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A Project entitled

"Transformation into online learning in Hong Kong local schools: Students' and teachers' attitudes and opinions towards hands-on experiences in science subjects during the COVID-19 pandemic"

Submitted by

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Declaration

I, *CHEONG Pui Sang* declare that this research report represents my own work under the supervision of *Dr. CHONG Yee Ling*, and that it has not been submitted previously for examination to any tertiary institution.

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Abstract

The importance of hands-on experiences among science subjects has been emphasized throughout recent decades. Under the influence of COVID-19 pandemic, the transformation of class mode from face-to-face to online mode learning shredded the opportunity of students to participate hands-on activities with practical hands-on skills. However, no research has been done locally to examine local students' and teachers' perceptions of all-round learning aspects upon online mode of learning and teaching in science subjects. This research study provides insights into perceptions of both target group of participants towards teaching and learning of laboratory skills and knowledge via online mode of learning. Hence, it is crucial to identify the potential issues and significance of hands-on experience in terms of students' learning needs, practicality issues of teaching and consequences of lacking laboratory skills in science subjects. Mixed mode of research has been implemented, in which 138 local in-service teachers (n=45) and senior secondary school students (n=93) were given two separate sets of questionnaires for completion, with individual interviews of students (n=7) and teachers (n=7) have been hosted to find out critical in-depth perceptions between face-to-face lessons (before the pandemic) and online lessons (during the pandemic) respectively. The findings collected were analyzed separately then aligned to draw suggestions and conclusion. The questionnaire results revealed in terms of the key learning aspects: acquirement of knowledge, experimental skills, soft skills, gain of motivation, and academic performance, the results from both group of participants implied there were statistically significant shifts in their perceptions, from high uniformity of agreement (face-to-face mode) to disagreement (online mode) respectively. Hence, the findings of perceptions in interviews could be well-aligned with questionnaires' results, in terms of four categories of content focused. The interviewees mentioned a variety of suggestions for online mode lesson-learning, where they could be supported by current research papers with beneficiary contributions to the mentioned learning aspects in science learning. The findings put forth are of paramount importance for educators in Hong Kong to provide all-around suggestions of how educators use varieties of approaches to boost students' learning by finessing their pedagogies, skills, teaching styles, or teaching aids. Ultimately, suggestions could provide insights for innovative learning and teaching methods.

Key words: *Laboratory sessions, practical lessons, science curriculum, scientific investigation, virtual learning*

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Part 1 (Introduction & Research Backgrounds)

1.1: Introduction and Research Backgrounds

Flashing back to early 2020, a global pandemic (COVID-19) posed transformation from original face-to-face learning session to online-mode lessons with the aid of various online platforms (such as Zoom, Google Meets). However, online learning shreds the opportunity of students to participate into these hands-on activities (Sadi & Cakiroglu, 2011; Stohr-Hunt, 1996) during face-to-face class suspension, let alone some research (Chan, Lo & Hew, 2018; Akomolafe & Adesua, 2016) have already found out students do not have enough time to undergo laboratory hands-on activities initially.

Hands-on experiences (especially laboratory sessions) have been widely recognized as a fundamental learning pillar upon the field of science education, it is believed that active participation and motivation of learners in science learning and related activities could contribute greatly to learners' learning effectiveness and overall achievement (Sadi & Cakiroglu, 2011; Stohr-Hunt, 1996). In the research published by Stohr-Hunt (1996), it analyzed the relationship between the amount of time that eight-grade (equivalent to secondary 2 students in Hong Kong) students spent in science hands-on activities and their science achievements, concluded that students who participated in hands-on experiences every day or once a week could gain better academic performances upon standardized tests, compared to those students who joined over once a month or never joined.

Another paper published by Glasson (1989) also supported that these hands-on activities could effectively boost students' declarative (conceptual and factual) knowledge and procedural knowledge achievement in science. The papers (Sadi & Cakiroglu, 2011; Stohr-Hunt, 1996; Brinson, 2015) had emphasized the criticalness of adding elements of hands-on experiences into science education could irrefutably affect students' achievement and even attitude (Sadi & Cakiroglu, 2011) in learning science positively. Flick (1993) also suggested that hands-on science activities could devote to three major dimensions of learning in science: Knowledge, skills and attitude, as well as various mental, physical, emotional functioning and soft skills.

A variety of virtual learning kit, such as Augmented Reality (AR) (Wang, 2020), Virtual Reality (VR) (Bogusevschi, Muntean, & Muntean, 2020) or e-learning hub (Oteri, 2020; Wisudariani, Darmayanti, & Satria, 2021; Alhumaid *et al.*, 2020) have been included in the curriculum; however, there is still a few reservations on the effectiveness of how these learning materials bring benefits on students' learning. Still, in majority of research papers, the virtual platforms or teaching aids created were proved to be useful for students to achieve experimental skills and aid their academic performances (such as Southgate, 2020; Monita & Ikhsan, 2020; Nersesian & Spryszynski, 2019), attached with merely small errors and improvement rooms.

It is concerned that if hands-on experience components have been rooted out in learning science, it could trigger potential dilemmas on students with losing most beneficial features in learning scientific concepts. Hence, teachers could lose versatility in teaching approaches and limited opportunities for undergoing student-centred classrooms, which affect learning effectiveness and efficiencies.

1.2: Problem Statements and Hypothesis

During the pandemic, students' learning effectiveness should have plunged. Also, laboratory skills could be barely gained by students during the online mode of learning in COVID-19 pandemic. Hence, the lack of experimental sessions could plunge the attainment of learning outcomes among students. However, no research has been done locally to examine and validate (the uniformity of perceptions) local students' and teachers' perceptions of all-round learning aspects upon online mode of learning and teaching in science subjects. Thus, suggestions are necessary to improve the learning effectiveness during the pandemic upon the learning aspects of acquiring knowledge, experimental skills, soft skills (or generic skills) and motivation upon online mode of learning.

1.3: Research Questions

1. What are the students' and teachers' attitudes and opinions (perceptions) towards the insufficient number of hands-on experiences during the pandemic?
2. What alternative teaching strategies or pedagogies were implemented during this pandemic?

The research questions proposed could lead to more insights upon the research objectives.

1.4: Research Objectives

1. To investigate into teachers' opinions towards teaching of laboratory skills and theoretical knowledge via online mode of teaching.
2. To investigate into students' opinions towards learning of laboratory skills and theoretical knowledge via online mode of learning.
3. To identify the potential issues and significance of hands-on experiences in terms of students' learning needs, practicality issues of teaching and consequences of lacking laboratory skills in science subjects.

Part 2 (Literature Review)

Hands-on experience profoundly affects students' learning effectiveness, as laboratory sessions can provide opportunities for students to learn by inquiry (National Research Council [NRC], 2000). Rather than memorizing conceptual knowledge, laboratory sessions could provide a learning approach to undergo inquiry-based learning (Brinson, 2015; Schwichow *et al.*, 2016), where it provides diverse approaches for students to study scientific concepts via observations, proposing ideas, questioning, explaining and justifying based on theoretical knowledge as evidence from previous findings (Hofstein & Lunetta, 2004; Glasson, 1989). Thus, they are the vital pillars of learning science-related subjects for students to achieve multiples of learning aspects and learning outcomes. Moreover, this indicates hands-on experiences of laboratory session is the fundamental in science education, students can consolidate and intact their own scientific knowledge and reasonings (Schwichow *et al.*, 2016) into better understanding of the topic by self-

experiencing the experimental procedures and handle with apparatus in hands-on laboratory experiences (Vesilind & Jones, 1996). More importantly, this emphasizes the ultimate goal and central focus of integrating the procedural knowledge and laboratory skills with theoretical knowledge (Bybee, 2000; Sunal *et al.,* 2008), rather than separating and learning them upon an individual basis, as stated by Hodson (1993). Thus, learning science does not solely depend on contextual or theoretical knowledge, it also includes with great criticalness upon practicality, for putting theories into applications and comprehensively finessing the whole curriculum framework. Hence, for instance, as stated in the curriculum guide in Biology for senior secondary school students, published by The Hong Kong Curriculum Development Council [CDC] and Hong Kong Examinations and Assessment Authority [HKEAA] (2015), students are required to grasp the respective laboratory skills of corresponding concepts (e.g. dissection of heart) and apply it into scientific concepts or facts (e.g., heart structures). Also, it could be a kind of authentic assessment (or school-based assessments) to examine students' understanding rather than using paper-and-pencil assessments (Struyven, Dochy, & Janssens, 2008).

Despite there could be supplementary verbal explanation or teaching materials to support the lack of hands-on experience nowadays, students can merely understand the proper procedures and skills in practice (Vesilind & Jones, 1996). Hands-on experiences and related practical hands-on skills require students' active participation in class with high practicability, skills acquirement and obeying teachers' instructions. Furthermore, the research (Almroth, 2015; Widodo, Maria & Fitriani, 2017; Makhleh, Polles & Malina, 2002) emphasized the criticalness of including laboratory sessions in science education. Hence, it strives for classrooms with constructivism or highlights the enriching learning progresses through laboratory hands-on experiences, in which they are essential for students to learn science effectively (Flick, 1993). Online mode learning could barely fulfil the hands-on activities upon mastering the concepts with inquiry-based learning (effective instruction approach) (Sesen & Tarhan, 2013; Yacoubian & BouJaoude, 2010) during hands-on tasks in classes. This consolidates

the importance of adding hands-on experiences in science education, for providing the best learning opportunities for students to learn science concepts and practice practical skills.

In addition, teachers could lose versatility (Sesen & Tarhan, 2013) in teaching approaches for undergoing student-centred classrooms, with applications of hands-on skills into daily-life situations which involves scientific concepts and reasonings. Hence, hands-on experiences are one of the learning approach for acquirement of experimental skills, applying prior or advanced experimental skills into practice (e.g. STEM activities) (Christensen, Knezek, & Tyler-Wood, 2015) or daily-life problems (Lumpe & Oliver, 1991). Instructing experiment components upon online learning mode cannot provide interactive teacher-instructing methods for students to actively respond teachers' questions during learning, or collaborative hands-on work among peers (Hofstein & Lunetta, 1982). This loses the positive features of a constructivism and student-centred classroom (Bleicher & Lindgren, 2005) with shredding dimensions of learning in a hands-on activity and minimizing the opportunity for students to undergo small-group collaborative learning environment to undergo a positive learning environment to investigate science concept through peers' learning (Hofstein & Lunetta, 1982; Mastropieri *et al.*, 2006). Thus, this plunges students' learning motivation (Paris, Yambor, & Packard, 1998), attitude (Johnson, Wardlow, & Franklin, 1997; Sadi & Çakıroğlu, 2011), interaction in class (Tobin, 1990), and acquirement of soft skills or generic skills (Flick, 1993; Haury & Rillero, 1994). Dutta (2020) and Bacon & Peacock (2021) also emphasized that during online learning, the plunging opportunity of hands-on activities would attribute to the lack of hosting collaborative activities (such as discussion or laboratory activities), as well as adverse effects on students' psychological factors of building social interactions between peers and peers' appraised learning.

As supported by the findings (Sadi & Çakıroğlu, 2011; Glasson, 1989; Tobin, 1990), involvement of hands-on experiences in science lessons could improve students' achievement results. Below is a

figure of table (Figure 1) adapted from Sadi & Çakıroğlu (2011), which proved experiments (i.e., one kind of hands-on experience) could devote to better academic results of students.

	Experimental Group		Control Group	
Scores on Science Achievement Test	Pretest	Posttest	Pretest	Posttest
N	72	72	68	68
Mean	6.64	15.25	7.32	11.57
Standard Deviation	2.53	3.39	2.57	3.87
Skewness	0.147	-0.506	-0.101	0.647
Kurtosis	-0.441	-0.583	-0.374	0.114
Range	11	14	11	17
Minimum	1	7	2	5
Maximum	12	21	13	22
Scores on Science Attitude Test	Pretest	Posttest	Pretest	Posttest
N	72	72	68	68
Mean	56.57	58.69	57.94	58.80
Standard Deviation	8.92	8.64	7.95	8.24
Skewness	0.283	-0.208	-0.306	-0.379
Kurtosis	1.78	-0.71	0.59	-0.453
Range	56	36	36	38
Minimum	33	36	39	37
Maximum	89	75	82	85

Figure 1: Table 2 of the journal paper (p.92), adapted from Sadi & Çakıroğlu (2011)

Descriptive statistics for the science achievement scores and science attitude scores.

The table had denoted the descriptive statistics for the science achievement scores and science attitude scores with a sample of study consisting of 140 elementary school students in Ankara, Turkey. The experimental group (with hands-on activities, e.g., group activities, laboratories) (72 people, with 31 boys and 41 girls) had a greater increase in difference in science achievement test and science attitude test between the pre-test and post-test, compared to the controlled group (traditional instructions without hands-on activities).

Lastly, some researchers begun to strive for better quality of teaching with the aid of virtual laboratory sessions. They include the use of multiples of technologies, software, or teaching skills added to a

virtual classroom or laboratory sessions, which are all innovatively new sets of teaching pedagogies to be put into practice. Hence, most of the findings published online stated a positive trend of result (e.g., Klein *et al.*, 2021; Caruso, 2021; Flynn *et al.*, 2021) with students' or participants' supportive and positive feedback towards the new mode of learning resources and settings. One research provided an argument (Yap *et al.*, 2021) of which it revealed that the participants had a declined trend of scores on interest and attainment on intended learning objectives among the undergraduate students in Taylor's University, Malaysia. However, the study compared the results among three groups of people: pre-COVID group (August 2019), COVID-MCO (Movement Control Order) group (March 2020) and recovery COVID group (August 2020). The team provided three-dimensional (3D) laboratory simulations for a course that has been offered by The Arizona State University. The team used 3D laboratory simulation software, which was invented in link with Danish company "Labster" and Google Daydream on the topics cell culture basics and animal biotechnology, which are simultaneously the two renowned topics included in local senior secondary Biology classrooms. Hence, the results found out that the students had lower ability to handle the simulated laboratory merely without supportive teaching or face-to-face learning opportunities. However, for the laboratory itself, the statistics revealed that students found the laboratory helpful during the pandemic period when face-to-face activities were strictly prohibited and controlled during the moment. Thus, there are still some concerns on substitution of face-to-face laboratory sessions with online mode learning or virtual mode of simulated laboratory sessions with the aid of provided software. Yet, during suspension of face-to-face classes, these virtual laboratories or online teaching aids could be irrefutably helpful for students to learn science.

Part 3 (Methodology)

3.1: Overview of Research Method in this Research Study

The below flowchart (figure 2) showed the approaches and content of each important step in the methodology for this research study. The following paragraphs are the brief introduction of methodologies in each approach.

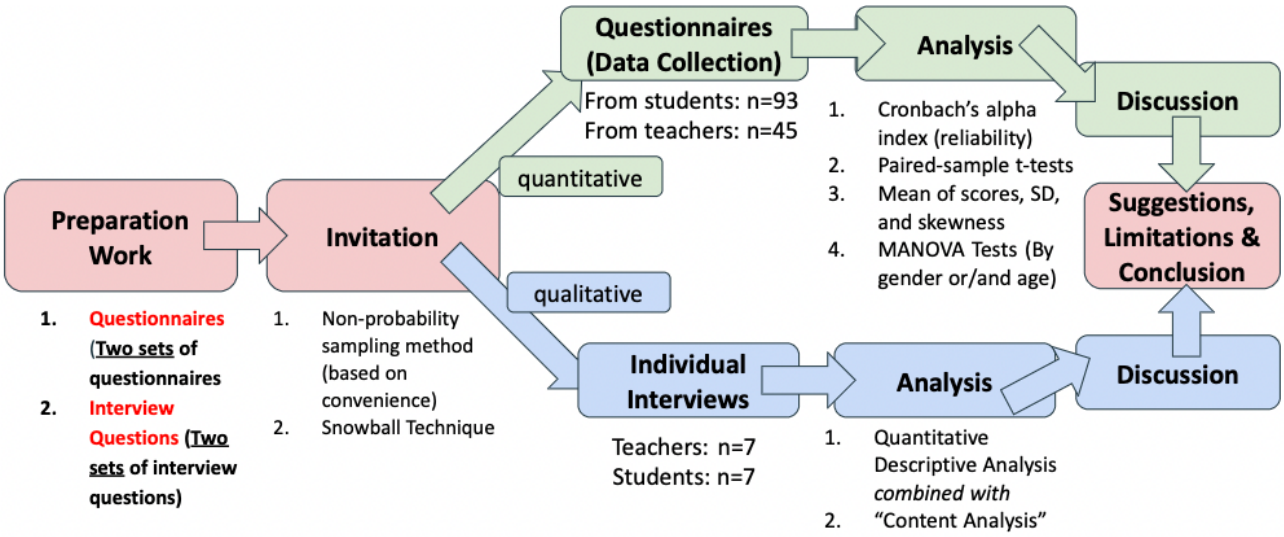

Figure 2: The flowchart of methodology of research *(adapted from page 10 of the presentation PowerPoint for the research seminar hosted on 17th March 2022)*

First, two sets of questionnaires and interview questions (i.e., four sets of documents in total, as *appendix 3-6*) for teachers and students were separately designed and invited with non-probability sampling method and snowball technique. In addition, some volunteering participants after filling the questionnaire ($n_{students} = 2$; $n_{teachers} = 1$) had shown interest to be participated into the individual interview for providing more implications and suggestion in the interview. Then, the research splits into two approaches, with data analyses were separately performed. For data analysis and treatment for questionnaires, Cronbach's alpha index tested for both sets of responses' reliability, paired sample t-tests for comparative means and test for statistical difference in between the perceptions of same group of people upon the comparison of before (face-to-face learning mode adopted) and during COVID-19 pandemic (online mode learning adopted). An extra test for MANOVA (multivariate) test to investigate into the significance in between the gender and face-to-face and online learning respectively.

For interview, as some of the participants used Cantonese as the language medium for the interview session, the content in the recording was then translated from Cantonese to English. Moreover, after the transcripts were ready in English, content analysis was used to trace the key words or points on perceptions of students and teachers, as well as highlighting the common perceptions and suggestions. Some traces of quantitative descriptive analysis (count of responses' frequencies) have been combined with content analysis approach. Progressively, discussion, suggestions, limitations, and conclusion of this research study were thereafter made after the analysis.

For the requirements of target group of participants in this research study (i.e., students and teachers), there were some requirements had to be fulfilled before they could be participated into this research study. For both approach of the study, the requirements of participating into this research were upon the same standard. This was to ensure the participants were of the same origin of science learning or teaching background requirements while participating into both part of study.

For students, all individuals who fulfilled every requirement below are eligible to fill in the questionnaire or participate into the interview:

- Who are over 16 years old, with consent had been granted by the participant,
- Studying in local secondary schools,
- Studying any curriculum at local schools (e.g., Hong Kong Diploma of Secondary Education [HKDSE], International Baccalaureate [IB], SAT etc.),
- And, currently studying one or more science subjects (Physics, Chemistry, Biology or Combined Science; STEM education) with laboratory hands-on experiences.

While, for teachers, all individuals who fulfilled every requirement below are eligible to fill in the questionnaire or participate into the interview:

- Current In-service secondary school teachers in Hong Kong,
- No minimum count of (years of) teaching experiences,
- Who are working in subsidized, governmental, or private local secondary schools (either CMI or EMI schools),
- Who are teaching one or more science subjects (Physics, Chemistry, Biology or Combined Science; Junior form Integrated Science (IS); STEM education)

In both part of research, primary students and in-service primary school teachers were initially added as the target group of participants for this research study. However, considering a more critical research findings focusing on the common science subjects available in the secondary schools, to prevent ambiguousness of the findings in this research, the above groups have been eliminated from the target group categories.

Furthermore, for the questions asked both in the questionnaire and interview, were mostly targeted on the following common learning aspects: acquirement of knowledge, acquirement of experimental skills, gain of soft skills, motivation, and academic results of students. Whilst, in the questionnaire, a broader view of learning aspects and issues regarding online learning was asked, including more perception questions, frequency issues, or adaptation issues. Supported by the findings obtained in the interview, the questions asked were mainly focused on the common learning aspects, as more in-depth of answers were expected to obtain, where supplementary and add-on questions were asked for providing more dimensions of discussion for later part of this research study.

3.2: Quantitative Approach

3.2.1 Overview of design

Two sets of 10-min questionnaires *(appendix 3 for students' set; appendix 4 for teachers' set)* with 54 questions (for students' set) and 57 questions (for teachers' set) had been separately designed to obtain participants' perceptions. The questionnaires consisted of several types of questions, including 5-point Likert scale questions (the majority), Yes-or-No questions, or "(multiple) choices of checkboxes" questions in the questionnaire. The 5-point Likert scale questions were designed for participants to scope scores with 5-point Likert scale (ordinal data in qualitative research approach) to quantify the qualitative data of participants into scores of ratings based on their own different aspects, statements, attitude, or issues related to academic needs; the mentioned learning aspects, or opinions towards the significance and insufficient amount of laboratory hands-on experiences during the worldwide pandemic in recent years. Hence, in addition, with comparing sessions to rate the perceptions in between the adoption of face-to-face learning (before the pandemic) and online mode

of learning (during the pandemic) for the highlighted part of the research (for paired-sample t-tests analysis). Hence, the 5-point scale was planned as 1 to 5, 1-point representing strongly disagree, with 5-point indicating the stance of strongly agree towards a question of issues or statement, with an "neutral" option of "3" included in the Likert scale. There were no open-ended questions included in the questionnaire. The three extra questions asked in the teachers' set of questionnaire were all about teaching pedagogies affection upon teaching students science subjects in face-to-face mode of learning (before the pandemic) and online learning mode of classes (during the pandemic).

