Redesigning Biomedical Science Practicum towards a New Frontier

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***Abstract*—Due to the COVID-19 pandemic, majority of the Biomedical Science students were not able to undergo their clinical internship at diagnostic laboratories and this has created an impact on students' skills and the future of the Malaysian healthcare system. Hence, our objective was to implement arevolutionized Biomedical Science practicum completely in a virtual environment, without compromising the learning outcomes during the pandemic in 2021. To achieve the intended learning outcomes, various online teaching-learning and assessment activities were carefully curated in accordance to standard program guidelines, learning outcomes, student learning time and thorough analysis of actual student logbooks. Learning materials were reinforced with various initiatives such as actual engagements with real-life scenarios via synchronous meetings with external panelists from hospitals. Online video-log (Vlog) and a logbook of daily activities were used as part of the assessment to ensure that students were able to learn and reflect on the activities performed. The study showed that all students displayed increased confidence levels in medical laboratory skills. They were also able to apply them in real-life situations due to the clear instructions and realistic experience via the virtual learning activities. Therefore, students who participated in the virtual practicum demonstrated almost similar levels of performance when compared to the students who went for physical practicums in the year 2020. Our virtual practicum has achieved its intended outcomes of empowering students with similar skills as those who underwent physical clinical placements in diagnostic laboratories. Those skills include successful acquisition of discipline-specific knowledge, collaborative and communication skills, as well as solid experimental methods and good laboratory practices.**

***Index Terms*—Biomedical Science, diagnostic laboratory, virtual internship.**

I. Introduction

Combining the fallout from COVID-19 with continuing advances in digital technology and an intense demand for student-centered learning has presented an unprecedented opportunity to transform conventional education styles. Flexible learning is a form of education that allows one to learn at their preferred pace, place, and/or mode of delivery [1]. The advancements in this learning method include the incorporation of technology to provide remote studying, work-based learning and employer engagements. A key point for this model is that students are encouraged to take responsibility and autonomy for their own learning progress to improve their learning outcomes [1].

In view of the rising global concerns about the spread of COVID-19, a growing number of tertiary institutions have taken safety measures to disallow physical learning initiatives. Similarly for hospital laboratory placements, a significant percentage of Biomedical Science students were not able to access Malaysian hospitals for their clinical placements in 2021. This situation highlights the necessity and potential for flexible learning in times of lockdowns and social distancing [2]-[4]. Therefore, we are introducing the first of its kind virtual practicum to transform conventional Biomedical Science practicums into newer endeavors more commonly known as virtual internships or e-internships [5], [6]. Virtual internships have been made available a decade ago, in countries such as the USA and United Kingdom, with strong dominance in the customer service jobs (marketing, sales), technical areas (IT-related) and journalism. This comes as no surprise as these jobs heavily rely on technology. New trends have also made virtual internships available for Biomedical Science students that use big data, bioinformatics and artificial intelligence algorithms to perform data analysis and statistical analysis. Recent studies have showed that traditional learning or face-to-face internships were not necessarily more effective than virtual internships [5], [7], [8].

The Biomedical Science practicum is a compulsory module under the Program Standards: Medical and Health Sciences (2016) as a partial fulfillment for the Bachelor of Biomedical Science (Hons.). However, due to the COVID-19 pandemic, most of the national hospitals were prioritizing COVID-19 cases. As COVID-19 vaccines were yet to be introduced in Malaysia, the most viable option to ensure student health and safety was to have reduced number of students undertaking physical practicum attachments in hospitals. In this paper, we have proposed and implemented a revolutionary virtual Biomedical Science practicum in January 2021, without compromising the learning outcomes.

II. Methodology

A. Samples and Module Information

The study was conducted using two cohorts of students (semester 4.5 and semester 5.5) that have undertaken the module "Biomedical Practicum" in year 2021 during COVID-19 lockdown. The module "Biomedical Practicum"

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is offered yearly to second year Biomedical Science undergraduates during their semester break, to equip the students with the knowledge and skills in the diagnostic and clinical laboratory, disease prevention and research fields. Students taking this module will be prepared for future careers in medical laboratory healthcare system.

