the experiences of F2F classes based on students' perceptions, such as having mini tutorial sessions with the TAs engaging students who have completed their tasks or engaging students during the waiting time of each experiment. We have yet to collect students' feedback on this improvisation. Future improvements to the long waiting time during F2F sessions may include having TAs engage students with mini quizzes to further test their understanding in laboratory work.

Limitations

The current curriculum planning and training of TAs in the way online classes are conducted contributed to certain learning experiences that did not necessarily align with the intended learning outcomes. Future iterations of similar programs could be improved by having more consistency and homogeneity in lesson facilitation and the availability of consultations to match the way F2F practical sessions are conducted.

To enhance the comprehensiveness of the analysis of students' perspectives, future investigations could be carried out by incorporating the Transactional Distance Theory (TDT) established by Moore (22), as a fundamental framework for designing and examining the online learning experience of students. In a recent review by Abuhassna and Alnawajha (23), the TDT has been identified as a widely used theory for the design and development of distance learning environments. It encompasses the components of course structure, learner autonomy, and dialog, where the transactional distance between the instructor and learner in distance learning contexts is constantly changing depending on whether a course is highly structured with less dialog or if the learner becomes more autonomous due to the isolation caused by the distance between the instructor and learner. The authors then posited that the TDT is a foundational concept best integrated with other theories that involve a learner's satisfaction, anxiety, motivation, acceptance, and preparedness for the use of technology and academic achievement. By utilizing this theory, we can gain a deeper understanding of the factors that mediate the transactional distance between students and their instructors in virtual classrooms/practicals and, thus, identify areas for improvement and enhance the overall quality of online education. It is proposed that designing a more interactive online learning experience to build inter-personal interactions and improve students' involvement in the practicals within a virtual environment would be beneficial. For example, breakout rooms could be set up for student discussion and subsequent presentation of their findings, integrating more interactive quizzes during the online session instead of relying on one-way delivery of the course content by the TAs.

The variety of contexts and scenarios based on the nature of the individual practical assignments influence students' perceptions. Due to the diverse nature of the four practicals in the course, students could have varied experiences when attending the F2F and online classes. For example, the fourth experiment in the course may not require physical presence since there were fewer hands-on activities and more demonstrations. Individual students could interpret their experiences in this experiment differently, depending on their backgrounds and expectations.

On the other hand, the students had the freedom of opting to attend any session in either the F2F or online mode. Hence, the results from the current study should be considered and interpreted with caution, bearing in mind the influence of individual differences of the students, as well as the teaching assistants.

AUTHOR AFFILIATION

[1]Department of Microbiology and Immunology, Yong Loo Lin School of Medicine, National University of Singapore, Singapore

AUTHOR ORCIDs

Chin Wen Png http://orcid.org/0000-0003-2509-0316
Lih Ing Goh http://orcid.org/0000-0002-5845-3067
Haiyan Liu http://orcid.org/0000-0002-4652-469X

AUTHOR CONTRIBUTIONS

Chin Wen Png, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing – original draft, Writing – review and editing | Lih Ing Goh, Data curation, Formal analysis, Investigation, Methodology, Validation, Visualization, Writing – original draft, Writing – review and editing | Yuanxiang Kenneth Chen, Data curation, Methodology, Project administration, Writing – review and editing | Huimin Yeo, Project administration, Writing – review and editing | Haiyan Liu, Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Supervision, Writing – review and editing

ETHICS APPROVAL

This study was approved by the NUSMed Medical Sciences Department Ethics Review Committee (MSDERC), MSDERC Ref Code: MSDERC - 2021 - 003. Informed consent was communicated to all students. Participation in the survey was voluntary and anonymous.

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