3.2.2: Design of questionnaire questions

The first part of both questionnaires included the retrieval of non-sensitive personal information for data analysis, including gender, age (in range), education level of both students and teachers (and qualification of teachers), the curriculum and types of schools currently learning or teaching, science subjects currently studying or learning and periods of science classes per week. MANOVA test was conducted upon investigating the significance between gender and perceptions of answers related to the face-to-face learning (before the pandemic) and online learning (during the pandemic).

Then, part II of both questionnaires progressed into the highlighted comparison of perceptions of the mentioned learning aspects in learning and teaching between face-to-face class (before the pandemic) and online mode classes (during the pandemic). The content of questions were designed the same except the planned scenarios as mentioned. The synonym of term "after the COVID-19 pandemic started" (i.e. during the COVID-19 pandemic) had added to the questionnaire to state clearly the scenario of questions.

The third part of both questionnaire asked in-depth perceptions towards online mode of teaching and learning and participating or hosting hands-on experiences in science subjects during COVID-19 pandemic. More in-depth questions with extensive horizons upon the participants' perceptions had been asked, including learning issues, adaptation issues, accessibility of online materials, learning

and teaching progress, Special Education Needs students support and academic achievement. Furthermore, in the second sub-part of this session, comparative questions (in between face-to-face mode of learning and online learning) had been asked toward the four highlighted learning aspects in this research study, including acquirement of knowledge, acquirement of experimental skills, gain of soft skills, and motivation. As premise mentioned, they were the highlights as these learning aspects are of paramount importance and pillars for students to study science in hands-on experiences, in which it could affect their science achievements.

Finally, the fourth part with the same three questions in both sets of questionnaires focused on the statements about the suggestions upon students' learning science online, in terms of students support of e-resources and virtual learning platforms, and the responsible persons of putting forth of creating the learning and teaching materials for students and teachers respectively. Thus, this is for later alignment of findings in both approaches of this research study.

3.2.3: Conduct of data analysis

The two sets of questionnaires were separately conducted with a series of analysis. The analytical method used were aided with the software, “IBM SPSS Statistics” (Version 27, licensed by IBM Corp.).

The first part of the analysis commenced with the reliability test (Cronbach’s alpha Index) on the consistency of responses in both questionnaires. This was to ensure that the data received were valid and reliable upon a long list of questions in the questionnaire (Overall reliability test). There were two questions in part III which were intentionally asked in a reversed view of perceptions of stances upon the statements had been reversely coded with 1→ 5, and 2→ 4, 3→ 3, and so on. Furthermore, upon the highlight of this study, the questions in both sets of questionnaires were categorized into the aspects, i.e., combined comparative aspects (face-to-face learning and before the pandemic VS online learning and during the pandemic; the two scenarios pre-set) to obtain a clearer view of reliability of

responses. The responses which were not using 5-point Likert scale for obtaining perceptions, would be specified with number during SPSS statistical analysis, i.e., Yes (as 1) or no (as 2), or male (as 1) or no (as 2).

The second part of the analysis focused on the comparison of perceptions of 5-point Likert scores in the same group of people (same individual) with face-to-face learning (before the pandemic) (including face-to-face hands-on experiences components) and online learning (during the pandemic) (including online hands-on experiences components). This was to test the statistical significance of difference in between two sets of data obtained from the designate planned questions. More importantly, it is an important parameter to recognize whether the change of perceptions of participants were significant between the two modes of learning under two situations, under the four highlighted (especially the acquirement of experimental skills) learning aspects planned. Together with paired-sample t-tests, comparative means, descriptive analysis (such as standard deviation [SD] and skewness) of some questions would be analysed and mentioned in the results part of this research study.

The third part of analysis was an extra test to test on gender could be a factor to alter the answers of perceptions in this research study. Hence, in which it tested on the significance of gender towards the two scenarios defaulted for this research study, and MANOVA tests were hosted separately to investigate the results of the two scenarios.

3.3: Qualitative Approach

3.3.1: Overview of design

Two sets of slightly different interview questions *(appendix 5 for students' set; appendix 6 for teachers' set)* were planned for two distinct groups of participants. Each of the participant was invited to participate into a 30-minute interview online or on phone individually. The interview questions consisted of ten questions and one additional question (on hybrid mode of learning), with some of the

questions included a series of sub-questions (i.e, questions “a” to “e”). Hence, referring to the participants’ responses, add-on questions had been asked for further elaboration of previous answers, extended topic and ideas of the previous discussing topics, or judgement questions on stances. There were no limits of the maximum number of questions asked interview, as the number of add-on questions to each participants were different. The findings in interviews could not only align with the findings which had been already well-recognized upon both sets of questionnaires but also it gave new implications, insights and innovative suggestions for the discussion part of the research study, providing complementary support of the opposite sets of data, findings and comments with validity, as well as proving the validity of the predictions made.

3.3.2: Design of interview questions

A wide range of comprehensive open-ended questions were asked towards the attitude, comments and suggestions on the significance and insufficient amount of laboratory hands-on experiences, the learning or teaching experiences upon online mode of learning or teaching during COVID-19 pandemic. Most of the questions were categorized into “why”, “how”, “explain”, “do you agree/think”, “what” and “compare”-typed questions, as this could give more accurate explanation on their perceptions and discussion made. The questions were designed to be pin-to-point, precise and concise with more details and dimensions, with the aid of ask-response approach for getting the most accurate in-depth information from the participants on their perceptions and ideas.

3.3.3: Conduct of data analysis

The data (opinions and perceptions) will be collected, analysed and interpreted in several of ways, for example, calculating the frequency of common response in between persons (quantitative descriptive analysis), highlighting important articulation within the interview, critically interpret the current possible dilemmas and predicaments (content analysis), or made suggestions under the opinions or attitude as discussed in the interview.

Part 4 (Results & Findings)

4.1: Questionnaire's Results (Quantitative Approach)

4.1.1: Students' results and findings

4.1.1A: Socio-demographic characteristics of respondents

The socio-demographic characteristics of respondents were tabulated (Table 1) with descriptive analysis. All respondents (n=93) fulfilled the requirements as stated in session 3.1 (overview of methodology) in this research study. For both gender and age, the portion was quite average between males (53.8%) and females (46.6%), and 16-17 (51.6%) and 18-19 (48.4%) in range respectively. Whilst, gender was later selected (reason: as both set of data were uniformed and averaged) for undergoing MANOVA test to examine the impact of gender towards the perceptions of answers of score in face-to-face learning and online learning. In addition, for education level, the respondents were mostly secondary 6 students (53.8%), and almost all of the respondents were studying HKDSE curriculum at that moment.

Table 1: *Socio-demographic profile of respondents (n=93) (results of students' questionnaire)*

Variables	Frequency (n)	Percentage (%)
Gender		
Male	50	53.8
Female	43	46.2
Age (years old)		
16-17	48	51.6
18-19	45	48.4
Education level		
Secondary 4	17	18.3
Secondary 5	26	28
Secondary 6	50	53.8
Education curriculum studying currently		
HKDSE	91	97.8
IB	2	2.2
SAT	0	0

4.1.1B: Reliability tests with Cronbach's alpha Index

The reliability tests were separated into four parts of results. The first part was the overall reliability of the responses obtained in all of the questions. The second part was the combined comparative aspects (i.e., the defaulted scenarios pre-set for this research study), in which it compared to the data of the third part of the reliability test, which similar to the last part of result but omitting the

factor of "face-to-face learning" and "online learning". The final part of reliability result focused on the reliability of the responses upon the suggestive statements, examining respondents' conformity of responses (i.e., perceptions) towards the suggestive statement provided.

In this research study of students' questionnaire, the overall reliability was 0.786, which had a good reliability overall, in which this meant the responses received were valid and overall reliable. The combined comparative aspects upon the two defaulted scenarios had acceptable to good reliability, i.e., 0.610 for "face-to-face learning and before the pandemic" aspect, and 0.721 for "online learning and during the pandemic" aspect. Whilst, by only comparing the scenarios of time, i.e., before the pandemic and during the pandemic, the reliability of aspect "before the pandemic" and "during the pandemic" were 0.610 and 0.681 respectively. The suggestive statements had high reliability as well (0.855), which made the suggestive statements very valid for discussion. Table 2 is a summary of all reliability tests resulted for this set of questionnaire.

Table 2: *Reliability test results on different testing aspect of the student's set questionnaire*

Aspects	**Reliability (Cronbach's Alpha Index)**	**Indication**
Overall	0.786	Good
Combined comparative aspects		
Face-to-face learning & before the pandemic	0.610	Acceptable
Online learning & during the pandemic (or after the pandemic started, as stated)	0.721	Good
Comparative sessions		
Before the COVID-19 pandemic	0.610	Acceptable
During the COVID-19 pandemic	0.681	Acceptable
Suggestive statements	0.747	Good

4.1.1C: Comparison on comparative mean score (with SD) of perceptions upon four highlighted learning aspects between face-to-face learning and online learning

In this research study, one of the highlighted focuses were the influences upon four learning aspects under the two scenarios of class mode and time, i.e., face-to-face learning and before the pandemic, and online learning and during the pandemic. The four learning aspects highlighted the main focus of the impacts that could be brought by the transformation of mode of learning. The comparative mean scores of perceptions of the acquirement or gain of the four learning aspects (i.e., knowledge, experimental skills, soft skills and motivation) had significantly dropped upon the transformation of learning mode of classes and time scenarios. Experimental skills had the largest extent of decrement of scores among the four learning aspects. Figures 3 and figures 4 showed the two bar charts with SD indication on the comparative mean scores of face-to-face learning before the pandemic, compared to the transformation of learning mode: online mode of learning during the pandemic. Table 3 is included for SD and skewness references of data.

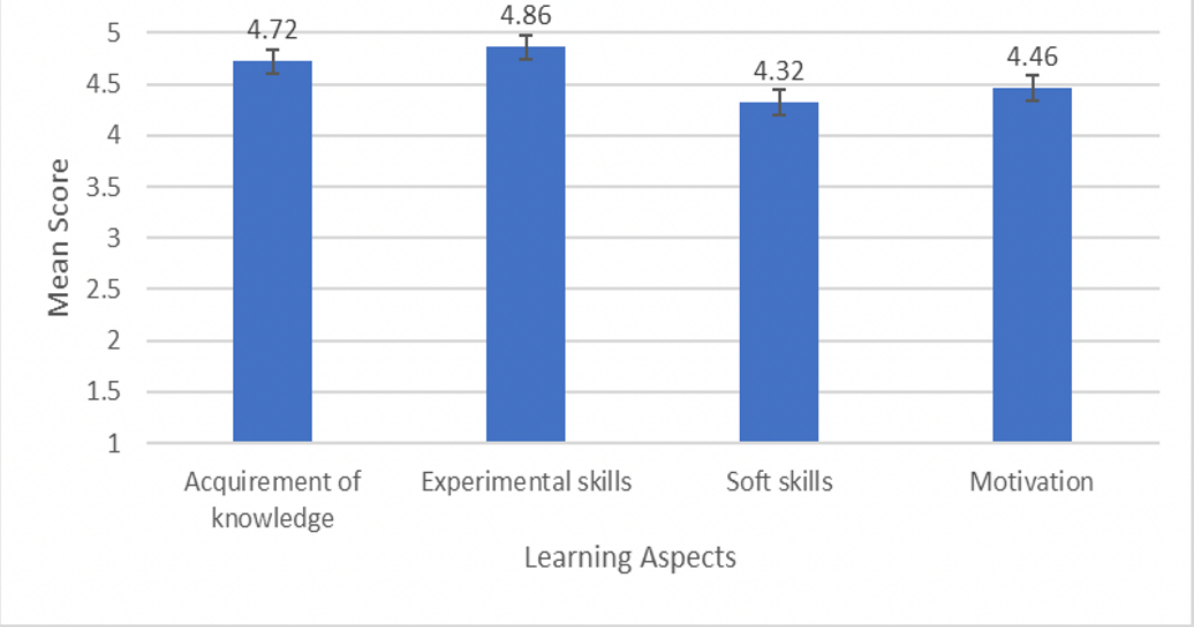

Figure 3: The comparative mean score of perceptions of the four highlighted learning aspect in face-to-face learning mode of lesson and before the COVID-19 pandemic (students' questionnaire). *The highest score of perception was the acquirement of experimental skills (4.86), indicating that the respondents thought that through face-to-face lesson before the pandemic, they highly agreed the acquirement of experimental skills could be achieved by the time when they were attending the said mode of lesson under the time frame. The rest of learning aspects also showed a high score of perceptions, i.e., acquirement of knowledge (4.72), soft skills (4.32), and motivation*

(4.46). Thus, before the COVID-19 pandemic, in face-to-face lessons, the respondents perceived that all these four learning aspects could be achievable in their studies.

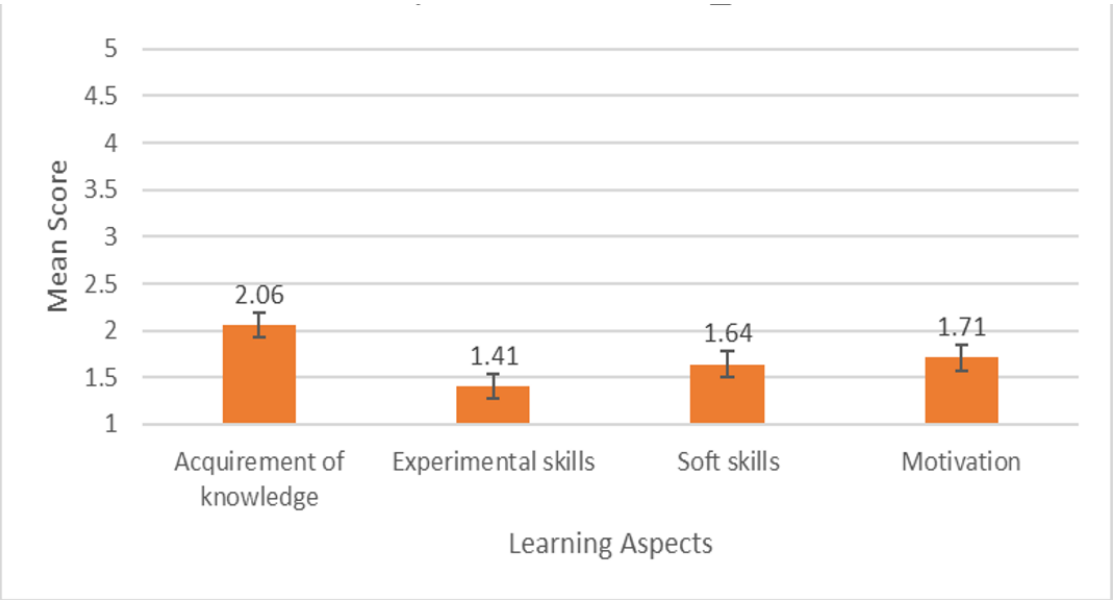

Figure 4: The comparative mean score of perceptions of the four highlighted learning aspect in online learning mode of lesson and during the COVID-19 pandemic (students' questionnaire).

Compared to the results of the previous section, all sections of comparative mean scores had dropped significantly upon all four learning aspects. Acquirement of experimental skills was the highest score in the previous session, whilst in online mode of learning during the pandemic, the score dropped to the lowest (1.41), in which this made the biggest difference in scores by comparing the two modes of learning. The highest score of perception was the acquirement of knowledge (2.06); however, the score tended to disagree that through online learning during the pandemic, they disagreed the acquirement of the four learning aspects could be achieved by the time when they were attending the said mode of lesson under the time frame, i.e., for the remaining two aspects, they also shared low mean scores, soft skills (1.64), and motivation (1.71). Thus, during the COVID-19 pandemic, in online lessons, the respondents perceived that all these four learning aspects could not be achievable in their studies.

Table 3: *SD and skewness of both set of data (results of students' questionnaire)*

Aspects	Standard Deviation (SD)	Skewness
Face-to-face learning and before COVID-19 pandemic		
Acquirement of knowledge	0.49707	-1.529
Acquirement of experimental skills	0.34864	-2.112
Gain of soft skills	0.57410	-0.145
Motivation	0.56259	-0.785
Online learning and during COVID-19 pandemic		
Acquirement of knowledge	0.52764	0.984
Acquirement of experimental skills	0.55632	1.339
Gain of soft skills	0.60154	0.643
Motivation	0.58199	0.812

4.1.1D: Paired-sample t-tests on comparisons of all learning aspects with scores of perceptions between face-to-face learning and online learning

The paired-sample t-tests were utilized for examining the statistical significance in between two sets of data (i.e., perceptions of scores in between "face-to-face mode learning before the pandemic" and "online mode learning and during the pandemic" in the same group of participants (i.e., same participant [students] filled in one integrated questionnaire with two parts of very similar content of questions). p-value (i.e., $p<0.05$) has been used as the benchmark of identifying whether two sets of data are statistically different and significant. In every learning aspect that were examined in this research study, comparative mean scores and the significance had been generated, including the four highlighted focuses of learning aspects in this research study, the perceptions of mean scores in all learning aspects under the two combined comparative aspects were found statistically different ($p<0.001$). Thus, this indicated that both part of responses was important, the decreasing trend of scores of perceptions and the changes were significant. Table 4 showed the comparative mean score and the significance value of the two sets of data, while the second column stated the comparative mean, with a huge difference of comparative mean scores in every aspect observed. The highest comparative mean difference was found to be the acquirement of experimental skills. Hence, that meant students thought that this learning aspect was greatly affected and less grasped upon online mode of learning.

Table 4: *Paired-sample t-tests on the comparisons of learning aspects with scores of perceptions between face-to-face learning and online learning, results of students' questionnaire*

Paired-sample t-tests aspects (i.e., (1) "face-to-face learning and before the pandemic" versus (2) "online learning and after the pandemic")	**Comparative Mean (Left score: score of (1), right score: score of (2), italic score: comparative mean)**	**Significance (p)**	**Statistically different**
Highlighted learning aspects			
Acquirement of knowledge	4.7204 VS 2.0645 *2.6559*	<0.001	Yes
Acquirement of experimental skills	4.8602 VS 1.4086 *3.4516*	<0.001	Yes
Gain of soft skills	4.3226 VS 1.6452 *2.6774*	<0.001	Yes
Motivation	4.4624 VS 1.7097 *2.7527*	<0.001	Yes
Other learning aspects			
Knowledge and academics	4.6061 VS 2.2576 *2.3485*	<0.001	Yes
Motivation in participation	4.3939 VS 1.9848 *2.4091*	<0.001	Yes
Knowledge (online/face-to-face hands-on experiences aids learning science concepts)	4.3636 VS 2.1212 *2.2424*	<0.001	Yes
Knowledge (online/face-to-face hands-on experiences aids revision)	4.3030 VS 2.0758 *2.2273*	<0.001	Yes
Academic performance (online/face-to-face hands-on experiences aids improvement of academic results)	4.1061 VS 2.0758 *2.0303*	<0.001	Yes

4.1.1E: MANOVA test on examining gender (factor) towards the significance of responses upon face-to-face (before pandemic) and online learning scenarios (during pandemic)

The results of MANOVA test (i.e., benchmark was also set as $p<0.05$) revealed in the students' respondents of this research study, when they attempted to respond the perceptions with scores towards the questions, gender was not a significant factor that altered the perceptions of answers

upon the defaulted scenarios of questions, i.e., "face-to-face mode of learning and before the pandemic" and "online mode of learning and after the pandemic", with the significance values of 0.608 and 0.198 respectively. Hence, both data were not significant as $p>0.05$ and null hypothesis (gender is a factor which influences the respondents' answers) shall be rejected. In addition, one-way ANOVA was further analysed for checking the Wilk's Lambda value and the estimated variance (partial η^2). Table 5 summarized the value of MANOVA tests in each session.

Table 5: *MANOVA tests results of each session of the two defaulted scenarios*

Scenarios	**Wilk's Lambda value**	**F**	**Significance (p)**	**ANOVA: Partial η^2**
"Face-to-face mode of learning and before the pandemic"	0.918	0.810	0.608	0.548
"Online mode of learning and during the pandemic"	0.576	1.345	0.198	0.516

4.1.2: Teachers' results and findings

4.1.2A: Socio-demographic characteristics of respondents

The socio-demographic characteristics of respondents were tabulated (Table 6) with descriptive analysis, just like the treatment of data in students' questionnaire. All respondents (n=45) fulfilled the requirements as stated in session 3.1 (overview of methodology) in this research study. For gender, the portion was slightly average between males (60%) and females (40%). For age, the range of age of responding this questionnaire was quite dispersed, the most populated age range of respondent was in range of 23-30 years old (48.9%). Whilst, gender was later selected (reason: as both set of data were relatively uniformed and averaged) for undergoing MANOVA test to examine the impact of gender towards the perceptions of answers of score in face-to-face learning and online learning, for aligning the treatment of data to examine whether gender is a factor to alter the perceptions among the participants in both questionnaires of different group of participants. In addition, for highest education level, the respondents were mostly qualified for Bachelor's degree (53.3%), with mostly of them obtained an education diploma (PGDE) (84.4%) and almost all of the respondents were teaching HKDSE curriculum at that moment (97.8%), mostly teaching local subsidized secondary schools (71.1%).