B. Design and Development

At Taylor's University, all assessments were designed in constructive alignment to the module and program learning outcomes of the Taylor's Curriculum Framework. The Taylor's Curriculum Framework focuses on designing to ensure students develop and exhibit the Taylor's Graduate Capabilities. Due to the COVID-19 pandemic, most of the hospitals and healthcare laboratories within the country ceased offering physical biomedical practicums to ensure students' safety. Therefore, the assessment design for the module "e-practicum" have been revised for the 2021 study cohort.

Briefly, in the revised Biomedical Science e-practicum, four major departments were designed, namely (i) Biochemistry/Serology/Molecular Biology; (ii) Histopathology and Cytopathology; (iii) Blood Bank and Hematology; as well as (iv) Microbiology. These departments were derived from a thorough analysis of actual students' logbooks and were prioritized based on the departments that the Biomedical Science students were commonly assigned.

To achieve the intended learning outcomes of Biomedical Science e-practicum, a variety of online teaching-learning and assessment activities were carefully curated in accordance to program guidelines, module learning outcomes and student learning time (Fig. 1). Selected online teaching-learning activities include videos, live stream lectures, scientific articles and protocols, as well as Standard Operation Procedure (SOP) documents adopted from the Malaysian Ministry of Health. The introduction of the SOP was essential for students to understand the level of hazards associated with laboratory and also to serve as an important reminder for them to always follow safe practices in an actual hospital setting.

The lab skill assessment was reinforced with different teaching-learning materials and activities, such as simulations, case-based studies, hands-on home laboratory experience and other virtual laboratory tools (eg: Labster) to increase students' knowledge and to promote an active, enquiry-based learning attitude. Video-based activities provided a step-by-step overview of a real laboratory procedure to enable visualization of the whole experimental process and its environment through a video [9]. Strong emphasis was also placed on ensuring that students were able to understand the theory and execution of these techniques as well as the analysis and interpretation of abnormal situations using simulated patients' data.. Synchronous meetings with external panelists from hospitals were also carried out to enable the students to experience the communication in an actual hospital setting whilst troubleshooting real-life scenarios.

As the development of the affective domain is challenging in a virtual environment, online video-log (Vlog) and daily activities logbook were used as part of the assessment to ensure that students were able to learn and reflect on the activities. Case studies were also one of the assessments to test student understanding, application and analytical abilities.

Fig. 1. A schematic diagram of online teaching-learning in the Hematology department using TIMeS (Taylor's Integrated Moodle e-Learning System) platform. (A) Task instructions, (B) scientific articles and protocols, (C) example of video protocols, and (D) live stream lectures.

C. Implementation

Fig. 2 demonstrates the walk-through of conveying a topic to students. Students were introduced to the department by respective lecturers on the first day, simulating the experience of a physical practicum in the hospital. The background for each test or assay would then be introduced through reading materials and related videos, followed by activities as mentioned previously, such as the virtual laboratory simulation (Labster), quizzes, and case-based discussion with lecturers and external panelists.

D. Data Collection

Data collection for 1) supervisor evaluation report/case study, 2) final internship report/self-reflection (V-log), 3) logbook, 4) completion of Labster activities, and 5) feedback from the external panel (Medical Lab Scientist) and Taylor's Biomedical Sciences' alumni who had their physical Biomedical Practicum in year 2020 were conducted in this

e-biomedical practicum. Students were encouraged to provide feedback about their perception and acceptance of this e-biomedical practicum practice.

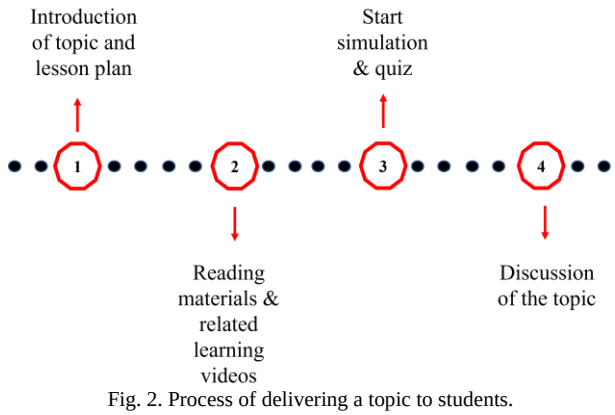

Fig. 2. Process of delivering a topic to students.