Table 6: *Socio-demographic profile of respondents (n=45) (results of teachers' questionnaire)*

Variables	Frequency (n)	Percentage (%)
Gender		
Male	27	60
Female	18	40
Age (years old)		
Below 22	1	2.22
23-30	22	48.9
31-40	16	35.6
41-50	3	6.67
51-60	2	4.44
Rather not say	1	2.22
Highest Education level		
Bachelor's degree	24	53.3
Master's degree	15	33.3
Doctor's degree	6	13.3
Education diploma (PGDE) obtained (excluding BEd, MEd, or EdD)	38	84.4
Education curriculum studying currently		
HKDSE	44	97.8
IB	1	2.2
SAT	0	0
Type of school currently working		
Local subsidized	32	71.1
Local governmental	4	8.9
Private schools and institutions (i.e., under Direct-Subsidy Scheme; International schools)	9	20

4.1.2B: Reliability tests with Cronbach's alpha Index

In this research study of teachers' questionnaire, the overall reliability was 0.735, which had a good reliability overall, in which this meant the responses received were valid and overall reliable. Two focuses were on the combined comparative aspect (i.e., face-to-face learning before the COVID-19 pandemic) and all questions related to face-to-face learning only (questions without wordings of "before the pandemic"), the reliability was relatively low (i.e., 0.421 for both items). Hence, the possible reason was that extreme opinions could have been made upon the perception on selecting the relative scores. However, the reliability of both sections of online mode learning were quite high overall. The suggestive statements also had good reliability as well (0.747), which made the suggestive statements valid for discussion. Table 7 is a summary of all reliability tests resulted for this set of questionnaire.

Table 7: *Reliability test results on different testing aspect of the teacher's set questionnaire*

Aspects	Reliability (Cronbach's Alpha Index)	Indication
Overall	0.735	Good
Combined comparative aspects		
Face-to-face learning & before the pandemic	0.421	Poor
Online learning & during the pandemic (or after the pandemic started, as stated)	0.896	High
Comparative sessions		
Before the COVID-19 pandemic	0.421	Poor
During the COVID-19 pandemic	0.805	High
Suggestive statements	0.747	Good

4.1.2C: Comparison on comparative mean score (with SD) of perceptions upon four highlighted learning aspects between face-to-face learning and online learning

The four learning aspects highlighted the main focus of the impacts that could be brought by the transformation of mode of learning. The comparative mean scores of perceptions of the acquirement or gain of the four learning aspects had very similar plummeting trend of results compared to the findings as students' questionnaire. The scores significantly dropped upon the transformation of learning mode of classes and time scenarios. Experimental skills also had the largest extent of decrement of scores among the four learning aspects. Figures 5 and figures 6 showed the two bar charts with SD indication on the comparative mean scores of face-to-face learning before the pandemic, compared to the transformation of learning mode: online mode of learning during the pandemic. Table 8 is included for SD and skewness references of data.

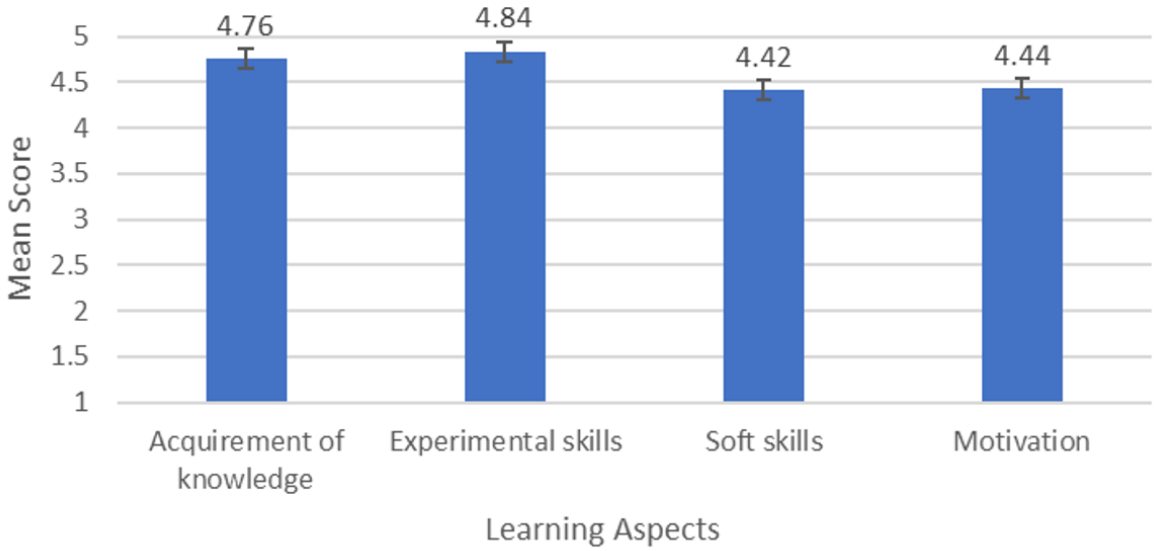

Figure 5: The comparative mean score of perceptions of the four highlighted learning aspect in face-to-face learning mode of lesson and before the COVID-19 pandemic (teachers' questionnaire). *Similar trend of score and findings were also revealed in the teachers' questionnaire. The highest score of perception was the acquirement of experimental skills (4.84), indicating that the respondents thought that through face-to-face lesson before the pandemic, they highly agreed the acquirement of experimental skills could be achieved by students by the time when the students were attending the said mode of lesson under the time frame. The rest of learning aspects also showed a high score of perceptions, i.e., acquirement of knowledge (4.76), soft skills (4.42), and motivation (4.44). Thus, before the COVID-19 pandemic, in face-to-face lessons, the teacher respondents perceived that all these four learning aspects could be achievable in their students' studies.*

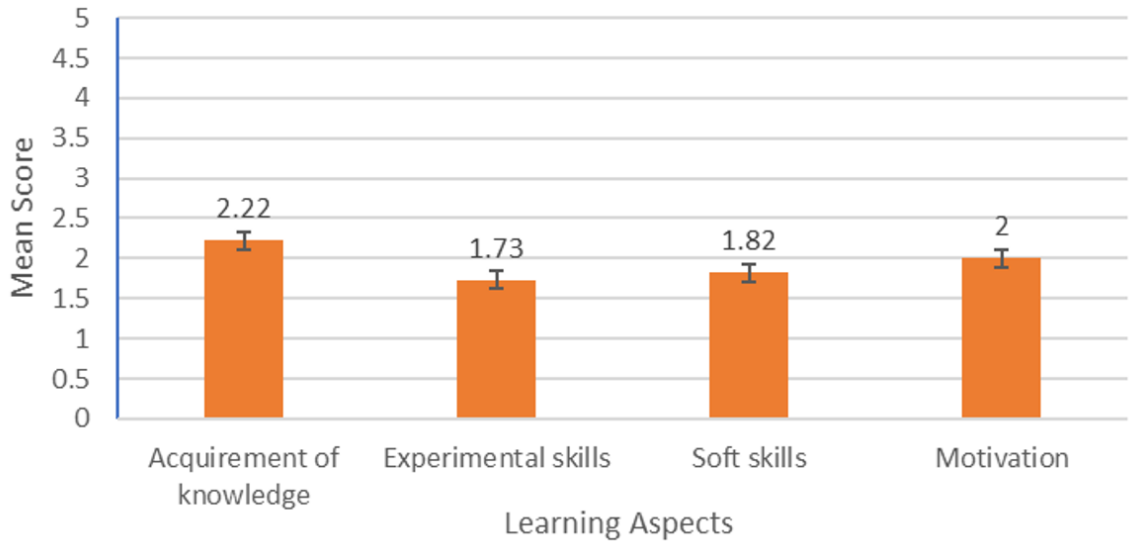

Figure 6: The comparative mean score of perceptions of the four highlighted learning aspect in online learning mode of lesson and during the COVID-19 pandemic (teachers' questionnaire).

Compared to the results of the previous section, and the results that showed very similar trend and findings as students' questionnaire, all sections of comparative mean scores had dropped significantly upon all four learning aspects. Acquirement of experimental skills was the highest score in the previous session, whilst in online mode of learning during the pandemic, the score dropped to the lowest (1.73), in which this made the biggest difference in scores by comparing the two modes of learning. The highest score of perception was the acquirement of knowledge (2.22); however, the score still tended to disagree that through online learning during the pandemic, the teacher respondents disagreed the acquirement of the four learning aspects could be achieved by their students when they were attending the said mode of lesson under the time frame. i.e., for the remaining two aspects, they also shared low mean scores, soft skills (1.82), and motivation (2). Thus, during the COVID-19 pandemic, in online lessons, the respondents perceived that all these four learning aspects could not be achievable in the students' studies.

Table 8: *SD and skewness of both set of data (results of teachers' questionnaire)*

Aspects	**Standard Deviation (SD)**	**Skewness**
Face-to-face learning and before COVID-19 pandemic		
Acquirement of knowledge	0.46818	-0.844
Acquirement of experimental skills	0.38665	-1.744
Gain of soft skills	0.58344	-0.402
Motivation	0.64979	-0.562
Online learning and during COVID-19 pandemic		
Acquirement of knowledge	0.63960	1.757
Acquirement of experimental skills	0.73718	0.969
Gain of soft skills	0.70568	1.042
Motivation	0.69413	0.669

4.1.2D: Paired-sample t-tests on comparisons of all learning aspects with scores of perceptions between face-to-face learning and online learning

Same underlying principle of utilizing paired-sample t-tests were performed for the data obtained from teachers' questionnaire. p-value (i.e., $p<0.05$) has been used as the benchmark of identifying whether two sets of data are statistically different and significant. Likely as the findings in students; questionnaire, the perceptions of mean scores in all learning aspects under the two combined comparative aspects were found statistically different ($p<0.001$). An additional question was asked upon the influence of teaching pedagogy (whether transformation of learning mode could facilitate the adjustment of teaching pedagogy of teachers). Thus, the similar results indicated that both part of responses was important, the decreasing trend of scores of perceptions and the changes were significant. Table 9 showed the comparative mean score and the significance value of the two sets of data, while the second column stated the comparative mean, with a huge difference of comparative mean scores in every aspect observed. The highest comparative mean difference was found to be the acquirement of experimental skills. Hence, that meant students thought that this learning aspect was greatly affected and less grasped upon online mode of learning.

Table 9: *Paired-sample t-tests on the comparisons of learning aspects with scores of perceptions between face-to-face learning and online learning, results of teachers' questionnaire*

Paired-sample t-tests aspects (i.e., (1) "face-to-face learning and before the pandemic" versus (2) "online learning and after the pandemic")	**Comparative Mean (Left score: score of (1), right score: score of (2), italic score: comparative mean)**	**Significance (p)**	**Statistically different**
Highlighted learning aspects			
Acquirement of knowledge	4.7556 VS 2.2222 *2.5333*	<0.001	Yes
Acquirement of experimental skills	4.8444 VS 1.7333 *3.1111*	<0.001	Yes
Gain of soft skills	4.4222 VS 1.8222 *2.6000*	<0.001	Yes
Motivation	4.4444 VS 2.0000 *2.4444*	<0.001	Yes
Other learning aspects			
Knowledge and academics	4.6250 VS 2.4250 *2.2000*	<0.001	Yes
Motivation in participation	4.6250 VS 2.4750 *2.1500*	<0.001	Yes
Knowledge (online/face-to-face hands-on experiences aids learning science concepts)	4.5000 VS 2.4500 *2.0500*	<0.001	Yes
Knowledge (online/face-to-face hands-on experiences aids revision)	4.4500 VS 2.4250 *2.0250*	<0.001	Yes
Teaching pedagogy adjustments	4.5000 VS 2.7500 *1.7500*	<0.001	Yes
Overall influence on academic performance of students (online/face-to-face hands-on experiences aids improvement of academic results)	4.2750 VS 2.2000 *2.0750*	<0.001	Yes

4.1.2E: MANOVA test on examining gender (factor) towards the significance of responses upon face-to-face (before pandemic) and online learning scenarios (during pandemic)

The results of MANOVA test (i.e., benchmark set as $p<0.05$) applied the same underlying principles of data analysis of the teachers' questionnaire. Similarly to the findings as students' questionnaire, gender was not a significant factor that altered the perceptions of answers upon the defaulted scenarios of questions, with the significance values of 0.697 and 0.561 respectively. Hence, both data were not significant as $p>0.05$ and null hypothesis (gender is a factor which influences the respondents' answers) shall be rejected. In addition, one-way ANOVA was also adopted for checking the Wilk's Lambda value and the estimated variance (partial η^2). Table 10 summarized the value of MANOVA tests in each session.

Table 10: *MANOVA tests results of each session of the two defaulted scenarios*

Scenarios	**Wilk's Lambda value**	**F**	**Significance (p)**	**ANOVA: Partial η^2**
"Face-to-face mode of learning and before the pandemic"	0.825	0.723	0.697	0.508
"Online mode of learning and during the pandemic"	0.440	0.942	0.561	0.313

4.2: Interview's Results (Qualitative Approach)

4.2.1: Overview of findings

Individual interviews were hosted with students (n=7) and teachers (n=7). After summarization of data by content analysis, the common perceptions or consensuses of ideas had been drawn out and categorized into four major categories. They included:

1. Learning aspects of hands-on experiences upon face-to-face learning
2. Learning aspects of hands-on experiences upon online learning
3. Major issues occurred upon transformation into online learning in science classes (teachers) or Major issues occurred upon transformation into online learning in science classes (students)
4. Common consensus of suggestions (between students and teachers)

Note that for the findings in parts 1 and 2, they would be combined for demonstration of findings, as this could facilitate the spotting on of changes and differences in between two sets of data.

4.2.2: Learning aspects of hands-on experiences upon face-to-face learning versus online learning

In this part of qualitative research, apart from the four highlighted learning aspects focused in students' questionnaire, broader aspects had been added for in-depth discussion, including motivation, frequency of hands-on activities (will be discussed in session 4.3 in details), acquirement of experimental skills, acquirement of soft skills and interactions, academic results (influences, including acquirement of knowledge), e-resources provided and their accessibility and multimedia learning.

For motivation of students, most of the respondents in both group agreed that face-to-face hands-on experiences could be "generally higher" (teachers, n=5), "spark up interests" (students, n=2) and "more attentive in class due to higher motivation" (students, n=2). However, shifting into online mode, all students participants (n=7) had a lower motivation on participating online hands-on activities, with six teachers (n=6) agreed that students' motivation were lower.

For acquirement of experimental skills, all teachers (n=7) and students (n=7) agreed that experimental skills are essential learning components of any science subjects, where most teachers (n=4) and all students (n=7) thought that they could gain experimental skills via face-to-face hands-on experiences. However, shifting into online hands-on experiences, all teachers (n=7) and students (n=7) disagreed that online learning is not a solid method for students to learn hands-on experimental skills.

For acquirement of soft skills and interactions, three teachers (n=3) and two students (n=2) had mentioned "sufficient", with two students each (n=2+2=4) mentioned "okay" and "better" respectively via face-to-face hands-on experience learning. However, shifting into online hands-on experience, the teachers mentioned "lower" (n=3), "not enough" (n=3), only one teacher mentioned "should be ok (or enough)" (n=1) for this learning aspect in online hands-on experience.

Also, four students mentioned “lower” (n=4) and the remaining respondents (n=3) mentioned “no chance” during online hands-on experiences were adopted in class.

For academic results, five teachers stated face-to-face hands-on experiences could “help” (n=5) students’ academic results, whilst three students said it could “help to facilitate learning” (n=3).

For e-resources provided and accessibility, the opinion were slightly dispersed in this session, especially among teachers: “sufficient” (n=2), “difficult but not that troublesome” (n=1), “cannot choose the right one for themselves” (n=1), whilst the students had a higher uniformity of answers, where five students thought it would be not enough (n=5), the remaining respondents stated e-resources were “enough” for them to study in online hands-on experiences sessions.

Lastly, for multimedia learning, i.e., hybrid mode of learning and teaching, which was an additional questions to ask for students’ and teachers’ perception. Three respondents for each group of participants (students: n=3; teachers: n=3) mentioned multimedia learning combined with traditional teaching (face-to-face) in class, could not only facilitate students’ learning but also “a good start of hosting hybrid mode of learning” (with both face-to-face and online hands-on experiences in a class).

Table 11 is a summary of the highlights of teachers’ and students’ responds in the interviews, with some items included supplementary information in the sub-categories of each session.

Table 11: *A summary of comparison table of the perceptions between students and teachers.*

Note: The bold words in the table were the common perceptions in between the students' and teachers' participants.

Aspects	Face-to-face hands-on experiences	Online hands-on experiences
Motivation	**Teachers**: "Generally higher" (Teachers A, B, D, E, F; n=5) → Teachers B, D, F also mentioned that it is a "medium" for students to participate well in class with sparking-interests activities. **Students:** "Spark up interests" (n=2), "more attentive in class due to higher motivation" (n=2)	**Teachers: "Lower"** (all teachers except teacher C; n=6) → Teachers B and D also mentioned "bored" upon online learning and related this word to motivation of students. **Students: "Lower"**(n=7) → Student A, E , F, G described the online lessons as "boring/bored" as they found there were no interests to participate. → Student A has mentioned the word of learning "ambience" at school with his peers could motivate his science study.
Frequency	**Teachers**: **"About once a week"** (Teachers A, B, G; n=3) **"Once a week to once in two to three weeks"** (remaining teachers; n=4) **Students: "About once a week"** (n=4), **"Once a week to once in two to three weeks"** (n=3), "More frequent than online during pandemic" (n=4)	**Teachers**: **"Decreased"** (n=7) → Teacher A, B, D, F and G used "significantly" or "dramatically" to describe the trend (n=5) **Students: "Decreased"** (n=7) → Students A, B, D, E used "a lot" to describe the decreased trend. (n=4)
Acquirement of experimental skills	**Teachers**: "**Agree** experimental skills are essential learning components of any science subjects" (all teachers; n=7); "could be gained" (Teacher A, B, D, E; n=4) **Students:** "**Agree** experimental skills are essential learning components of any science subjects (n=7) → Students A, C, D, E, F and G mentioned that hands-on experiences provide them insights of getting experimental skills, especially in the experiments	**Teachers**: **"Disagreed"**: Online learning is not a solid method for students to learn hands-on experimental skills (n=7) **Students: "Disagreed"**: Online learning is not a solid method for "us" to learn hands-on experimental skills (n=7) → Whilst, student E said they would not have chances to have hands-on experiences on picking up the apparatus in laboratories.

Acquirement of soft skills and interactions	**Teachers: "Sufficient"** (Teachers A, B, C; n=3) **Students:** "okay" (n=2), **"sufficient"** (n=2), "better" (n=2)	**Teachers: "Lower"** (n=3); "not enough interactions" (n=3) "should be ok (or enough)" (n=1) **Students:** "No chance" (n=3); **"lower"** (n=4) → Student A emphasized that there were no chances for him to gain interaction chances during the online lessons.
Academic results	**Teachers:** "could **help**" (n=5) **Students:** "**help** to facilitate learning" (n=3)	**Teachers:** "hard to say" (n=2), **"could not help"** (n=2), "deteriorate during online learning" (n=3) **Students:** "mostly **could not help**" (n=5, except student B and C)
E-resources provided and accessibility	N/A for this research study	**Teachers:** "Sufficient" (n=2), "Difficult but not that troublesome" (n=1) "cannot choose the right one for themselves" (n=1) **Students:** "Enough" (n=2), "not enough"(n=5) → Student D, F, G: "required subscription and cancelled afterwards" (n=3)
Multimedia learning (hybrid mode of learning)	N/A for this research study	**Teachers:** "Could provide learning and revision (revise back) chances to students after classes, which is **a good start of hosting hybrid mode of learning**. (Teacher B, C, D) **Students**: "**A good start of hosting hybrid mode of learning**". (n=3)

4.2.3: Major issues occurred upon transformation into online teaching in science classes (teachers)

For teachers, there were four major concerns sparked upon transformation into online learning in science classes. Three of the four major concerns could be linked up or as the same point of students' perceptions.

Aiming on teachers, two respondents (n=2) reported they had to seek technical support from their colleagues during online mode teaching was adopted.

For the common consensuses between the concerns in students and teachers, they were the "interaction issues" (teacher: n=5), "hands-on skills issues" (teacher: n=6), "puzzled and confused" when explaining abstract science concepts in online lessons, or "no responses" could be gained from their fellow students.

Table 12 summarized the major perceptions with brief demonstration of their perceptions' explanation for each category.

Table 12: *Summarization of points among teachers' perceptions of major issues occurred upon transformation into online teaching in science classes (teachers)*

Note: The bold words in the table were the common perceptions in between the students' and teachers' participants.

Major concerns and issues	Explanation
Technical support (n=2)	Teachers E and F needed much support from his colleagues for technical support.
Interaction issues (n=5)	Teacher B, D, E, F, G also agreed that the science lessons held online was not interactive for students to make discussions. → Teacher D mentioned that the school software used ("Google Meets") does not provide breakout room function, which makes a lower opportunity for students to make interactions in class.

"Hands-on skills issues" (n=6, except teacher C)	The hands-on experiences were not generally given to students in class, as the restrictions of the online mode classes via online platforms. → Teacher C has put forth a "Biotechnology" project for students to join during online classes, by making use of the third-party simulators with tangible materials given to students.
"**Puzzled** and confused" when explaining abstract science concepts in online lessons, or "no responses" (n=5)	Teacher B and D also mentioned some of the students found it difficult to understand the science concepts when they are studying online.

4.2.4: Major issues occurred upon transformation into online learning in science classes (students)

For students, there were five major concerns sparked upon transformation into online learning in science classes. Three of the five major concerns could be linked up or as the same point of teachers' perceptions. Hence, it could be aligned with the perceptions obtained (with data analysis) from the questionnaire, with most of the findings could be aligned among both approaches.

Aiming on students, four respondents (n=4) reported they had time limitation (i.e., decreased of duration of classes) of class which could possibly dragged down their learning progress in online mode of learning during the COVID-19 pandemic. Another important issue on students was the fact that on "school-based" issues, two respondents (n=2) mentioned that they have changed three Biology teachers among three-year of senior secondary Biology curriculum study, in which they changed the teacher once every year. Thus, that posed learning issues on these two students because of teachers' different teaching styles. More importantly, the consensuses of points between students and teachers had been denoted in the previous session (session 4.2.3).

Table 13 summarized the major perceptions with brief demonstration of students perceptions' explanation for each category.

Table 13: *Summarization of points among students' perceptions of major issues occurred upon transformation into online teaching in science classes (students)*

Note: The bold words in the table were the common perceptions in between the students' and teachers' participants.

Major concerns and issues	Explanation
"Time limitation" and "learning progress" issues (n=4)	The time limitation of the class when they shifted to online mode has decreased in duration which dragged down the learning progress of students, as mentioned.
Interaction issues (n=7)	Students agreed that the science lessons held online was not interactive for students to make discussions. → Student E: Restriction of software of "Google Meets" (aligned with teacher D's explanation).
"Hands-on skills issues" (n=7)	The hands-on experiences were not generally given to students in class. → The restrictions of the online mode classes via online platforms limited the learning content in science classes, mentioned by students A, B, C, D, E and G.
"**Feeling puzzled** during learning: on the difficult learning content" (n=3)	Online lessons would be more difficult for students to learn complex ideas, compared to face-to-face lessons, with face-to-face hands-on experiences components.
"School-based issues" (n=2)	Students C and E said that they changed three Biology teachers in these three years.

4.2.5 Common consensuses on suggestions (between students and teachers) (with a view of comparison table)

The consensuses on the suggestions for online mode of learning were very similar and could be aligned well in both group of the participants in qualitative approach, whilst it also could be aligned and validated with the findings of perceptions score among the two sets of questionnaires. There were six common key points between students and teachers, with one additional point for suggestion for the students.

They include more online resources, more virtual laboratories, 3D simulators, clearer and more instructive demonstration videos, more experimental skills components to stimulate critical thinking, with multimedia is a good start of hybrid learning classrooms. A few students also mentioned artificial intelligence (AI), augmented reality (AR) for online experiments, in which they could learn more realistic situations of experiments.

Table 14 is a comparison table which summarized the common consensus and the additional point of suggestion from the students.

Table 14: *A comparison table of summarization of the common consensus and perceptions of suggestions upon online mode learning and teaching (with fellow hands-on experiences components), in between students and teachers, with an additional point of suggestion from students.*

Note: The bold words in the table were the common perceptions in between the students' and teachers' participants.

Aspects	Teachers	Students
More online resources	**More online resources are necessary** for online lessons. (n=7)	**More online resources are necessary** for online lessons. (n=7)
More online platforms (in terms of virtual laboratories)	**More online platforms** should be introduced to students **in terms of the virtual laboratories** (n=4).	**More online platforms** should be introduced to students **in terms of the virtual laboratories** (n=6), the content should be aligned with HKDSE syllabus (n=2).
Adoption of using (3D) simulators	A database of **simulators** should be established for students to access (n=3) → Teacher D: Should be aligned with the HKDSE curriculum.	**3D simulators** should be great for learning (n=6), with a database provided (student E).

More, clearer, and more instructive demonstrative videos (e.g., experimental components)	**Demonstrative videos** provided by the **book publisher, shall be clearer and more instructive with reminding messages** in the video (n=2).	**Demonstrative videos** provided by the **book publisher or teachers, shall be clearer and more instructive with reminding messages** in the video. (n=3).
More experimental skills components to stimulate critical thinking	**More experimental skills components** to stimulate critical thinking (n=2).	Adding **experimental skills components** to the e-learning platforms to **stimulate critical thinking** (n=2), with more guidance on the experimental procedural steps (n=2).
Additional question: Adopting hybrid mode of learning	**Hybrid mode** of learning **is good** for students (n=6).	**Hybrid mode** of learning **is good** (n=7). → Solve the learning needs of individual learners. (Students C and F)
Additional suggestion by students	N/A	Artificial intelligence, augmented reality (AR) (n=1), or markers could be added to the database for students to learn more realistic situations of experiments (n=2).

4.3: Other Essential Findings

4.3.1: Suggestive statements' perceptions (of score) of the questionnaire

Figures 7 and 8 denoted the mean of perceptions score in the three suggestive statements for online mode learning during the pandemic, that were planned in the questionnaire (session III, questions 4a to 4c). The mean score of students (figure 7) and teachers (figure 8) were illustrated in the below bar charts. Table 15 denoted the SD and skewness of both sets of data.

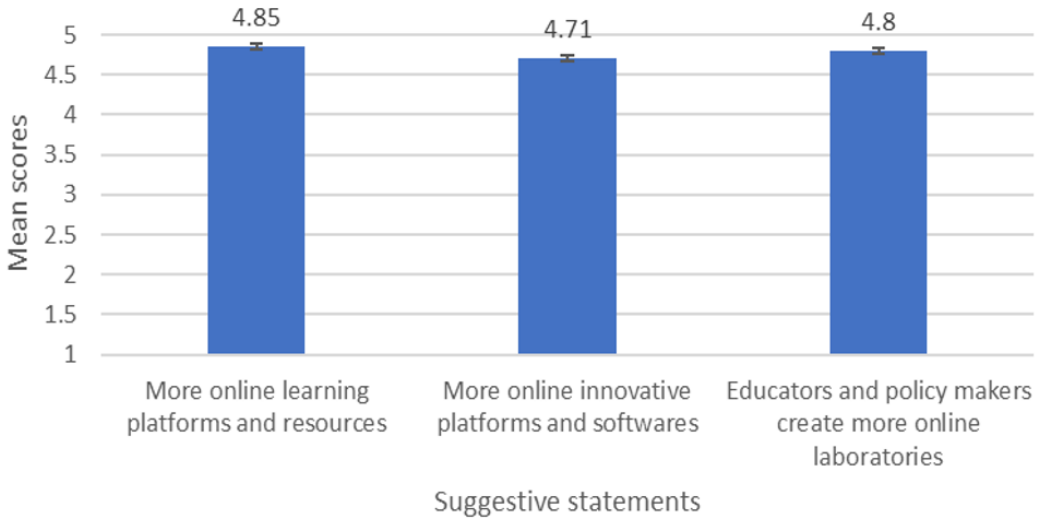

Figure 7: The mean of perception score among students questionnaire's participants in the three suggestive statements for online mode learning during the pandemic. *An overall of high agreement was achieved in the three statements. The statements were more online learning platforms and resources should be planned for compensating the insufficient areas or easing the learning needs of students (4.85); more online innovative platforms and software to aid students' learning (4.71); and educators and policy makers should pay heed to the create more online resources on online laboratories, in order to support students' learning in science subjects (4.8).*

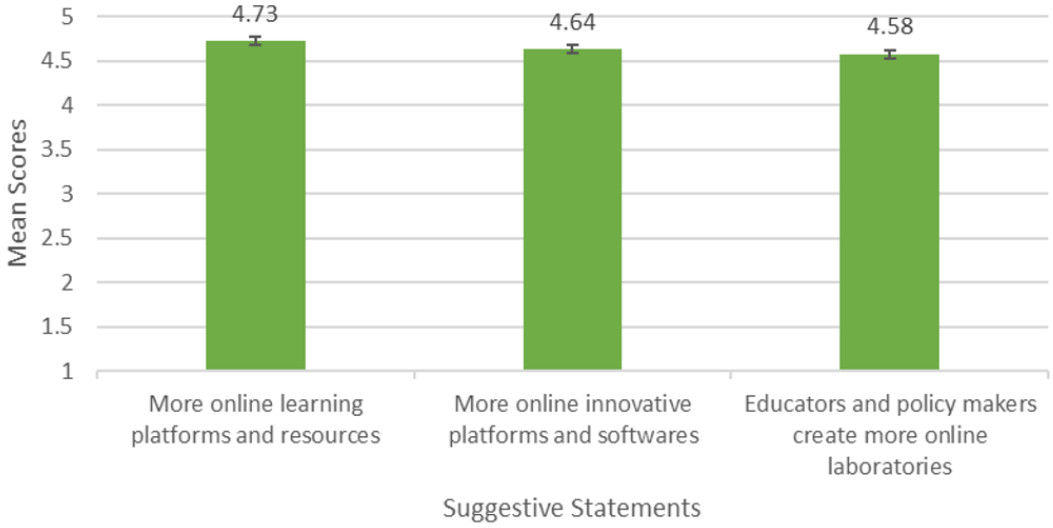

Figure 8: The mean of perception score among teachers questionnaire's participants in the three suggestive statements for online mode teaching during the pandemic. *An overall of high agreement was achieved in the three statements, as similar uniformity of results found in the*

students' questionnaire. The statements were more online learning platforms and resources should be planned for compensating the insufficient areas or easing the learning needs of students (4.73); more online innovative platforms and software to aid students' learning (4.64); and educators and policy makers should pay heed to the create more online resources on online laboratories, in order to support students' learning in science subjects (4.58).

Hence, the desire and perceptions of varieties of suggestive statements mentioned in the interview could align with perceptions of students and teachers' questionnaire participants, where these three statements were all about more online resources and innovative platforms to aid students learning with generally high agreement.

Table 15: *Table of SD and skewness of both sets of data among the three suggestive statements*

Suggestive Statements	**Standard Deviation (SD)**	**Skewness**
Students' questionnaire		
More online learning platforms and resources	0.41563	-2.863
More online innovative platforms and software	0.50175	-1.456
Education and policy makers should create more online learning resources (e.g., online laboratories)	0.45586	-2.168
Teachers' questionnaire		
More online learning platforms and resources	0.49543	-1.664
More online innovative platforms and software	0.48409	-0.625
Education and policy makers should create more online learning resources (e.g., online laboratories)	0.54309	-0.768

4.3.2: Patterns of frequency changes of hands-on experiences before and during the COVID-19 pandemic

The patterns of frequency changes of hands-on experiences before the pandemic in face-to-face lessons and during the pandemic in online lessons had significantly changed. The persons who reported that they had hands-on experiences in face-to-face lessons (students: n=92; teachers: n=45) had significantly dropped in number when they compared to the scenarios of having hands-on experience in online mode of learning (students: n=66; teachers: n=40). Hence, the decreased in trend of having hands-on experiences in between two modes of learning had dropped by 28.3% (compared in between the number of responses reported for having participating experience in online and face-to-face hands-on experiences) and 11.1% in participants' responses for students and teachers respectively. Table 16 showed the changes of number of response in which they reported they had hands-on experiences in both mode of classes.

Table 16: *The changes of number of responses in the participants' response, of which they had hands-on experience in both mode of classes. Note: n=93 (students), n=45 (teachers)*

Scenarios	**Students (n)**	**Percentage (%)**	**Teachers (n)**	**Percentage (%)**
Have hands-on experiences in face-to-face science lesson before the COVID-19 pandemic	92	98.9	45	100
Have hands-on experiences in online science lesson during the COVID-19 pandemic	66	71.0	40	88.9
Cumulative differences		-28.3		-11.1

Moreover, the pattern of frequency changes of hosting hands-on experiences by teachers in the two modes of learning and participation of hands-on experiences by students were shifted and plunged in frequency (i.e., less frequent) in patterns. The pattern of both students and teachers participants shifted the frequency pattern from once a week or once in two to three weeks (before the pandemic

in face-to-face lessons) to once a month or more than once a month (during the pandemic in online lessons) for participating or hosting hands-on activities. Table 17 showed the patterns changed in the two sets of data obtained in the frequency of hands-on experiences in face-to-face lessons and online lessons.

Table 17: *Patterns of frequency changes of hands-on experiences before and during the COVID-19 pandemic*

Note: Majority of the two choices (with the two greatest number of responses had been bolded for references of spotting the pattern of changes.

Frequency	**Number of responses ($n_{students}$)**	**Percentage (%)**	**Number of responses ($n_{teachers}$)**	**Percentage (%)**
Face-to-face learning and before COVID-19 pandemic				
Twice a week	3	3.26	0	0
Once a week	**40**	**43.5**	**21**	**46.7**
Once in two to three weeks	**45**	**48.9**	**23**	**51.1**
Once a month	2	2.17	1	2.2
More than once a month	2	2.17	0	0
Online learning and during COVID-19 pandemic				
Twice a week	0	0	0	0
Once a week	1	1.51	1	2.5
Once in two to three weeks	9	13.6	8	20
Once a month	**22**	**33.3**	**12**	**30**
More than once a month	**34**	**51.5**	**19**	**47.5**

Part 5 (Discussions of Results)

5.1 Overview of overall perceptions of participants in this research study

To wrap up for all findings in the questionnaire obtained, all responses received were overall quite reliable. The mean score of perceptions of both students and teachers participants dropped upon all aspects, especially in the four highlighted learning aspects, as similar results reported by Alabdulkareem (2015). MANOVA test proved that in this research study, gender is not a significant factor which affected the respondents to make decisions upon their perceptions of different mode of learning or teaching during different period of time. Hence, this finding is supported by Yu (2021) and Wu & Cheng (2019), reported that gender would not significantly affect online learning outcomes and achievements. However, participants' gender preferences (e.g., perceptions, personality of individuals, capability on adapting online mode of learning) could be factors in online learning and affect learning achievements (Yu, 2021). If gender is a significant factor of which affect the results, the possible reasons could be 1) girls are less adaptive to the virtual mode learning to the boys (Yu, 2021). 2) Boys are underdeveloped upon the skills of self-regulation and time management learning online, as well as related to their inherent personality (McSporran & Young, 2001; Yu, 2021). Hence, further research on multi-variation on the three aspects, 1) face-to-face and online learning and teaching, 2) before and after the COVID-19 pandemic, and 3) significance of gender on the perceptions made.

Summarizing the findings obtained in the interview, most of the points mentioned by the teachers and students participants could aligned back to the findings and perceptions in the questionnaire. Majority of the participants disagreed the experimental skills could be effectively gained in the science lessons online. As a result of only demonstrative videos could be given. Moreover, most of the teachers and students thought that online mode of learning could deteriorate the academic performance, one teacher specifically mentioned that students' writing skills and the lower achievers could already appear with serious dilemmas in learning. A variety of suggestions were made by both teachers and students separately on establishing or modifying the online platforms for better online learning.

Hybrid mode of learning for students could benefit their learning progress, together with multimedia learning, students could have chances to revise the learning contents and have another practice opportunity to go through the learning topics once again.

5.2 Discussion

5.2.1: Importance and the importance of frequency of hands-on experiences

The importance of inclusion and frequency of hands-on experiences (as a vital learning and teaching component) has been advocated and emphasized by a wide range of research. Back to a research in 1996 (Stohr-Hunt, 1996), it revealed that students who had frequent hands-on experiences (for everyday or once of every week) would have higher academic achievements in standardized tests of science subjects. Ornstein (2006) supported that more frequent hands-on experiences provided by the teachers would contribute to better positive learning attitude of students in science subjects, hence, it is a parallel-affecting factor which could influence students' learning motivation and attitude in learning science. Thus, the book (Foley & McPhee, 2008) supported the previous statement by comparing two groups of participants with hands-on activities group and a textbook-based curriculum group, students would have higher motivation and positive attitude towards the science subjects' learning if more hands-on activities were adopted in the curriculum, compared to a textbook-based curriculum, which stated the importance of hands-on experiences. Schwichow *et al.* (2016) added hands-on experiences could positively impact students in learning science concepts, hands-on experiences (especially experiment learning) is essential for students to consolidate their theoretical knowledge, as well as reasoning. By participating hands-on experiences, students could get better understanding of the topic by self-experiencing the experimental procedures and handle with apparatus in hands-on laboratory experiences (Vesilind & Jones, 1996). More importantly, this emphasizes the ultimate goal and central focus of integrating the procedural knowledge and laboratory skills with theoretical knowledge (Bybee, 2000; Sunal *et al.*, 2008), rather than separating and learning them upon an individual basis, as stated by Hodson (1993).

For inquiry-based learning, which is another hot topic in terms of science learning, especially related to the hands-on activities (e.g., especially for experiments), they could profoundly affect

students' learning efficiency and effectiveness, as laboratory sessions can provide opportunities for students to learn by inquiry (National Research Council [NRC], 2000). Thus, supported by Brinson (2015), Schwichow *et al.* (2016) and Nakhleh, Polles, & Malina (2002), rather than memorizing conceptual knowledge, laboratory session could provide a learning approach to undergo inquriry-based learning. Hence, it provides iverse approaches for students to study scientific concepts via observations, proposing ideas, questioning, explaining and justifying based on theoretical knowledge as evidence from previous findings (Hofstein & Lunetta, 2004; Glasson, 1989). Therefore, huge significance of hands-on experiences have to be included in the curriculum. However, the COVID-19 pandemic situation shredded the opportunity for students to participate into the hands-on activity in online mode of learning, where the frequency also dropped.

5.2.2 Effects of the lack of hands-on experiences in science class

As discussed, hands-on experiences are essential for students to learn in science subjects, as they would directly (on hands-on experiences of science topics) and indirectly (on other aspects, such as motivation, confidence and soft skills or nine generic skills) affect students (Sadi & Çakıroğlu, 2011; Glasson, 1989; Tobin, 1990). The nine generic skills (CCCCSSPIN) were listed in the Table 18, where the bold items were indicated as the major impacts if hands-on experiences is lacked or even omitted.

Table 18: *The nine generic skills (CCCCSSSPIN)*

Nine generic skills (CCCCSSPIN)	**Explanation of major impacts**
C: Collaboration	Decreased interaction of class between peers.
C: Communication	Decreased interaction of class upon peers' learning or interaction in between the teacher and the students, or among peers.
C: Critical thinking	Hands-on experiences mostly consisted of critical thinking components (e.g., scientific investigation).
C: Creativity	Hands-on experiences (e.g., experiment) may require students to design experimental set-up for undergoing experiments in a series of scientific investigation.

S: Self-management

S: Self-learning

P: Problem-solving	Most hands-on experiences may consist of questions for students to ponder, or undergo a scientific investigation or experiments, there could be follow-up questions for students to answer. Hence, which may consist of critical thinking skills as well.

I: Information Technology

N: Numeracy

In addition, instructing experiments upon online learning mode cannot provide such interactive teacher-instructing methods for students to actively respond teachers' questions during learning an experiment, or collaboration between peers which posed the "interaction issues" as mentioned by most of the students and teachers participants in the interview.

Moreover, it loses the positive features of a constructivism and student-centred classroom (Bleicher & Lindgren, 2005) with teaching orientations mostly shifted to direct teaching and shredding dimensions of learning content in a hands-on activity.

Hence, looking into the results of questionnaire and findings provided, it could be proved that the consequences were partly attributed to restricted conditions and scenarios of delivering content via online platforms, comparatively lower-efficient teaching pedagogies involved, together with limitations of the resources or teaching materials that could be given to students, and which could affect their cognitive thinking and ability and performance of critical thinking, supported by Colvin, Reesman & Glen (2022).

5.2.3: Effects of hands-on experiences and online learning on the students' academic results

Both students and teacher participants mostly did not find online lesson and online hands-on activities useful and disagreed they could achieve a better academic result. Some participants even reported in the interview of which their (or their student's) academic results deteriorated (or

fluctuated so much) after the pandemic started when online lessons were adopted. Hence, the majority of student participants disagreed that the transformation of learning mode could drive them attain a better academic result. In addition, the participant also disagreed online learning and related hands-on experience online could aid them to fulfill the intended learning outcomes, or maintain their academic results confidently. Furthermore, for teacher's perceptions, online mode learning and online hands-on activities were not effective for students to study science subjects and improve or able to maintain their academic results. The lack of hands-on experience could negatively affect the students' standardized test results, supported by the finding of Bulunuz, Bulunuz, & Peker (2014), students were found with higher achievements as they have more thorough understanding of the textbook content, and these students could be able to connect and apply the concepts more effectively in different learning topics seamlessly, vice versa.

However, scarcely there were a small portion of single-digit students in the questionnaire, and one student in the interview (student B) mentioned that the actual influence towards academic results during online mode of learning, was not in a huge negative influence, could be maintainable (or as neutral stance), or even upon a positive rate of improvement. Hence, this would partly due to the fact that, as teacher B and C, and student C mentioned, they are mostly more self-disciplined and industrious students, or high achievers in the science subjects. Moreover, it would be related to the students' personality and their positive attitude towards learning, where industrious students who already had productive learning could still get benefit from the current online learning styles, supported by Akgunduz & Akinoglu (2016) and Schibeci (1984), i.e., or multimedia learning currently adopted in Hong Kong online-based classrooms. As a result, the adoption of online lessons and hands-on experience could alternatively contribute to improvement in their academics, or higher achievements (Akınoğlu & Tandoğan, 2007; Narmadha & Chamundeswari, 2013).

5.2.4: Negative impacts on students' results and motivation because of insufficient chances for interactions

Due to the restrictions of the online mode lessons (e.g., the design of online classroom's software or requirements of devices' hardwire) during the pandemic, students were claimed to be unmotivated in online classes due to lack of hands-on experiences provided to students, where interactions is also one of the big reasons among all factors.

Interaction is used to be a practice with a positive learning environment for students to learn from their peers. Various studies have suggested that the laboratory sessions (i.e., hands-on experiences of students in class) can provide a small-group collaborative learning environment to investigate into a scientific concepts (Hofstein & Lunetta, 1982) or relationships in between theories (Lazarowitz & Tamir, 1994; Tobin, 1990; Lunetta, 1998). Hence, laboratory sessions itself could be a way for shifting the teaching instruction approach from solely direct-teaching to student-centred classrooms with addition of interactions, questioning and discussion spaces.

5.2.5: Discussion on the common consensuses of suggestions to alleviate for inadequate experimental skills gained in online mode science classes

In the interview sessions, both group of participants have mentioned a medley of suggestions that could be used for alleviating the inadequate experimental skills, as well as the restriction of online classes in learning the science concepts and hands-on skills components in corresponding learning topics. Hence, these suggestions could be supported with findings in various research projects in which the suggestions have been applied into the science curriculum, where the report revealed that these suggestions of creating various learning approaches or teaching aids would be of much beneficiary effects to students' science achievements.