III. Results and Discussions

Biomedical practicum enables students to equip themselves with the knowledge and skills required in the clinical and diagnostic laboratory, as well as disease prevention. However, the outbreak of COVID-19 in early 2020 had an unfavorable impact on students' learning, where physical face-to-face teaching and learning activities had to be replaced with online lessons. In addition, many students were unable to attend their biomedical practicum placements in hospitals; this was a measure to ensure their health and safety during the time where COVID-19 vaccines have yet to be introduced. There was an urgent need to develop relevant and meaningful online teaching materials to ensure that the students' learning experience was not affected by the COVID-19 pandemic. Therefore, this exercise (e-practicum) was part of an effort for Taylor's biomedical science students to gain sufficient knowledge, employability skills and work experience in the biomedical industry. Our Biomedical e-practicum has been designed such that students can have "job rotation" in different laboratory departments, which simulates the experience of undergoing biomedical practicum in an actual hospital and enables the students to achieve different learning outcomes.

A. Feedbacks from External Panelists and Taylor's Biomedical Sciences' Alumni

Transformation of the physical Biomedical practicum to an online e-practicum was associated with several challenges. Firstly, teaching staff mainly relied on online resources such as reading materials and videos to design the learning activities and assessments. However, some may not be familiar with the state-of-the-art equipment that is currently used in clinical and diagnostic laboratories in various hospitals. Proper physical training is required for the usage, handling and technical maintenance of each equipment, which is a skill that cannot be imparted to students via the e-practicum. Secondly, laboratory experience for Biomedical Science students is largely dependent on hands-on activity, as most of the laboratory tests involve the use of patient specimens and diagnostic equipment. Without being physically present in the laboratory, it becomes difficult for the students to experience routine laboratory activities. Thirdly, there was insufficient technical support for teaching staff to conduct a good laboratory simulation due to the lack of online learning support devices or platforms available to educators[10], [11].

Working around these unavoidable limitations, we have focused on developing to-date and relevant content for the e-practicum. A feasible home-based laboratory activity that involves minimal usage of diagnostic equipment was designed, where students can easily source most of the required materials either in their home or supermarkets. Prior to the implementation of this e-practicum, the teaching materials were moderated by two external panelists who were Medical Lab Scientists at local hospitals. Both panelists agreed that with the current content, the e-practicum will allow students to gain more knowledge and concept of working in a laboratory. Given that some activities were rather challenging, students will be able to develop their critical thinking skills despite not being physically present in the laboratory.

"Due to the pandemic, experiential learning can't be carried out physically in the laboratory, I find that this e-practicum platform is a very good idea to guide and assess the knowledge in students especially what we have learnt through theory. With this experience, I believe the students are able to gain even more knowledge and develop understanding in the respective departments via the different cases or scenarios given in the e-practicum."
(Medical Lab Scientist 1)

"This e-practical learning (is) able to provide the concept of working in the laboratory despite (students) inability to experience it physically. Applying the knowledge learned in the case study enable the students to develop critical thinking as only visualization can be done without being physically present in the lab. With this e-learning, I believe that students (will be) able to understand more on the theory and reasons behind the tests conducted and understand the workflow of the lab in the given scenarios."
(Medical Lab Scientist 2)

The contents of the e-practicum were also moderated by two Biomedical Sciences' alumni who had experienced the physical practicum in 2020. Briefly, they mentioned that the content of e-Practicum was informative, resourceful, and mostly similar to what they have learnt previously in the hospital. To compensate for the physical learning experience experienced by these alumni, students undertaking the e-practicum also had the opportunity to participate in a synchronous online learning environment, where they attended live lectures and had real-time interactions with teaching staff and the invited Medical Lab Technologists. Through this, the students were able to obtain instant feedback, which was beneficial for their learning. A previous study also reported that synchronous learning can provide multiple opportunities for instant feedback and social interaction [12].