First of all, multimedia learning would be beneficiary to students' science learning, as most of the students are visual learners (Almara'beh, Amer, & Sulieman, 2015). Multimedia components could bring huge benefits upon their effectiveness of acquirement of knowledge and experimental skills (Almara'beh, Amer, & Sulieman, 2015; Kiat *et al.*, 2020; Plass & Schwartz, 2014), where simultaneously it provides opportunity for students to revise back the learnt knowledge that had

been taught years ago, hence, this favours the revision and learning progress of students, with solving the learner's diversity issues on the classroom's teaching in which students have unique learning needs towards a science topic. The multimedia information could provide a series of different information to nurture their studies, where elite students could make use of the materials for obtaining advanced knowledge, for other students, it could be as a supplementary source of materials to enrich the learning content of a topic.

Secondly, AR or gaming approach, Chen (2020) reported that games could boost students' learning effectiveness by increasing their arousal of interest towards learning science. Thus, this could boost one of the key learning aspects investigated in this research study, i.e., motivation. Hence, in which motivation is also one of the key factors which could alter students' academic performance, participation level, and attitude towards their study.

In addition, virtual laboratories could also be one of the viral teaching aids to be implemented in science curriculum throughout the recent years. The virtual laboratories provide hands-on skills simulation for students to learn the procedural knowledge and the related experimental skills of a set of experiment. "Labster" (a Danish company) is one of the famous third-party virtual laboratories provided simulation of students to use their devices to perform virtual experiments by using a computer mouse or fingertips. Hence, Yap *et al.* (2021) utilized Labster and Google Daydream to plan two separate virtual laboratories on cell culture basics and animal biotechnology, in which simultaneously are the two heat topics that would be taught in senior secondary HKDSE Biology classrooms. Upon the completion of the virtual laboratories, the students found the laboratory components helpful during the pandemic when face-to-face classes were strictly suspended. However, guidance is still crucial when students try to use these simulators included in the virtual laboratories, just like some of the concerns mentioned by students in the interview.

Last but not least, 3D simulators could be applied into science curriculum, as students could utilize the three-dimensional simulators to investigate into the structure of anatomy of human organs and body structure of animals. For instance for the Biology topic "trunk and limbs" of human bodies, which is also one of the learning topics in HKDSE curriculum, the research (Klein *et al.*, 2021) found out that 3D simulators could be useful to explain the complex ideas of science physiological

functioning in animals, upon a medley of components. Thus, it is beneficial for supporting students' science learning and teachers' teaching by applying the 3D simulators as the teaching aids. Hence, the research (Smetana & Bell, 2012) validated the 3D simulators could boost students' effectiveness and efficacy in learning complicated and abstract concepts.

Referring to the HKDSE curriculum of Biology (The Hong Kong Curriculum Development Council [CDC] & Hong Kong Examinations and Assessment Authority [HKEAA], 2015), "performing dissection of a pig's heart and examine its structures" is one of the essential activities in linking up and relating the scientific concepts, anatomy of human's heart, and their corresponding functions in human. In addition, this activity is one of the hands-on skills requirements under the HKDSE curriculum, where it requires an advanced level of experimental skills for students to perform a sophisticated experiment with a medley of procedural steps and dissection skills. During the pandemic in online lessons (current situation), Hong Kong students scarcely had opportunities to maneuver the experiments with apparatus in their hands. Thus, the current situation posed issues on inability on fulfilling the learning outcomes, in which the experiment components need active participation of students in related hands-on activities, as premise mentioned, where active participation is important for students to gain various insights under classrooms with constructivism (Almroth, 2015; Widodo, Maria & Fitriani, 2017; Makhleh, Polles & Malina, 2002; Flick, 1993). As a result, students could not understand the proper procedures and skills in practice without any hands-on experiences. Argumentatively, demonstrative videos could only help students in a small extent to understand the skills of handling the experiments, which posed incomprehensiveness of coverage of components (Lekang, Nain, & Singh, 2017) and applicability of science concepts into practice in learning science (Mubin *et al.*, 2013).

Part 6 (Suggestions, Limitations & Conclusion)

6.1 Conclusion

Respondents in this research study generally disagreed that online learning or online hands-on experiences could bring benefits towards learning, upon the four main aspects investigated in this study, with good reliability of statistical results. The paired-sample t-tests and comparative analysis

could mutually prove that the perceptions made upon face-to-face learning (before the COVID-19 pandemic) and online learning (after the pandemic started) were statistically significant and valid, and consisted of major opposing stances in comparing of both scenarios. MANOVA tests also proved that age (for students only) and gender shall not be the factors of affecting the perceptions' decisions. Hence, the findings in content analysis could align with the findings of the questionnaires well. As premise mentioned, acquirement of experimental skills, lack of interactions, "puzzled and confused" (emotions) in online learning, and inadequacy of online resources are the most prone-mentioned and potential issues of insufficiencies of hands-on experiences.

A series of suggestions had been suggested by the respondents, where the suggestions could be supported by various findings, and feasible to be implemented in schools or science curriculums.

6.2 Limitation and corresponding suggestions of solutions and implication for future research

In this research study, there are two categories of potential limitations, where the suggestions put forth could provide horizons and implications for future research.

The first category of limitation related to the sampling method and methodology of this research study. This research study dominantly relied on non-probability sampling method and snowball technique for participants' invitation, which could have contained bias among the researcher. Therefore, as considering alternative sampling method, probability sampling (random sampling) could further increase the level of convincement of the findings. However, the well-aligned findings with great uniformity of responses and perceptions revealed in this research study, the results were convincing and valuable for readers' references.

Moreover, bias could be included in between students or teacher, in which it affected the initial perceptions of participants. For the bias which may affecting students, as different teachers have different teaching styles, pedagogies and methods, which made students' perceptions different in

different schools. On the other hand, different levels of groups of students related to the "banding" of the school background, which are correlated to the inherent cognitive levels (better achievements) of the students initially, may affect teachers' answers on their perceptions score. Therefore, considering a better comparison of changes of students' all-around performance in science learning, the future research could look into the science achievements of the participants (before/after the pandemic; face-to-face and online mode of learning), with external-influencing factors (such as "banding" of schools), and their experimental skills gained in lessons or hands-on experiences held online or face-to-face mode of learning (with the aid of pre-tests and post-tests, or focus group interviews) taken into account.

The second category of limitation was on the research findings, there were no analysis of data by subjects, the further researchers should consider to host a research study by breaking down from a broaden horizon (i.e., all science subjects) to a single subject (e.g., Biology, Chemistry, or Physics) at a time, in order to get a better overview of students performance precisely in one subject.

Moreover, the research study attempted to collect data for Special Education Needs [SEN] learners' data analysis on their learning during the COVID-19 pandemic, in both learning mode targeted in this research study. However, inadequate data were received for analysing the potential problems in online mode learning for the SEN learners, as the respondents are mostly not SEN learners or teachers who had no experiences in teaching SEN learners. Therefore, for future research pathways, separate researches targeted on SEN learners only are necessary, as scarcely there are research that aimed on this group of students in science learning.

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Appendix (Supplementary Materials)

Appendix 1: Profile of participants and Integrated transcripts of interviews (Students)

Integrated transcripts of Interview (**Students**)

Interviewer: Mr. CHEONG Pui Sang

*Interviewee: Student A, B, C, D, E, F, G (Individually) (Students F, G's interview progresses were not recorded, as the request of the participants. Therefore, main points were only noted in these interviews; same/similar meaning **with the same key wordings [the standard]** of the point would be integrated as one line of conversation)*

Table 19: *Profile of students' participants in the interview*

ID	Age	Type of school Currently Studying	EMI/CMI	Science Subjects Currently Studying	Area of Current School (or 18 districts)	Medium language of interview
Student A	17	Governmental	EMI	Biology, Chemistry	Kwai Tsing	Cantonese with English
Student B	18	Subsidized	EMI	Biology, Chemistry	Kwai Tsing	Cantonese in major, English as supplement
Student C	17	Governmental	CMI + EMI	Biology	Eastern	Cantonese with English
Student D	18	Subsidized	CMI	Biology	Eastern	Cantonese
Student E	17	Governmental	CMI + EMI	Biology, Chemistry	North Point District (Eastern)	English
Student F (no recording)	17	Private (DSS)	EMI	Chemistry, Physics	Kowloon East	English

Student G (no recording)	17	Subsidized	EMI	Biology, Chemistry, Physics	Kwun Tong	English

Greetings & Granted for consent (for all participants)

您現正受邀參與一項由香港教育大學科學與環境學系所統籌的短期研究，此項研究是由張予菱博士所督導，並由莊培生先生擔任主研究員。

此項研究的主要目的是探究在 COVID-19 疫情期間，因防疫措施和校舍不能如常正常開放的關係下，老師和學生對所有科學類（理科）科目的實驗課、實踐經驗及學習的一些看法和感受。

如您願意參與本次的研究，我們會現在開始今天的面談。

Interviewer: Thanks for your agreement. First of all, I would like to ask you some of your personal information. Please exclude all specific organizational background and personal sensitive information. I would like you…. to ask you (what is) your age?

Student A: I'm now 17 years old.
Student B: 18 years old right now.
Student C: I'm 17.
Student D: 18.
Student E: 18 years old, oh no, 17 years old.
Student F: 17.
Student G: 17.

Interviewer: Alright (thanks a lot!). So, what type of school are your currently studying? Subsidized school, governmental school or private institution?

Student A: Um……. It is a governmental school.
Student B: I am not sure; I think it is a subsidized school.
Student C: Governmental.
Student D: Subsidized school.

Student E: Mine is governmental.

Student F: Private school, direct-subsidy ones.

Student G: Subsidized school in Kwun Tong.

Interviewer: Is it a CMI or EMI school?

Student A: EMI

Student B: EMI

Student C: Actually, my school provided a two-sided medium class for us to choose with, so I would say both?

Student D: CMI

Student E: I think it's both, because recently we open for NCS.

Student F: Private school, direct-subsidy ones.

Student G: Subsidized school in Kwun Tong.

Interviewer: (Thanks.) What science subjects are you currently studying?

Student A: Biology and Chemistry.

Student B: Science subjects, I have Biology and Chemistry for my electives.

Student C: Only Biology.

Student D: I only study (for) Biology.

Student E: Currently studying Biology and Chemistry.

Student F: I am currently doing with Chemistry and Physics.

Student G: All, I mean Biology, Chemistry and Physics.

Interviewer: How long have you been studying these science subjects?

Student A: Two and half more years.

Student B: Three years.

Student C: Two and a tad more years, same for the hands-on experience

Student D: Two and a half, wait, reaching 3 years I would say, as I will be going the HKDSE examination.

Student E: About three years

Student F: 2.5 years, same for the hands-on experience.

Student G: 2.5 years, same for the hands-on experience.

Add-on question for students A, B, D, E

Interviewer: How long and did you join any hands-on experiences in the science lessons during this period?

Student A: Same duration, and I have joined (those hands-on experiences)

Student B: Same.

Student D: Should be the same.

Student E. Yes, the same (about three years).

Interviewer: Where is your school located?

Student A: New Territories

Student B: Kwai Tsing

Student C: Eastern, in North Point

Student D: Eastern

Student E: North Point (Eastern)

Student F: Kowloon East

Student G: Kwun Tong

Add-on question for student A

Interviewer: Can you mentioned which district of the 18 districts in Hong Kong?

Student A: Kwai Tsing

Interviewer: Thanks a lot (thank you), now let's proceed. To your understanding, what are some examples of hands-on experiences or activities?

Student A: Experiments, like those in chemistry. And Dissections I think, in Biology.

Student B: Experiments majorly I would say. Discussion with some materials should count.

Student C: Experiments.

Student D: Experiments, including those online lab resources that we can find online.

Student E: Experiments.

Student F: Simulators and experiments in my opinion.
Student G: Experiments should be the key thing, I think.

Interviewer: How about those hands-on experiences online? Can you list out some examples?

Student A: Virtual laboratories but I didn't use it, and those 3D simulators somehow available online these days, I saw them on Google.
Student B: I had a Biotechnology project in online class, just once online learning hands-on experience. →was further discussed in later session
Student C: Online laboratories, sounds interesting but I have never tried that before.
Student D: I don't know. May be talking about the hands-on components online like simulators, that we can use a laptop computer to do the drag and drug motions with a mouse?
Student E: During the suspension of class, I have had a project to do with my classmates. →was further discussed in later session
Student F: Virtual laboratories, I have tried once for the Chemistry experiment, that's the metal plus add acid chemical reaction.
Student G: Online videos, and those laboratories available on Google. I have just heard about it but did not try to go through it by myself.

Interviewer: To your studying experience in science subjects before and during the COVID-19 pandemic, what are the differences in frequencies 頻次 of participating these hands-on experiences? How?

Student A: Lower and **decreased a lot**, I mean that is quite less frequent during the pandemic. Probably, we scarcely have chance to participate into these hands-on activities, may be **once in more than a month** I would say. Face-to-face much higher, about **once a week**, I would say.
Student B: Usually **once a week before the pandemic**, but now we just have once only.
Student C: **Once in two to three weeks I would say, sometimes once a week before the pandemic**. **Just decreased in amount and frequency**, not good for me.
Student D: **Decreased a lot, from once a week to more than a month for once.**
Student E: **Definitely lesser, a lot lesser, I had once in two weeks' time, and it is way more frequent** when I am studying in face-to-face mode of learning.
Student F: **Dropped**

Student G: **Decreased** quite a lot. **I don't even have once for a month, usually its once a week to once in two to three weeks.**

Add-on questions

Student B's

Interviewer: So let's say it is **once in more than a month**?

Student B: Yup.

Interviewer: And that is a decreased trend, right?

Student B: Yup, a lot.

Student F's

Interviewer: How it is dropped?

Student F: I mean I **usually its once a week to once in two to three weeks but now I just had once in a month, or even more than a month.**

Interviewer: Can you recall some examples (in learning topics) that online hands-on activities are available for you to participate in class/after the class during the pandemic when we have online mode lessons?

Student A, C, D, F, G: Sorry, I can't remember. / Sorry, I really forgot what the learning contents and the components of the online lab were.

(Student A: But sometimes, we do have certain demonstrative videos provided by the teacher.)

Student B: The teacher gave us a set of tangible resources for us to learn at home. We got them at school and the teacher would use those materials to show us how DNA fingerprinting would work at home. We guided the instructions of the teacher.

Student E: It is related to a virus. It was a project about infectious diseases, MERS, and we have to talk about the knowledge, symptoms from the book, such as which area of the body is affected, as well as how it is transmitted. We have made a model for the MERS virus as well. That's the only thing we have done so far.

Interviewer: (To students A, C, D, F, G: That's fine.) So, is there any time limitation for you to access these e-laboratories sessions, e.g., in class for just 10 minutes, or you can access it freely online?

Student A, B, C, D, E, F, G: Freely online.

Student C: Actually, the teacher would put on the Google classroom for us to access them when we were free. Sometimes, they would directly post the video on the WhatsApp group.

Interviewer: Do you know are there any special school arrangements, policies, or learning/teaching plans on hands-on experience for both face-to-face classes and online classes?

Student B, C, F: I don't think so.
Student D, E, G: The lesson period is lesser (in time) than the previous settings.
Student A: I don't think we have it but the lessons duration for classes decreased.

Additional questions for students A, D, E, G

Interviewer: Like how?

Student A: Every lesson is 10 minutes lesser than a normal period of lesson (which was 40 minutes usually), that's make my learning progress a bit affected.
Student D, E: We only have 30 minutes left for each lesson, every lesson is so hurried to complete…… That's affecting my learning progress.
Student G: We only have 20 minutes for each lesson, half of the time. Even the teachers thought that was not enough for students to learn. Somehow, we always had to arrange much time to do supplementary after-school classes to chase back the learning progress.

Interviewer: Thanks, so throughout the duration of pandemic, from your perceptions 認知, what are your learning needs 學習上的需要?

Student A: I would say the hands-on skills because we don't have experiment in online classes right now. That also drags down my motivation to participate into the class, because there is no interaction between my friends and me.
Student C, D: I don't think the online lesson during the pandemic could spark up my interest to learn, compared when I am in the face-to-face lesson, I am more attentive in class.
Student B, E: Face-to-face classes are usually attached with interesting activities (Student E), but now, everything is boring and seemed could not be linked up between the learning content into the asked questions in science and in practice for the experiments.
Student F, G: Interaction issues and hands-on experimental skills issues

Add-on questions for A, B, C, D, E

Interviewer: Can you explain these issues a bit more? How does it affect your hands-on skills and motivation in participating the class?

Student A: We don't have group activities anymore, and we don't have conversation in class between students, the teachers kept talking all the time in the lesson. Hands-on activities, very seldom have it, we don't have interaction and I lost motivation to learn. I don't have chance to perform any experiment on my own. That killed the learning ambience of our class. I am more motivated in class during the face-to-face class, as the hands-on experiences can spark up my interests.

Students B, C, D, E: Lack of hands-on skills could be gained in the online class, and we don't have much interaction/communication/contact with our peers in the same class. I also felt puzzled when I come across difficult learning content or some experimental component (student E).

Student F, G: Interaction and hands-on skills issues are the major learning issues. We don't have group work, we don't have experiments, sometimes, I (student F, G) felt puzzled when the teachers were talking about the abstract science concepts during learning.

Student E: Google meets also killed our group discussion opportunity, as the restriction of the software itself.

Student A, B, C, D, E and G: The restrictions of the online mode classes via online platforms limited the learning content in science classes.

Interviewer: Thanks. On the other hand, do you receive any (or extra) supportive measures from your school/ teachers in learning science subjects?

Student A: I don't think so.

Students C and E: We do have supplementary classes on weekends. Once a week.

Students B, D, F, G: Don't know/not sure.

Student C and E: Another thing – which dragged our learning progress is the school-based issues, of which we always changed our teacher each year?

Additional question for students C and E

Interviewer: Can you explain this a little more?

Students C and E: Actually, we had changed three teachers in just three years for Biology, the teachers kept changing when a new academic year starts.

Interviewer: Are you a learner with special education needs (SEN) 有特別學習需要?

Student A, B, C, D, E, F, G: I'm not.

Interviewer: So, during the pandemic, did your school buy any kind of software, e-learning kits, virtual laboratories (simulators/activity-based kit) that are currently using or will be used in the future?

All: I don't think so. / We don't have it.

Interviewer: So, did you try any kind of virtual labs during the pandemic on your own, as you have mentioned you have seen those online?

Student A, C, D, E: No, I didn't because I don't know how to use those.
Students B, F, G: I know those virtual laboratories a bit but did not (did not attempt) to use it.

*Interviewer: What do you observe upon **the changes** of your academic results and learning progress **before and during** the COVID-19 pandemic? Can you list some examples?*

Student A, D, E, F, G: Deteriorated. I mean my academic results got affected so much during the period.
Student B: Somehow not much affected, in some cases, I improved.
Student C: Somehow not much affected, could be maintained.

Interviewer: How about the science subjects?

Student A, D, E, F, G: The same, keep dropping, online lesson could not help.
Student B & C: Could be maintained (both). (Student B said it would be great for him to get an improvement in Biology).
Students B, C, G: Hands-on experience in face-to-face lessons helps to facilitate the learning but not in online lessons.

Interviewer: Is it because of the inadequacies of hands-on experiences online?

All: Definitely that is one of the factors. As experimental skills are essential learning components of any science subjects. + Online learning does not allow us to learn hands-on skills of experiments.

(In addition) Student A, B, C: I think there are some correlations to it, but I would say the learning vibes and motivation are the most important factors, the lesson is just boring online during the pandemic.

Interviewer: Do you think you can achieve a better result during the pandemic?

Student A, D, E, F, G: I don't think so (Student A and F laughed; Student G giggled).

Student B and C: It depends, in current situation, it's still fine.

Student B: But in the beginning of the pandemic, I don't think I am confident enough to achieve a better result during the pandemic.

Interviewer: Do you think you can achieve the learning objectives 學習目標 that are set by the teachers confidently?

Student A, D, E, F, G: I don't think so too.

Student B and C: It is ok, except for those experimental components.

Student C: For example, for the use of microscope, even if I watched through the videos online, I still cannot get the important information of how we could use a microscope, which is one of the learning objectives in my one of the revision lessons at school for Biology.

Interviewer: Do you think you can learn everything effectively, not only the theoretical knowledge but also the experimental skills (that are expected to gain from the hands-on experience?) in science classes during the pandemic?

All: I don't think so.

Students A, C, D, E, F and G mentioned that hands-on experiences provide them insights of getting experimental skills, especially in the experiments.

Student A: I don't think so, how can I learn experimental skills (hands-on skills) without using the apparatus, that's impossible, even the demonstrative videos could somehow cannot help us to grasp the skills of using it. Hands-on experiences actually gave me the insights of getting experimental skills, I want to do that by hands not via online videos.

Student C, E and F: I think the interaction issues caused a lot of problems when we tried to share the skills and knowledge in science lesson, such as during the experiments, we would do discussion in between the peers and the students and teachers. But the whole thing right here has been omitted, which somehow makes we are less motivated and attentive in class (students C, E: More attentive during class)

Interviewer: Thanks for your opinion. Any learning difficulties in your online-based lessons?

Student A: Lack of interactions, and not enough e-resources to learn. Oh no models for us to structure of human body is also one of them. We don't have chances for interactions during online lessons.

Students B, C, D, E: Lack of interactions, some of the students in the class would not talk, that's make some communication issues.

Student F: I think, for the soft skills and interactions, a little lesser (lower) than normal, and I'm unmotivated for the classes.

Students D, F, G: Every time when we tried to use a e-resources available only, most of them required subscription, and we can no longer used them afterward, so I have to cancel the order.

Students B, C: Soft skills are sufficient during face-to-face classes before the pandemic.

Students A, E: Better before the pandemic, (much) lower during the pandemic.

Students D and G: Okay for the soft skills but not the interactions (no chance).

Interviewer: Can you explain a bit more for the later opinion, about the model issues?

Student A: Somehow, we don't have any tangible or online model that suits for our study and revision.

Interviewer: So, do you have any feeling regarding your revision/learning/study progress during the pandemic?

Student A: I'm quite unmotivated during online learning.

Students B-G: Omitted for this question

Interviewer: Can you list out a total of two to three (positive and negative) adjectives that could psychologically describe your current learning progress during the COVID-19 pandemic?

Student A: Lazy, stressful, exhausting, bored etc.

Students B, C, D, E, F, G: Harsh and hectic, exhausting, dull and bored (students E, F, G)

Students E, F, G: Unmotivated

Interviewer: What kind of resources you think you need in learning during online learning and online hands-on experience learning classes, for science subjects?

Student A, B, C, D, E, F: 3D Simulators (except student B, student E suggest a database), and actually virtual laboratories is also great. (aligned with HKDSE curriculum, students D and E) Students

Interviewer: Do you agree more online-based resources should be created for e-learning?

All students: Of course we want them (of course we need more), especially platforms (except student F), we don't have many platforms which could facilitate our studies.

Interviewer: Any suggestion on the current learning materials / modification or additional items of learning materials on online laboratories?

Student A, C, E: I think those demonstrative videos could be more clearer with reminders, especially on those experimental skills. Student A and E: More guidance would be great for revision purposes. Hence, student C and E: I think it will be a good supplement for us to learn the experimental skills, and that's how we achieve critical thinking, I would say…….Yup.
Student E and F: Artificial intelligence, augmented reality (AR) (student F), or markers could be added to the database for students to learn more realistic situations of experiments (student E and F).

Interviewer: This is an additional question. Do you think the fusion of hybrid mode of lessons (face-to-face and online) with multimedia of learning is a good way for us to learn and study science subjects?

All: I think it's good for hybrid learning mode, as I can do my self-learning anytime I want. The teacher can focus other issues during the lesson.
Students C and F: Multimedia learning is a good start of multimedia learning, as it could solve the learning needs of each of the student as well.

To all participants:
That's the end of the interview. I sincerely thanked you for your participation into this interview.

Appendix 2: Integrated transcripts of interviews (Teachers)

Integrated transcripts of Interview (**Teachers**)

Interviewer: Mr. CHEONG Pui Sang

*Interviewee: Teachers A, B, C, D, E, F, G (Individually) (Teachers E, F, G's interview progresses were not recorded, as the request of the participants. Therefore, main points were only noted in these interviews; same/similar meaning **with the same key wordings [the standard]** of the point would be integrated as one line of conversation)*

Table 20: *Profile of teachers' participants in the interview*

ID	Years of teaching experience	Type of School Working Currently	EMI/CMI	Current Teaching Science Subject(s)	Teaching Position(s)	Working Area (or 18 districts)	Medium language of interview
Teacher A	7	Subsidized	EMI	Integrated Science (IS), STEM, Chemistry	GM (IS Panel Head)	Kwai Tsing	Cantonese with English
Teacher B	12	Subsidized	EMI	Biology, IS, STEM	GM (Biology Panel Head)	Yuen Long	English
Teacher C	1.5	Subsidized	EMI	Biology, STEM	GM	Kwai Tsing	English
Teacher D	0.5	Subsidized	CMI	Biology, IS	GM	North Point (Eastern)	Cantonese with English
Teacher E (no recording)	18	Governmental	EMI	Chemistry, IS, STEM	GM	Kwun Tong	English
Teacher F (no recording)	28	Private (DSS)	EMI	Chemistry, STEM	SGM (Chemistry Panel Head)	Central and Western	English
Teacher G (no recording)	5	Private (DSS)	CMI	Physics, IS	GM (Physics Panel Head)	Tseung Kwan O	Cantonese with English

Granted for consent (for all participants)

您現正受邀參與一項由香港教育大學科學與環境學系所統籌的短期研究，此項研究是由張予菱博士所督導，並由莊培生先生擔任主研究員。

此項研究的主要目的是探究在 COVID-19 疫情期間，因防疫措施和校舍不能如常正常開放的關係下，老師和學生對所有科學類（理科）科目的實驗課、實踐經驗及學習的一些看法和感受。

如您願意參與本次的研究，我們會現在開始今天的面談。

Interviewer: Thanks for your agreement. First of all, I would like to ask you some of your personal information. Please exclude all specific organizational background and personal sensitive information. I would like you…. to ask your number of year(s) of teaching experiences?

Teacher A: 7 years
Teacher B: 12 years
Teacher C: Um…. It's about 1.5 years.
Teacher D: 0.5 years, I have just started my teaching this academic year.
Teacher E: 18.
Teacher F: 28 years.
Teacher G: 5 years.

Interviewer: Alright (thanks a lot!). So, what type of school are your currently teaching? Subsidized school, governmental school or private institution?

Teacher A: Subsidized, EMI
Teacher B: Subsidized and EMI
Teacher C: Subsidized and EMI
Teacher D: Subsidized
Teacher E: Governmental.
Teacher F: Private school, direct-subsidy scheme school in Central and Western District.
Teacher G: Private, in Tseung Kwan O.

Interviewer: Is it a CMI or EMI school?

Teacher A: *Answered*
Teacher B: *Answered*
Teacher C: *Answered*
Teacher D: CMI
Teacher E: EMI
Teacher F: EMI
Teacher G: CMI

Interviewer: (Thanks.) What science subjects are you currently teaching, and your teaching positions?

Teacher A: Graduate Master (GM) in Integrated Science (IS) (as well as I am a IS panel head), STEM and Chemistry.
Teacher B: I teach as a GM in Biology (I am a biology panel head as well), IS, STEM.
Teacher C: GM in Biology and I teaches STEM education as well.
Teacher D: Biology and IS, and I am a GM
Teacher E: Chemistry, IS, and STEM, GM
Teacher F: Chemistry and STEM, Senior GM
Teacher G: Physics and IS, GM panel head in Physics

Interviewer: Where is your school located?

Teacher A: Kwai Tsing
Teacher B: Yuen Long
Teacher C: Kwai Tsing
Teacher D: North Point (Eastern)
Teacher E: Kwun Tong
Teacher F: *Answered*
Teacher G: *Answered*

Interviewer: Thanks a lot (thank you), now let's proceed. To your understanding, what are some examples of hands-on experiences or activities?

Teacher A: That's a lot to share, we have experiments, models, simulators, and software. Sometimes, we have card games for student to play as well, for study purposes.
Teacher B: Experiments majorly I would say, because it consists of most hands-on skills. STEM education will have robotics items, simulators are used to use in class as well.
Teacher C: Experiments, hands-on skills will be taught in class with experiments usually. Sometimes, I will also prepare some videos for student to watch and make revision.
Teacher D: Experiments, including those online lab resources that could be downloaded from the book publisher, where they are mostly the 3D simulators prepared by the book publisher.
Teacher E: Experiments, software and models
Teacher F: Simulators and experiments in my opinion.
Teacher G: Experiment is the major thing, sometimes I'll prepare the purchased model for the students, let those objects be tangible (such as the pendulum).

Interviewer: How about those hands-on experiences online? Can you list out some examples?

All teachers: Most of the time, we would use demonstrative videos to substitute the experimental hands-on experiences, as the COVID-19 restriction on the school classes.
Teacher A, D, E, F: Those demonstrative videos were downloaded and provided from the book publisher. Sometimes, we will make use of the YouTube videos for substitution when the videos provided by the book publisher is not appropriate to use (teacher A, D, F)
Teacher C: I have planned a Biotechnology product in which we provide tangible resources for students to complete a simple DNA fingerprinting at home, and with the aid of third-party simulators, just like the sense of running an ink chromatography.

Interviewer: To your teaching experience (for these 5 years), before and during the pandemic, what are the differences in frequencies of hosting these hands-on experiences? How?

All: Decreased a lot. (Teachers A, B, F: Dramatically; Teachers D and G: Significantly)
Teachers A, B, G: Usually the experiment session (or including any hands-on experience sessions) before the pandemic in face-to-face classes are **once a week**. **But after the pandemic started, it dropped to the frequency of once in a month (Teacher A and B) or even worser, once in two months (Teacher G).**
Teacher C, D, E, F: At the beginning, **we planned and started the hands-on experiences with once a week to once in two to three weeks at most**, as students need hands-on activities to learn

any science concepts. However, once the pandemic started, it **decreased in frequency** for the number of hands-on experiences hosted.

Interviewer: Can you recall some examples (in learning topics) that online hands-on activities are available for you to host in class/after the class during the pandemic when we have online mode lessons?

All teachers (except C): I don't have much example /or any, except for the demonstrative videos we are currently using right now. That's the reasons why students cannot gain any kind of experimental hands-on skills through online activities, that's a huge issue (teacher B).
Teacher C: Just like what I have mentioned, I think that will be the only hands-on experience I have done so far after the pandemic started, with online lessons adopted.
Teacher A, B, D: Actually, the school (or the teacher himself/herself) very depends on the demonstrative videos online or provided by the book publisher.

Interviewer: So, is there any time limitation for students to access these e-laboratories sessions (demonstrative videos), e.g., in class for just 10 minutes, or they can access it freely online?

Teacher A, B, C, D, E, F, G: Freely online.
Teacher C, D, F: Actually, I would put on the Google classroom for us to access them when we were free. Sometimes, I would directly post the video on the WhatsApp group (C, D) for quick access for students.

Interviewer: Do you know are there any special school arrangements, policies, or learning/teaching plans on hands-on experience for both face-to-face classes and online classes?

All teachers: Once the pandemic situation started, the school's lesson duration has been shredded, as the request by the EDB, only half-day mode of lesson adopted.
Teacher B, C, D, F: Actually, this is an issue of why some students fell behind during the learning progress.

Interviewer: Thanks, so throughout the duration of pandemic, from your perceptions 認知, what are the learning needs of students 學習上的需要?

All teachers: **Hands-on skills** issues (except C), which pose **motivation issues** (except C and G).

Teachers A, B, D, E: In the face-to-face lessons, I would observe students **can grasp the experimental skills**, in which the experimental skills could be gained (teachers A, B, D, E) **but never in the online lessons (all teachers).**

All teachers (except Teacher A and C): I found students would be **puzzled and confused** (n=4, except teacher F) when I **tried to teach difficult and abstract learning science topics**.

Teacher B: When you tried to explain the topics to students and ask whether students understand a certain topic or not, they would have **no response** to you, this made me very difficult to keep track on students' learning progress, and how much did they learn.

Teacher B and D: Some of the students found it difficult to understand the science concepts when they are studying online.

Teacher D: **inadequate of e-resources**

Teacher E: The students **cannot choose the right e-resources for themselves, no pin-to-point to HKDSE curriculum e-learning package**.

Teacher B, D, E, F, G: **interaction issues** and which are somehow related to students' motivation in class. The **motivation of most of the students dropped** (including teacher A), compared to the face-to-face lessons before the pandemic.

Teacher D: The school software used ("Google Meets") does not provide breakout room function, which makes a lower opportunity for students to make interactions in class.

Teacher A: We **don't have experiment in online classes right now. That also drags down students, learning motivation on many topics**. I can observe their intention to join becomes lower, and failed to participate into the class, because there is **no interaction indeed between the students.**

Interviewer: Do you have students with special education needs (SEN) currently teaching 有特別學習需要?

All teachers: No.

Interviewer: So, during the pandemic, did your school buy any kind of software, e-learning kits, virtual laboratories (simulators/activity-based kit) that are currently using or will be used in the future?

All: I don't think so. / We don't have it.

Interviewer: So, did you try any kind of virtual labs during the pandemic on your own, as you have mentioned you have seen those online?

Teacher A, C, D, E, F, G: (Should be; teacher A and F) no.
Teacher B: Yes, but I would say it is quite hard for students to use. Also, they still cannot get the hands-on skills in science learning. The skill part of the experiment still could not be attained.

*Interviewer: What do you observe upon **the changes** of your academic results and learning progress **before and during** the COVID-19 pandemic? Can you list some examples?*

Teacher A, B, D, E, F, G: Most of the students, their results are deteriorated/ Decreased in academic performance in science subjects.
Teacher B, C: Somehow not much affected for those high-achiever students, they can still get improvement or remain a high score.
Teacher B: But for the low achievers, they even cannot write complete sentences to answer the questions in the assessments and fell very behind on their learning progress.

Interviewer: Is it because of the inadequacies of hands-on experiences online?

All: Definitely that is one of the factors. As experimental skills are essential learning components of any science subjects. + Online learning does not allow us to learn hands-on skills of experiments.
(In addition) Teacher B, F, G: In most extent, somehow, yes, but I would say the learning vibes, interaction, and motivation are the most important factors that affect students' participation and attentiveness in class, I agreed sometimes the lesson is just boring in online during the pandemic for students to participate in.

Interviewer: Do you think you can learn everything effectively, not only the theoretical knowledge but also the experimental skills (that are expected to gain from the hands-on experience?) in science classes during the pandemic?

All: I don't think so.
All teachers mentioned that hands-on experiences provide them insights of getting experimental skills, especially in the experiments.
Teacher B: I don't think so, how students can learn experimental skills (hands-on skills) without using the apparatus, that's impossible, even the demonstrative videos could somehow cannot help

us to grasp the skills of using it. Hands-on experiences actually gave me the insights of getting experimental skills, I want to do that by hands not via online videos.

Teacher C, E and F: I think the **interaction issues caused a lot of problems** when the students tried to share the skills and knowledge in science lesson, such as during the experiments, they are allowed to make discussion in between the peers.

Teachers A, B, D, E, F: I agree that somehow the learning issues, shown as academic results, are rooted from the hands-on experiences learning in science classes. As, hands-on experiences can help students' understanding in science concepts. Understanding concepts is very essential in science subjects (teachers A, B, E), where face-to-face learning is important for hands-on experiences, **they could help to boost students' academic results**. However, after the online learning mode is adopted, hands-on experiences could not boost students' academic results (Teachers, A, B, D), hard to say (teacher C, F), could further deteriorate during online learning (teacher B, F, G).

Interviewer: Thanks for your opinion. Any teaching difficulties in your online-based lessons? Apart from the learning needs and issues in the previous part of questions (as teachers' have already answered quite a lot for the answer)

Teacher E and F: I need much support from my same-subject colleagues and IT technician in schools.

All teachers (except C): It is quite difficult for us to teach the hands-on skills with demonstrative videos. The skills and steps were not very appropriately (n=2) and comprehensively (n=5) to be included in the videos. Some of the important messages have not been included in the video, and that makes students very difficult to learn the hands-on skills.

Teacher A, B, C: For the soft skills, actually when they are in the face-to-face lessons, they have sufficient chances for them to nurture soft skills (e.g., communication skills), but somehow when we use online lessons, they would have lower chance to gain soft skills, especially when they are in online lessons, as well as for the interaction issues (teacher D, E, G).

Teacher F: Should be okay, I have let them to use the chat box function in the google meets software, and make use of the questions-answers responses with the microphone in the lesson.

E-resources provided and accessibility: Split opinions

Teacher C, F: They are sufficient for students to use.

Teacher C: I have given a lot of videos for my students' references, so it should be enough for their study.

Teacher F: I have tried to make more flipped classrooms for them to study during the pandemic, which should be enough and helpful to achieve productive learning of students during this hard time.
VS
Teacher E: Actually it is difficult for students to access but not complicated and troublesome at all, they can learn it in one or two go, somehow the students are way smarter than us.
VS
Teacher D: I think the students could not be able to choose the right e-resources for their studies for themselves, and they are quite hard to be accessed online, some needs subscriptions, some needs login (of an account), which made the learning easiness becomes an issue.

Interviewer: Can you list out a total of two to three (positive and negative) adjectives that could psychologically describe your current teaching progress during the COVID-19 pandemic?

Teacher A: Demanding, considerate
Teacher B, C, D, E, F, G: Harsh and hectic, exhausting, dull and bored (students E, F, G)
Teacher E, F, G: Unmotivated for students, unmotivated for teachers as well

Interviewer: What kind of resources you think you need in learning during online learning and online hands-on experience learning classes, for science subjects?

Teacher B, D, F: **3D Simulators** (teacher D suggest a database)
Teacher A, C, D, G: virtual laboratories is also great. (by all teachers in this section: aligned with HKDSE curriculum)

Interviewer: Do you agree more online-based resources should be created for e-learning?

All teachers: **Of course we want them** (of course we need more), especially platforms (except teacher E, F, G), we don't have many platforms which could facilitate our students' studies.

Interviewer: Any suggestion on the current learning materials / modification or additional items of learning materials on online laboratories?

Teacher A, D: I think those demonstrative videos **could be clearer with reminders, especially on those experimental skills.**

Student B and D: More **guidance** would be great for revision purposes when using these e-learning hubs, videos, simulators or third-party teaching materials and aids.

Hence, teacher A and D: I suggest the book publisher to add some more reminding messages to the demonstrative videos, as well as the **"questions to ponder" part for students to think more, i.e., critical thinking.**

Interviewer: This is an additional question. Do you think the fusion of hybrid mode of lessons (face-to-face and online) with multimedia of learning is a good way for us to learn and study science subjects?

All teachers except C: **I think it's good for hybrid learning mode**, as this could facilitate students to do self-learning anytime they want, and it can tackle learning diversity in class, with some students are psychomotor learners (teacher E) /visual learners (teacher F, G).
Teacher B, C, D: It is a good start of hosting hybrid mode of learning, as it could provide learning and revision (revise back of previous content) chances to students after classes, and cater for learners' diversity.
Teacher C: Multimedia learning is a good start of multimedia learning, as it could solve the learning needs of each of the student as well, but the students must know what ones should be used for their study before they tried to choose one for them, some are too difficult, some are too simple, at the end of the cases, the teachers have to explain those concepts again. Therefore, the demonstrative video in hybrid mode of learning (which relates to the multimedia learning) could be somehow not useful for a batch of students who are dependent.

To all participants:
That's the end of the interview. I sincerely thanked you for your participation into this interview.

Appendix 3: Questionnaire (Students' set)

Questionnaire (Student's Version)
問卷 （學生版本）

Part I. Basic information on recent learning forms and methods, and personal information and experiences towards learning
第一部分：近期學習方式的基本資料、個人資料和近期在學習上的經驗
Please choose only one answer for each question (unless specified).
每一道題目只能選擇一個答案（除非題目有所註明）。

1. Personal information 個人資料

1.1 Gender 姓別 Male 男 ☐ Female 女 ☐
1.2 Age (*Participants of this questionnaire are required to be over 16 years old.) 年齡 （請注意：本問卷的所有參與者需年滿16歲。） 16-17 ☐ 18-19 ☐
1.3 Education level 教育程度/學歷 Secondary 4 中四級 ☐ Secondary 5 中五級 ☐ Secondary 6 中六級 ☐

2. Learning experiences on science subjects 科學類科目的學習經驗

2.1 Which education curriculum are you currently studying at in Hong Kong? 你現正在香港接受哪一教育體制下的科學科課程？ ☐ Hong Kong Diploma of Secondary Education Examination (HKDSE) 香港中學文憑試 International Baccalaureate (IB) 國際文憑 ☐ SAT （前稱：學術能力測驗和學術評估測試）☐ ☐ Other education curriculum, please specify: _____ 如你在香港就讀其他教育體制，請註明：_____
2.2 Science subjects currently studying/have been studied (You can choose more than one answer for this question) 請勾選你現正就讀/曾經就讀的所有科學類（理科）科目（本題可以勾選多於一個答案） Biology 生物科 ☐ Chemistry 化學科 ☐ Physics 物理科 ☐ ☐ Integrated science; with a mixed subject of 綜合科學（並選出以下組合） Biology 生物科 ☐ Chemistry 化學科 ☐ Physics 物理科 ☐ ☐ Other science subjects, please specify: _____ 其他相關科學類的科目，請註明：_____
2.3 How many science-related lessons (i.e., Biology, Chemistry, Physics or Integrated Science) do you have routinely **for a week**? 在以一個星期計算的上學週中，您每一星期會有多少節與科學類科目相關的課節？ 1-2 ☐ 2-3 ☐ 4-5 ☐ 6-7 ☐ over 7 超過七節 ☐

Part II. Experiences of hands-on activities in *face-to-face* mode classes and *online* mode classes before and during COVID-19 pandemic
第二部分：在 COVID-19 疫情時，於面授課和網上授課中所進行「親自動手」的實踐課堂活動的經驗調查

1. *Focus:* For **face-to-face classes** which consist of hands-on activities **before the COVID-19 pandemic started**
*焦點：*在**COVID-19疫情前**，所有**面授課**中的「親自動手」的實踐課堂活動

1a. Do you have any hands-on experience when learning science subject(s) at school **for face-to-face lessons *before* the COVID-19 pandemic**?
(You may take a quick reference of the examples of hands-on activities that are listed on question 1c)
您在**COVID19疫情前**，有沒有曾於學習科學類科目時，參與**面授課堂中**的任何「親自動手」的課堂活動？
（如您不清楚甚麼活動可歸類為親自動手」的課堂活動，您可參考問題1c的選項，作為參考）

Yes 是 ☐ No 否 ☐

1b. Hence, if you have chosen "yes" for the previous question [1a],
How frequently have you experienced hands-on activity (e.g., experiments, activities using simulators or models) **before the COVID-19 pandemic** (started from January 2020 in Hong Kong) i**n face-to-face lessons**?
承上題，如您於題目1a選擇了「是」，
您在**COVID-19 開始前**（於 2020 年 1 月在香港開始發生），您在**面授課中**可以參與到多少次「親自動手」的課堂活動？

Twice a week 一星期兩次 ☐ Once a week 一星期一次 ☐
Once in two to three weeks 兩至三星期一次 ☐ Once a month 一個月一次 ☐
Once in more than a month 多於一個月一次 ☐

1c. What kind of hands-on activities have you experienced in all of your science subjects, **in those face-to-face lessons before the COVID-19 pandemic**? (You can choose more than one answer for this question)
在您所有上過的科學類（理科）科目中，在**COVID-19 疫情開始前**，你曾在**面授課堂**上參與到甚麼種類的「親自動手」課堂活動？（本題可以勾選多於一個答案）

Experiments 實驗 ☐ Using models 使用模型 ☐
Using simulators or software 使用虛擬模擬器或軟件 ☐
Drawing schematic diagrams or charts to learn a topic
繪畫不同圖案或有系統的圖表作學習用途 ☐
Using or constructing robotics 使用或建造機械人（及其技術） ☐
Learning with card games 卡牌遊戲作學習用途 ☐
Roleplay (with tangible prepared materials) 角色扮演（並提供可接觸的教學材料） ☐
☐ Others, please specify: _____
其他，請註明：_____

For the following questions, please rate 1-5 points towards the statements stated.
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)

下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。

1d. Do you agree these hands-on activities **could support your study**?
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.) *(5分為十分同意，1分為十分不同意；3分為中立。)*
你多大程度同意這些「親自動手」的課堂活動在**面授課**時**能幫助你的學習？**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1e. Do you agree these hands-on activities **could motivate you to learn and study science subjects**?
你多大程度同意這些「親自動手」的課堂活動在**面授課**時可以讓你**有學習動力學習科學類的科目？**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1f. Do you agree these hands-on activities **could let you understand the scientific concepts** that were learnt in the science class(es)?
你多大程度同意這些「親自動手」的課堂活動在**面授課**時可以**讓你明白在課堂中學習的（與科學有關的科目）概念？**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1g. Do you agree these hands-on activities **could provide an opportunity for you to revise the science concepts** that were learnt in the science class(es)?
你多大程度同意這些「親自動手」的課堂活動在**面授課**時可以**讓你溫習上課時曾經學習過的（與科學有關的科目）概念？**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1h. Do you agree these hands-on activities **could let you improve your academic results in science subject(s)?**
你多大程度同意這些「親自動手」的課堂活動在**面授課**時可以改善你**在與科學有關的科目的學業成績？**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2. *Focus:* For **online classes** which consist of hands-on activities **after the COVID-19 pandemic started (i.e., during the COVID-19 pandemic)**
*焦點：在***COVID-19疫情開始後**，所有**網課**中的「親自動手」的實踐課堂活動

2a. Do you have any hands-on experience when learning science subject(s) at school **for online lessons *during* the COVID-19 pandemic**?
(You may take a quick reference of the examples of hands-on activities that are listed on question 2c)
您在COVID19疫情**開始後**，有沒有曾於學習科學類科目時，參與網上課堂中的任何「親自動手」的實踐課堂活動？
（如您不清楚甚麼活動可歸類為「親自動手」的實踐課堂活動，您可參考問題2c的選項，作為參考）

Yes 是 ☐ No 否 ☐

2b. Hence, if you have chosen "yes" for the previous question [2a],
How frequently have you experienced hands-on activities (e.g. experiments, activities using simulators or models) **during the COVID-19 pandemic** (started from January 2020 in Hong Kong) in **online lessons**?

承上題，如**您**於題目2a選擇了「是」，

您在**COVID-19 開始時（直到現在）**（於 2020 年 1 月在香港開始發生），您在**網課中**可以參與到多少次「親自動手」的實踐課堂活動？

Twice a week 一星期兩次 ☐ Once a week 一星期一次 ☐
Once in two to three weeks 兩至三星期一次 ☐ Once a month 一個月一次 ☐
Once in more than a month 多於一個月一次 ☐

2c. What kind of hands-on activities have you experienced **on online** in all of your science subjects?
在您所有上過的科學類（理科）科目中，在**COVID-19疫情開始後**，您曾在**網上課堂**上參與到甚麼種類的「親自動手」實踐課堂活動？

Experiments (including online experimental learning materials with tangible experiment materials) 實驗（並提供可接觸的實驗**教**學材料） ☐
Using models 使用模型 ☐
Using simulators or softwares 使用虛擬模擬器或軟件 ☐
Drawing schematic diagrams or charts to learn a topic 繪畫不同圖案或有系統的圖表作學習用途 ☐
Using or constructing robotics 使用或建造機械人（及其技術） ☐
Learning with card games 卡牌遊戲作學習用途 ☐
Roleplay (with tangible prepared materials) 角色扮演（並提供可接觸的**教**學材料） ☐
☐ Others, please specify: _____
其他，請註明：_____

For the following questions, please rate 1-5 points towards the statements stated.
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)
下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。

2d. Do you agree these **online** hands-on activities **could support your study**?
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.) *(5分為十分同意，1分為十分不同意；3分為中立。)*

您多大程度同意這些「親自動手」的實踐課堂活動在**網課**時**能幫助您學習？**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2e. Do you agree these **online** hands-on activities **could motivate you to learn and study science subjects**?
您多大程度同意這些「親自動手」的實踐課堂活動在**網課**時可以**讓您有學習動力讓你學習科學類的科目？**

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2f. Do you agree these **online** hands-on activities **could let you understand the scientific concepts** that were learnt in the science class(es)? *您多大程度同意這些*「親自動手」的實踐課堂活動在**網課**時可以**讓您明白在課堂中學習的（與科學有關的科目）概念？** 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2g. Do you agree these **online** hands-on activities **could provide an opportunity for you to revise the science concepts** that were learnt in the science class(es)? *您多大程度同意這些*「親自動手」的實踐課堂活動在**網課**時可以**讓你您復習上課時曾經學習過的（與科學有關的科目）概念？** 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2h. Do you agree these online hands-on activities **could let you improve your academic results in science subject(s)**? *您多大程度同意這些*「親自動手」的實踐課堂活動在**網課**時可以改善您**與科學有關的科目的學業成績？** 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Part III. In-depth Perceptions towards Online Mode of Learning and Hands-on Experiences in Science Subjects during COVID-19 pandemic

第三部分：在COVID-19疫情時，問卷參與者對科學類科目的網上學習及其「親自動手」的實踐課堂活動的深入見解及感受

1. In your opinion, please rate 1-5 points to indicate your stance towards the following statements below. *(Only one answer for each row.)*

下列的題目，請以1至5分對提出的陳述作出評分。

5分為十分同意，1分為十分不同意；3分為中立。（每一行只能填寫一個答案）

Statements 陳述	**Ratings 評分**				
	1 Strongly disagree 十分不同意	2 Disagree 不同意	3 Neutral 中立	4 Agree 同意	5 Strongly agree 十分同意
1a. e-Resources are readily available for revision at any time. 網上有很多學習資源提供，使我能夠隨時溫習。					
1b. Online learning and related hands-on experience create a better time management of learning and revision. 網上學習及網上「親自動手」的實踐課堂活動可以讓我有更好的時間管理及溫習安排。					
1c. Convenient to access online to different learning materials.					

我能**夠**方便地獲取不同的網上學習材料。					
1d. Multimedia could boost learning effectiveness (i.e., able to grasp the learning content well). 多媒體學習能**夠**提升學習效能。（例如：能**夠**掌握學科知識）					

2.1. To what extent do you agree the following aspects regarding **face-to-face learning and hands-on experiences** could **achieve the learning outcomes** of a science topic. *Please indicate your level of agreement with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*

*您多大程度同意以下關於**面授課及其**「親自動手」的實踐課堂活動*能否讓您在不同科學課目的課題中，**達成不同方面的學習成果方針**？

下列的題目，請以1至5分對提出的陳述作出評分。

*5分**為**十分同意，1分**為**十分不同意；3分**為**中立。*

2.1a. In terms of **knowledge**, "face-to-face learning and hands-on experiences" is an effective way for me to learn any science subject. 在**獲取知識**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.1b. In terms of **laboratory skills of undergoing experiments**, "face-to-face learning and hands-on experiences" is an effective way for me to learn any science subject. 在**獲取實驗知識及技巧**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.1c. In terms of **soft skills (e.g., communication, collaboration, organizational skills)**, "face-to-face learning and hands-on experiences" is an effective way for me to learn any science subject. 在**獲取軟實力（例如：溝通、合作、組織能力等技巧）**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.1d. In terms of **learning motivation**, "face-to-face learning and hands-on experiences" is an effective way for me to learn any science subject. 在**學習動機（學習動力）**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2.2. To what extent do you agree the following aspects regarding **online learning or hands-on experiences** could let you achieve the learning outcomes of a science topic. *Please indicate your level of concurrence with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*

*您多大程度同意以下關於**網課及其**「親自動手」的實踐課堂活動*能否讓您在不同科學課目的課題中，**達成不同方面的學習成果方針**？

下列的題目，請以1至5分對提出的陳述作出評分。

*5分**為**十分同意，1分**為**十分不同意；3分**為**中立。*

2.2a. In terms of **knowledge**, "online learning and hands-on experiences" is an effective way for me to learn any science subject. 在**獲取知識**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.2b. In terms of **laboratory skills of undergoing experiments**, "online learning and hands-on experiences" is an effective way for me to learn any science subject. 在**獲取實驗知識及技巧**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.2c. In terms of **soft skills (e.g., communication, collaboration, organizational skills)**, "online learning and hands-on experiences" is an effective way for me to learn any science subject. 在**獲取軟實力（例如：溝通、合作、組織能力等技巧）**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.2d. In terms of **learning motivation**, "online learning and hands-on experiences" is an effective way for me to learn any science subject. 在**學習動機（學習動力）**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓我學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3. To what extent do you agree the following general statements suit **your learning experiences and perceptions throughout the pandemic**? *Please indicate your level of concurrence with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*

*您多大程度同意以下關於**在COVID-19疫情時你的學習經驗**、深入見解及感受之陳述？*

下列的題目，請以1至5分對提出的陳述作出評分。

*5分**為**十分同意，1分**為**十分不同意；3分**為**中立。*

3a. I need to spend more time studying during the COVID-19 pandemic because the learning content is difficult. 在COVID-19疫情時，因**為**學習內容困難，所以我需要用更多時間學習。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
3b. I need extra support from my teachers during revision for my tests or examinations. 我需要老師的額外協助，讓我可以**為**接下來的測驗或考試複習。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3c. I have adequate peer-peer interactions throughout the learning progress throughout the COVID-19 pandemic.

在COVID-19疫情時，我和朋友在學習上能夠有足夠的互動。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3d. I learnt adequate hands-on experiences or related experiment skills in e-learning sessions.

我在網課時能夠學習到足夠的「親自動手」的實踐課堂活動、實驗經歷及技巧。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3e. During the pandemic when online learning is adopted, I have an appropriate environment to learn (e.g., a quiet place without interference, with adequate supportive equipment or learning materials for access).

在COVID-19疫情進行網課時，我有一個適合的環境學習。（例如：有一個安靜、沒有任何干擾的地方、有足夠學習的設備及能夠獲取足夠的學習材料）

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3f. I am motivated in participating in online classes and activities or working on e-learning laboratory sessions.

我有動力去參與網上授課，包括所有網上提供的各種實驗活動。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3g. My learning progress dropped once online mode learning was adopted during the COVID-19 pandemic.

在COVID-19疫情時，因為網課的推行，使我的學習進度有所下降。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3h. Most of the time, I got puzzled when the teachers were explaining abstract science knowledge to me during virtual mode of learning.

在很大部份的時間，當老師在網課授課時，嘗試解釋一些比較抽象的科學概念，我會感到困惑。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3i. During the pandemic, I enjoy attending science classes online.

在COVID-19疫情時，我很享受以網上授課的形式，上科學類科目的課堂。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3j. During the pandemic, I feel confident in achieving goals and maintaining satisfactory academic results in science subjects.

在COVID-19疫情時，我有信心可以達成科學類科目學習上的目標，及維持我滿意的學業成績。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3k. I can adapt to the virtual mode of learning dominantly during the pandemic, including those virtual laboratories (e.g., videos, stimulators, or software).

我能夠適應以網上授課為主要形式進行學習，包括虛擬實驗教學（例如：實驗影片、虛擬模擬器及軟件）

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3l. I have Special Education Needs (SEN) which I need special help in learning. (If you have checked "yes" for this question, please complete the next question [3m].) (If not, please skip the next question [3m] and continue to complete the following question [3n].)

我有特殊學習需要（SEN）。 （如果你於本題選擇「是」，請回答下一題[3m]。） （如果你於本題選擇否，你可以跳過題目[3m]，並繼續回答由題目[3n]的下列各題。） Yes 是 ☐ No 否 ☐
3m. ***(For SEN learners ONLY)*** Virtual learning has posed problems on my learning and learning progress. ***（只供有特殊學習需要（SEN）的學習者填寫）*** 網上學習對我的學習及其進度構成學習上的問題。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
3n. Overall, my academic performance **has improved** because of the new teaching styles (shifting to online learning) of schools. 總括而言，我的學業成績因為有新的教學模式和方法（由傳統面授課轉為網上授課）而有所進步。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

4. To what extent do you agree with the following statements **about the suggestions upon learning science online**? *Please indicate your level of agreement with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*
您多大程度同意以下關於**在網上學習科學類科目的建議？**
下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。

4a. More online learning platforms and resources should be established for compensating the insufficient areas or easing my learning needs during the pandemic. 應該建立更多的網上學習平台及資源，讓學習者能夠在COVID-19疫情中學習時，彌補學習上的不足及其學習需要。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
4b. More online innovative platforms and software should be put forth to aid students' learning. 應該建立並推行使用更多網上創新的平台及軟件，協助學生學習。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
4c. Educators and policy makers should pay heed to create more online resources (e.g., online laboratories) on online laboratories, in order to support students' learning in science subjects. 教育學家及政策推行者應著眼建立更多網上不同學習的資源及網上實驗學習組合，以協助學生在學習科學類的所有科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Additional Information 附加資料

5. If you wish to *voluntarily participate in an interview* (about 20-30 minutes) to provide more opinion or any other perceptions regarding this research topic, or you have any opinion or inquiry upon this questionnaire, please check this box and leave a contact method for the researcher. We will approach you shortly. ☐

Contact method: _____

If you are not interested, this is the end of the questionnaire. Thank you for your precious time.

如您願意參與額外的面見（大約20至30分鐘；自願並無償），並在此面見中提供更多意見、對本研究項目有其他任何見解，或對本問卷有任何意見或疑問，請勾選以下空格，及留下您的聯絡方式。我們會盡快聯絡您。 ☐

聯絡方式：_____

如您沒有興趣參與任何額外的面見，您已經完成本問卷所有問題，謝謝你寶貴的時間。

THE END OF THE QUESTIONNAIRE
- A sincere thank you for your participation. -

問卷完
- 誠心致謝您對本研究的參與 -

Appendix 4: Questionnaire (Teachers' set)

Questionnaire (Teacher's Version)
問卷 （老師版本）

Part I. Basic information on recent teaching forms and methods, and personal information and experiences towards teaching
第一部分：近期教學方式的基本資料、個人資料和近期在教學上的經驗

Please choose only one answer for each question (unless specified).
每一道題目只能選擇一個答案（除非題目有所註明）。

1. Personal information 個人資料

1.1 Gender姓別
Male 男 ☐ Female 女 ☐

1.2 Age年齡
Below 22 二十二歲以下 ☐ 23-30 ☐ 31-40 ☐
41-50 ☐ 51-60 ☐ Over 60 超過60 ☐ Rather not say不願透露 ☐

1.3 Highest Education level 最高教育程度/學歷
Bachelor's degree holder學士學位 ☐ Master's degree holder 碩士學位 ☐
Doctor's degree holder 博士學位 ☐

Check the box if you have achieved an education diploma qualification with your university's degree (**if Bachelor/Master/Doctor of Education was obtained**, **DO NOT** check this box) ☐
如您有獲取教育文憑課程證書，請勾選此空格（但，如你獲取的學位是**教育學士、教育碩士或教育博士**，請不要勾選此空格）

2. Teaching experiences on science subjects 科學類科目的教學經驗

2.1 Which education curriculum are you currently teaching in Hong Kong?
你現正在香港教授哪一教育體制下的科學類科目的課程？
Hong Kong Diploma of Secondary Education Examination (HKDSE) 香港中學文憑試 ☐
International Baccalaureate (IB) 國際文憑 ☐
SAT （前稱：學術能力測驗和學術評估測試） ☐
☐ Other education curriculum, please specify: _____
如你在香港教授其他教育體制，請註明：_____

2.2 What kind of secondary school are you currently working in Hong Kong?
你現在在哪一種類的本地學校中執行教師的工作？
☐ Local government-subsidized secondary/primary school 本地政府資助中小學
☐ Local governmental secondary/primary school 本地政府官立中小學
☐ Local private secondary/primary school schools 本地私立中小學
☐ Other, please specify: _____
其他，請註明：_____

2.3 Science subjects currently teaching/have been teaching **in recent 5 years** (You can choose more than one answer for this question)
在**最近五年**中，請勾選你現正教授/曾經教授的所有科學類（理科）科目（本題可以勾選多於一個答案）

Biology 生物科 ☐ Chemistry 化學科 ☐ Physics 物理科 ☐

☐ Integrated science; with a mixed subject of 綜合科學（並選出以下組合）

Biology 生物科 ☐ Chemistry 化學科 ☐ Physics 物理科 ☐

☐ Junior Integrated Science (For local Secondary 1 to Secondary 2/Secondary 1 to Secondary 3 students; with respect to the school's policy)
初中科學科（中一至中二/中一至中三；根據其本地學校制度）

☐ Other science subjects, please specify: _____
其他相關科學類的科目，請註明：_____

2.4 How many science-related lessons (i.e., Biology, Chemistry, Physics, STEM courses or Integrated Science) do you teach routinely **for a week**?
在以一個星期計算的上學週中，您每一星期會有多少節與科學類科目相關的課節？

2-4 ☐ 5-7 ☐ 8-10 ☐
11-13 ☐ over 14超過十四節 ☐

Part II. Experiences of hands-on activities in *face-to-face* mode classes and *online* mode classes before and during COVID-19 pandemic
第二部分：在COVID-19疫情時，於面授課和網上授課中所進行「親自動手」的實踐課堂活動的經驗調查

1. *Focus:* For **face-to-face classes** which consist of hands-on activities **before the COVID-19 pandemic started**
*焦點：*在**COVID-19疫情前**，所有**面授課**中的「親自動手」的實踐課堂活動

1a. Have you taught any hands-on experience sessions for any science subject(s) at school **for face-to-face lessons *before* the COVID-19 pandemic**?
(You may take a quick reference of the examples of hands-on activities that are listed on question 1c)
If you answer "no" for this question, you may skip questions 1b to 1i and proceed to question 2.
您在 **COVID-19疫情前**（於 2020 年 1 月在香港開始發生），有沒有曾於教授科學類科目時，於面授課堂中提供任何「親自動手」的實踐課堂活動？
（如您不清楚甚麼活動可歸類為「親自動手」的實踐課堂活動，您可參考問題1c的選項，作為參考）
如您於本題選擇「否」，請跳至本部分的題目2繼續作答，並，您不需要作答問題1b至1i

Yes 是 ☐ No 否 ☐

1b. Hence, if you have chosen "yes" for the previous question [1a],
how frequent have you taught a hands-on activity (e.g., experiments, activities using simulators or models) **before the COVID-19 pandemic** (COVID-19 pandemic started from January 2020 in Hong Kong)?
承上題，如您於題目1a選擇了「是」，
您在**COVID-19 開始前**（於 2020 年 1 月在香港開始發生），您在面授課中可以提供到多少次「親自動手」的實踐課堂活動的機會？

Twice a week 一星期兩次 ☐ Once a week 一星期一次 ☐
Once in two to three weeks 兩至三星期一次 ☐ Once a month 一個月一次 ☐

Once in more than a month 多於一個月一次 ☐

1c. What kind of hands-on activities have you used in any of your science subjects?
在您所有教授過的科學類（理科）科目中，在**COVID-19 疫情開始前**，您曾在**面授課堂**上提供到甚麼種類的「親自動手」的實踐課堂活動？

Experiments 實驗 ☐ Using models 使用模型 ☐
Using simulators or software 使用虛擬模擬器或軟件 ☐
Drawing schematic diagrams or charts to learn a topic
繪畫不同圖案或有系統的圖表作學習用途 ☐
Using or constructing robotics 使用或建造機械人（及其技術）☐
Learning with card games 卡牌遊戲作學習用途 ☐
Roleplay (with tangible prepared materials) 角色扮演（並提供可接觸的教學材料）☐
☐ Others, please specify: _____
其他，請註明：_____

For the following questions, please rate 1-5 points towards the statements stated.
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)
下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。

1d. Do you agree these hands-on activities could **support students' learning by observing the improvement of their academic results?**
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.) *(5分為十分同意，1分為十分不同意；3分為中立。)*
您多大程度同意這些「親自動手」的實踐課堂活動在**面授課**時，從**學生的有改善的學業成績中**，得知這些活動**能幫助學生的學習？**
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1e. Do you agree these hands-on activities **could motivate students to learn science subjects before the pandemic**?
您多大程度同意這些「親自動手」的實踐課堂活動在面授課時可以讓學生有學習動力學習科學類的科目？
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1f. Do you agree these hands-on activities **could let students understand the scientific concepts** that were learnt in the science class(es)?
您多大程度同意這些「親自動手」的實踐課堂活動在面授課時可以**讓學生明白在課堂中學習的（與科學有關的科目）概念？**
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1g. Do you agree these hands-on activities **could provide an opportunity for you to revise the science concepts with students** that were learnt in the science class(es)?
您多大程度同意這些「親自動手」的實踐課堂活動在面授課時可以**讓學生溫習上課時曾經學習過的（與科學有關的科目）概念？**
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1h. Do you agree these hands-on activities **could provide an opportunity for you to adjust your teaching pedagogy in the *following* science class(es)**?
*您多大程度同意在**完成**這些*「親自動手」的實踐課堂活動後，能讓您調整您未來課節的教學法及策略？

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

1i. Do you agree these hands-on activities **could let students improve their academic results in science subject(s)?**
您多大程度同意這些「親自動手」的實踐課堂活動在面授課時可以改善學生在與科學有關的科目的學業成績？

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2. *Focus:* For **online classes** which consist of hands-on activities **after the COVID-19 pandemic started (i.e., during the COVID-19 pandemic)**
*焦點：*在**COVID-19疫情開始後**，所有網課中的「親自動手」的實踐課堂活動

2a. Do you have any hands-on experience when teaching science subject(s) at school **for online lessons *during* the COVID-19 pandemic**?
If you answer "no" for this question, you may skip questions 2b to 2i and proceed to part III of the questionnaire.
(You may take a quick reference of the examples of hands-on activities that are listed on question 2c)
您在 COVID-19疫情開始後，有沒有曾於教授任何科學類科目時，提供網上課堂中的任何「親自動手」的實踐課堂活動？
如您於本題選擇「否」，請跳至本部分的題目2繼續作答，並，您不需要作答問題2b至2i
（如您不清楚甚麼活動可歸類為「親自動手」的實踐課堂活動，您可參考問題2c的選項，作為參考）

Yes 是 ☐ No 否 ☐

2b. Hence, if you have chosen "yes" for the previous question [2a], how frequent would you have experienced a hands-on activity (e.g., experiments, activities using simulators or models) **during the COVID-19 pandemic** (COVID-19 pandemic started from January 2020 in Hong Kong)?
承上題，如您於題目2a選擇了「是」，
您在 **COVID-19 開始時（直到現在）**（於 2020 年 1 月在香港開始發生），您在網課中可以提供到多少次「親自動手」的實踐課堂活動？

Twice a week 一星期兩次 ☐ Once a week 一星期一次 ☐
Once in two to three weeks 兩至三星期一次 ☐ Once a month 一個月一次 ☐
Once in more than a month 多於一個月一次 ☐

2c. What kind of hands-on activities have you taught/hosted **on online** in all of your science subjects?
在您所有教授過的科學類（理科）科目中，在 **COVID-19 疫情開始後**，您曾在**網上課堂**上提供到甚麼種類的「親自動手」的實踐課堂活動？

Experiments (including online experimental learning materials with tangible experiment materials) 實驗（並提供可接觸的實驗**教**學材料）☐

Using models 使用模型 ☐

Using simulators or software 使用虛擬模擬器或軟件 ☐

Drawing schematic diagrams or charts to learn a topic 繪畫不同圖案或有系統的圖表作學習用途 ☐

Using or constructing robotics 使用或建造機械人（及其技術）☐

Learning with card games 卡牌遊戲作學習用途 ☐

Roleplay (with tangible prepared materials) 角色扮演（並提供可接觸的**教**學材料）☐

☐ Others, please specify: _____
其他，請註明：_____

For the following questions, please rate 1-5 points towards the statements stated.
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)
下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。

2d. Do you agree these **online** hands-on activities could **support students' learning by looking into their academic results?**
(5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.) *(5分為十分同意，1分為十分不同意；3分為中立。)*
您多大程度同意這些「親自動手」的實踐課堂活動在**網課**時，從**學生的有改善的學業成績中**，得知這些活動**能幫助學生的學習？**
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2e. Do you agree these **online** hands-on activities **could motivate students to learn science subjects before the pandemic**?
您多大程度同意這些「親自動手」的實踐課堂活動在**網課**時可以讓學生**有學習動力學習科學類的科目？**
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2f. Do you agree these **online** hands-on activities **could let students understand the scientific concepts** that were learnt in the science class(es)?
您多大程度同意這些「親自動手」的實踐課堂活動在**網課**時可以**讓學生明白在課堂中學習的（與科學有關的科目）概念？**
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2g. Do you agree these **online** hands-on activities **could provide an opportunity for you to revise the science concepts with students** that were learnt in the science class(es)?
您多大程度同意這些「親自動手」的實踐課堂活動在**網課**可以**讓學生溫習上課時曾經學習過的（與科學有關的科目）概念？**
1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2h. Do you agree these **online** hands-on activities **could provide an opportunity for you to adjust your teaching pedagogy in the *following* science class(es)**?
您
*多大程度同意在**完成**這些**網上***「親自動手」的實踐課堂活動**後**，能讓您調整您未來課節的**教**學法及策略？

1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
2i. Do you agree these **online** hands-on activities **could let students improve their academic results in science subject(s)?** *您多大程度同意這些*「親自動手」的**實踐**課堂活動在**網課**時可以改善**學生在與科學有關的科目的學業成績？** 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐				

Part III. In-depth Perceptions towards Online Mode of Teaching and Hosting Hands-on Experiences in Science Subjects during COVID-19 pandemic
第三部分：在COVID-19 疫情時，問卷參與者對科學類科目的
網上教學及其進行「親自動手」的實踐課堂活動的深入見解及感受

1. In your opinion, please rate 1-5 points to indicate your stance towards the following statements below. *(Only one answer for each row.)*
下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。（每一行只能填寫一個答案）

Statements **陳述**	**Ratings評分**				
	1 Strongly disagree 十分不同意	2 Disagree 不同意	3 Neutral 中立	4 Agree 同意	5 Strongly agree 十分同意
1a. e-Resources are readily available for students' revision at any time. 網上有很多學習資源提供，使學生能夠隨時溫習。					
1b. Online learning and related hands-on experience could possibly create a better time management of learning and revision for students. 網上學習及網上「親自動手」的實踐課堂活動可以讓學生有更好的時間管理及温習安排。					
1c. Students are convenient to access to different learning materials provided by the teacher. 學生能夠方便地獲取由老師提供的不同網上學習材料。					
1d. Multimedia could boost learning effectiveness of students. (i.e., able to grasp the learning content well) 多媒體學習能夠提升學生的學習效能。（例如：能夠掌握學科知識）					

2.1. To what extent do you agree the following aspects regarding **face-to-face learning and hands-on experiences** could achieve the learning outcomes of a science topic of students. *Please indicate your level of concurrence with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*
*您多大程度同意以下關於**面授課及其**「親自動手」的實踐課堂活動能否讓您的學生在不同科學課目的課題中，**達成不同方面的學習成果方針**？*
下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。

2.1a. In terms of **knowledge**, "face-to-face learning and hands-on experiences" is an effective way for students to learn any science subject. 在**獲取知識**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.1b. In terms of **laboratory skills of undergoing experiments**, "face-to-face learning and hands-on experiences" is an efficient and effective way for students to learn any science subject. 在**獲取實驗知識及技巧**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.1c. In terms of **soft skills (e.g., communication, collaboration, organizational skills)**, "face-to-face learning and hands-on experiences " is an effective way for students to learn any science subject. 在**獲取軟實力（例如：溝通、合作、組織能力等技巧）**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.1d. In terms of **learning motivation**, "face-to-face learning and hands-on experiences " is an effective way for students to learn any science subject. 在**學習動機（學習動力）**方面，進行**面授課及進行「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2.2. To what extent do you agree the following aspects regarding **online learning or hands-on experiences** could drive students attain the learning outcomes of a science topic. *Please indicate your level of concurrence with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*
*您多大程度同意以下關於**網課及其**「親自動手」的實踐課堂活動能否讓您的學生在不同科學課目的課題中，**達成不同方面的學習成果方針**？*
下列的題目，請以1至5分對提出的陳述作出評分。
5分為十分同意，1分為十分不同意；3分為中立。

2.2a. In terms of **knowledge**, "online learning or hands-on experiences" is an effective way for students to learn any science subject. 在**獲取知識**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.2b. In terms of **laboratory skills of undergoing experiments**, "online learning or hands-on experiences" is an effective way for students to learn any science subject. **獲取實驗知識及技巧**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.2c. In terms of **soft skills (e.g., communication, collaboration, organizational skills)**, "online learning or hands-on experiences" is an effective way for students to learn any science subject. 在**獲取軟實力（例如：溝通、合作、組織能力等技巧）**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
2.2d. In terms of **learning motivation**, "online learning or hands-on experiences" is an effective way for students to learn any science subject. 在**學習動機（學習動力）**方面，進行**網課及進行網上「親自動手」的實踐課堂活動**是一種有學習效能的方式，讓學生順利學習任何一科科學類的科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3. To what extent do you agree the following general statements suit **your teaching experiences and perceptions throughout the pandemic**? *Please indicate your level of concurrence with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*

*您多大程度同意以下關於**在COVID-19疫情時您的教學經驗、深入見解及感受之陳述**？*

下列的題目，請以1至5分對提出的陳述作出評分。

5分為十分同意，1分為十分不同意；3分為中立。

3a I need to spend more time teaching during the COVID-19 because the learning content is difficult. 在COVID-19疫情時，因為其學習內容困難，所以我需要用更多時間進行教學。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
3b. I need extra support from my colleagues for technical support. 我需要其他同工的額外技術上的協助。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
3c. I have given adequate peer-peer interactions to students throughout the learning progress throughout the pandemic in the online science lesson(s). 在COVID-19疫情時，進行網課的時候，我能在學生學習上給予學生（和他們的朋友）足夠的互動。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3d. I believe students should have learnt adequate hands-on experiences or related experiment skills in the e-learning sessions prepared.
我相信我在進行網課時能夠讓學生學習到足夠的「親自動手」的實踐課堂活動、實驗經歷及技巧。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3e. During the pandemic when online learning is adopted, I have an appropriate environment to host a class for teaching purposes (e.g., a quiet place without interferences, with supportive equipment or teaching materials for access).
在COVID-19疫情進行網課時，我有一個適合的環境進行教學。（例如：有一個安靜、沒有任何干擾的地方、有足夠學習的設備及能夠獲取足夠的教學材料）

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3f. My teaching progress dropped once online mode learning was adopted during the COVID-19 pandemic.
因為COVID-19疫情而網課在這段期間持續進行，所以對我的教學進度也因此而減慢。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3g. Most of the time, I found that students were puzzled when I was explaining abstract science knowledge to them during virtual mode of learning.
在很大部份的時間，當我在網課授課時，嘗試解釋一些比較抽象的科學概念，我會發現同學會感到困惑。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3h. During the COVID-19 pandemic, I feel confident in teaching students online in which they could achieve the learning outcomes well.
在COVID-19疫情時，我有信心進行教學，並可以讓學生達成科學類科目學習上的目標。

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3i. I can adapt virtual mode of teaching dominantly during the pandemic, including those virtual laboratories (e.g., videos, stimulators, or software).
我能夠適應以網上授課為主要形式進行學習，包括虛擬實驗教學（例如：實驗影片、虛擬模擬器及軟件）

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3j. I have Special Education Needs (SEN) student(s) which they need special help in learning. (If you have checked "yes" for this question, please complete the next question [3k].) (If not, please skip the next question [3k] and continue complete the following question [3l].)
我有特殊學習需要（SEN）的學生。
（如果您於本題選擇「是」，請回答下一題[3k]。）

（如果您於本題選擇否，你可以跳過題目[3k]，並繼續回答由題目[3l]的下列各題。） Yes 是 ☐ No 否 ☐
3k. ***(For teachers who teach SEN learners ONLY)*** Virtual learning has posed problems on their learning and learning progress. ***（只供有特殊學習需要（SEN）學生的教師填寫）*** 網上學習對我的學生的學習及其進度構成學習上的問題。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
3l. Overall, I could recognize the academic performance of my students **have improved** because of the new teaching styles (shifting to online learning) of schools. 總括而言，我能得悉到學生的學業成績因為有新的教學模式和方法（由傳統面授課轉為網上授課）而有所進步。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

4. To what extent do you agree the following statements about the suggestions upon students' learning science online? *Please indicate your level of agreement with ratings of 1 to 5. (5 indicates strongly agree, 1 indicates strongly disagree; and 3 indicates a neutral stance towards the statement.)*

你多大程度同意以下關於**學生在網上學習科學類科目的建議？**

下列的題目，請以1至5分對提出的陳述作出評分。

5分為十分同意，1分為十分不同意；3分為中立。

4a. More online learning platforms and resources should be established for compensating the insufficient areas of students' learning or easing students' learning needs during the pandemic. 應該建立更多的網上學習平台及資源，讓學習者能夠在COVID-19疫情中學習時，彌補他們學習上的不足及其學習需要。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
4b. More online innovative platforms and software should be put forth to aid students' learning. 應該建立並推行使用更多網上創新的平台及軟件，協助學生學習。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
4c. Educators and policy makers should pay heed to create more online resources (e.g., online laboratories) on online laboratories, in order to support students' learning in science subjects. 教育學家及政策推行者應著眼建立更多網上不同學習的資源及網上實驗學習組合，以協助學生在學習科學類的所有科目。 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Additional Information 附加資料

5. If you wish to *voluntarily participate* an interview (about 20-30 minutes) to provide more opinion or any other perceptions regarding this research topic, or you have any opinion or inquiry upon this questionnaire, please check this box and leave a contact method for the researcher. We will approach you shortly. ☐

Contact method: _____

If not, this is the end of the questionnaire. Thank you for your precious time.

如您願意參與額外的面見（大約20至30分鐘；自願並無償），並在此面見中提供更多意見、對本研究項目有其他任何見解，或對本問卷有任何意見或疑問，請勾選以下空格，及留下您的聯絡方式。我們會盡快聯絡您。 ☐

聯絡方式：_____

如您沒有興趣參與任何額外的面見，您已經完成本問卷所有問題，謝謝你寶貴的時間。

THE END OF THE QUESTIONNAIRE
- A sincere thank you for your participation. –

問卷完
- 誠心致謝您對本研究的參與 -

Appendix 5: Interview Questions (Preliminary Planned Questions for Students)

Interview – Research Aspects & Questions (for Student's)

您現正受邀參與一項由香港教育大學科學與環境學系所統籌的短期研究，此項研究是由張予菱博士所督導，並由莊培生先生擔任主研究員。

此項研究的主要目的是探究在 COVID-19 疫情期間，因防疫措施和校舍不能如常正常開放的關係下，老師和學生對所有科學類（理科）科目的實驗課、實踐經驗及學習的一些看法和感受。

如您願意參與本次的研究，我們會現在開始今天的面談。

1. Personal information (excluding all specific organizational background and personal sensitive information)

- age (in range)
- type of school (subsidized/governmental/private institutions) & (EMI/CMI),
- Science subjects currently studying/ have been studied so far for the senior level of school life
- Years of studying science-related subjects (*students) + years of participating hands-on experiences before the pandemic,
- area (18 districts) of the school attending

2a. To your understanding, what are some examples of hands-on experiences or activities?

2b. To your studying experience in science subjects before and during the COVID-19 pandemic, what are the differences in frequencies 頻次 of participating these hands-on experiences? How?

2c. Can you recall some examples (in learning topics) that online hands-on activities are available for you to participate in class/after the class during the pandemic when we have online mode lessons?

2d. Any time limitation for you to access these e-laboratories sessions, e.g., in class for just 10 minutes, or you can access it freely online?

2e. Do you know are there any special school arrangements, policies, or learning/teaching plans on hands-on experience for both f-t-f classes and online classes?

3a. Throughout the duration of pandemic, from your perceptions 認知, what are your learning needs 學習上的需要? （e.g., insufficient of time, resources, academic support, lack of learning duration in class, no hands-on activities etc.）

3b. Do you receive any (or extra) supportive measures from your school/ teachers in learning science subjects?

→ *If yes, what, and how?*

3c. Are you a learner with special education needs (SEN) 有特別學習需要?

3d. Did your school buy any kind of software, e-learning kits, virtual laboratories (simulators/activity-based kit) that are currently using or will be used in the future?

If yes, → *What and How would you make use of it?*

3e. Did you try any kind of virtual labs during the pandemic?

If yes, → *Can you name the virtual lab that you are currently using?*

4a. What do you observe upon **the changes** of your academic results and learning progress **before and during** the COVID-19 pandemic?

4b. (Hence, can you list some examples?)

4c. Do you think you can achieve a better result during the pandemic?

4d. Do you think you can achieve the learning objectives 學習目標 that are set by the teachers confidently?

5a. Do you think the assessment tasks 測試 after the online mode classes are adopted have changed significantly, compared to the ones before the pandemic?

5b. Do you think you can learn everything effectively, not only the theoretical knowledge but also the experimental skills (that are expected to gain from the hands-on experience?) in science classes during the pandemic?

6. Any learning difficulties in your online-based lessons?

Some examples:

- Lack of interactions 互動 / hands-on activities 實踐活動
- Difficult to follow the teacher
- Cannot use tangible resources (e.g., models) to learn
- Lack of online resources to learn

7. Perceptions (made by yourself, related to your learning during the pandemic)

- Any **feeling** regarding your revision/learning/study progress during the pandemic?
- Anymore observations (except academic performance of students) regarding on your learning?
- Any individual step-by-step guidance 引導 given by teachers via online learning?
- Any comments to your current learning styles 模式?

8. Can you list out a total of two to three (positive and negative) adjectives that could psychologically describe your current learning progress during the COVID-19 pandemic?

- e.g., Fear 恐懼, motivated 有動力, confident 自信, stressful 倍感壓力, delighted 開心, ambitious 雄心勃勃, aggressive 氣, demanding, exhausting, bored etc.

9. What kind of resources you think you need in learning during online learning and online hands-on experience learning classes, for science subjects?

10a. Do you agree more online-based resources should be created for e-learning purposes in science subjects?

→ *If agree, how? (give concrete examples if you have; some aspects for my analysis will be very fine as well)*

10b. Any suggestion on the current learning materials / modification or additional items of learning materials on online laboratories?

Additional question: Fusion of hybrid mode of lessons and Multimedia of learning.

This is the end of the interview. A sincere thank you to your participation.

Appendix 6: Interview Questions (Preliminary Planned Questions for Teachers)

Interview – Research Aspects & Questions (for Teacher's)

您現正受邀參與一項由香港教育大學科學與環境學系所統籌的短期研究，此項研究是由張予菱博士所督導，並由莊培生先生擔任主研究員。

此項研究的主要目的是探究在 COVID-19 疫情期間，因防疫措施和校舍不能如常正常開放的關係下，老師和學生對所有科學類（理科）科目的實驗課、實踐經驗及學習的一些看法和感受。

如您願意參與本次的研究，我們會現在開始今天的面談。

1. Personal Information (excluding all specific organizational background and personal sensitive information)

- Include the following items: Years of teaching experience,

type of school (subsidized/governmental/private institutions) & (EMI/CMI),

teaching subjects, positions (e.g., GM, panel head, STEM subject coordinator etc.),

school district

Thank you for your information.

2a. To your understanding, what are some examples of online hands-on experiences or activities?

2b. To your teaching experience for these 5 years, before and during the pandemic, what are the differences in frequencies of hosting these hands-on experiences? How?

2c. Any time limitation on the e-laboratories sessions?

2d. Do you have any special school arrangement, policies, or teaching plans on hands-on experience for both f-t-f classes and online classes?

3a. Throughout the duration of the pandemic, what are the learning needs of students?

e.g., In terms of time, resources, duration of the class, learning contents/issues

3b. Do you have supportive measures for students in studying _____ (science subjects)? *"What and how?"*

3c. How your teaching pedagogy, teaching plans and curriculum changed due to students' learning needs or in the pandemic situation of which online classes are adopted? (Anything added/had been taken out; teaching aids/skills/pedagogy added)

3d. Did your school buy any kind of software, e-learning kits, virtual laboratories (simulators/activity-based kit) that are currently using or will be used in the future?

If yes → How would you make use of it?

3e. Did you try any kind of virtual labs during the pandemic online?

4a. What do you observe upon the changes of students' academic results and learning progress before and during the COVID-19 pandemic?

4b. (Hence, can you list some examples?)

5a. How would you plan assessment tasks for online classrooms, especially for those which are expected to be a hands-on activity initially?

5b. How would ensure students' learn everything effectively in a shorter period of time, not only the theoretical knowledge but also the experimental skills (that are expected to gain from the hands-on experience?)

6. Teaching difficulties in your online-based lessons?

Some examples:

- Response rate of students in class

- Difficult in tracking students' learning progress

- Cannot use tangible resources (e.g., models) to teach → Create what influences?

- Lack of e-resources to teach students

- If there are SEN students, what are your teaching difficulties?

7. Perceptions (of teachers and students, related to teaching during the pandemic)

- Any feeling regarding students' learning/study progress during the pandemic?
- Anymore observations (except academic performance of students) regarding on your teaching progress/ students' learning?
- Any individual step-by-step guidance given to students via online learning?
- Any voices (comments) said by students regarding their learning?

8. Can you list out a total of two to three (positive and negative) adjectives that could psychologically describe your current teaching progress during the COVID-19 pandemic?

- e.g., Fear, motivated, confident, stressful, delighted, ambitious, aggressive etc.

9. Resource needs of teaching during online teaching and online hands-on experience teaching?

10a. Do you agree more online-based resources should be created for e-learning purposes in science subjects? If agree, how? (give concrete examples if you have; some aspects for my analysis will be very fine as well)

10b. Any suggestion on the current teaching materials / modification of teaching materials on online laboratories?

Additional question: Fusion of hybrid mode of lessons and Multimedia of learning.

This is the end of the interview. A sincere thank you to your participation.

--THE END OF HONOURS PROJECT REPORT—