"In my opinion, the E-practicum is quite informative and resourceful. In terms of hands-on experience, it is quite regretful as the students are unable to perform their

practicum in the actual hospital. Besides hands-on activity, the contents prepared by the lecturers are similar to those I did in the hospital back then. The lecturers put a lot of effort in preparing the E-practicum. The time allocated for each department is enough as each department has a duration of 2 weeks for the students to learn while I only had a 1 week duration for each department previously." (Biomedical Science alumni 1)

"After going through the content of the e-practicum with Dr Teoh and comparing it with what I have learned during my own practicum period in 2020, I can see that the content of the course is mostly similar to what I have learned. The learning content from all the 4 departments is well organized and sufficient, which would provide the best learning opportunity for students during this unfortunate Covid-19 situation. Students will undergo 2 weeks in each department which I think is the right amount of time for them to learn about the various purposes and tests that each department is responsible for. Overall, I believe that the students will be able to learn what I have learned through the learning materials and case studies provided, even though they will not be able to get any hands-on experience."

(Biomedical Science alumni)

B. Student Overall Performance

Three main sections accounted for the student overall performance: i) supervisor evaluation report/case study, ii) final internship report, and iii) logbook. Based on Fig. 3, students in e-practicum reported similar achievements in their overall performances when compared to the students who went for physical practicum in the year 2020. All three main sections showed similar percentages which indicated that e-practicum does not affect student learning outcomes.

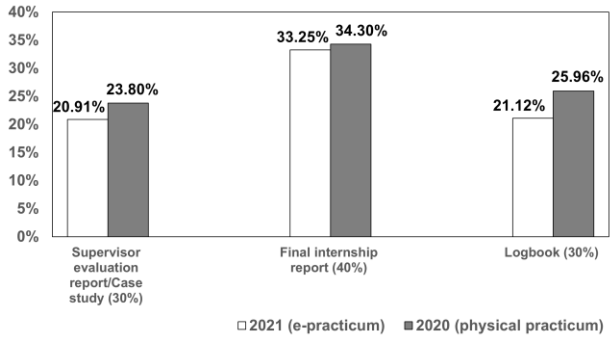

Fig. 3. Student performance comparison between e-practicum in year 2021 (white bar) and physical practicum in year 2020 (grey bar).

By implementing online learning activities such as the use of video-assisted technology and Labster simulation in this e-practicum, students were able to learn at their own pace and repeat the content whenever needed. The inclusion of various videos as teaching material enabled the students to become more independent learners. In cognitive terms, it can facilitate the understanding and memory of information and messages for students who are weak in reading [13]. The use of these platforms and the selection of adequate methods is crucial as it could diversify the activities carried out by the students as well as support self-education and independent task performance [8]. In the context of online assessment, case study analysis was used to achieve the goal of developing laboratory knowledge and skills. The case study in this e-practicum was designed to ensure students who have successfully completed the assessment will be able to apply their knowledge in the laboratories in the future.

Although COVID-19 has severely impacted the conventional learning method of Biomedical Science students, it has also enabled educators to design various innovative and adaptive teaching approaches, such as this e-practicum [14]. However, it must be acknowledged that as with every new teaching approach, it might not be effective for every student as we should consider individual learning differences, style and support needed by each individual. Hence, novel teaching approaches should always be pilot-tested and the staff should be trained whenever possible, prior to their long-term implementation [15].

C. Hands-on Home Laboratory Experience (HoHLE)

One of the core activities in the histopathology department of a diagnostic laboratory is to process human tissues into histopathologic tissue slides for microscopic examination. Therefore, as the first step in tissue processing, it is important for students to understand the macroscopic examination of human tissues to select the best representative piece for processing into a tissue slide. In our HoHLE activity, students were required to prepare "human tissue" to be submitted for diagnosis. The "human tissue" needed to be accessioned, measured, weighed and subsequently visually examined to identify any parts with abnormal texture or color. After which, the abnormal "tissue" parts will be excised and submitted for the next processing steps (Fig. 4). Through this HoHLE activity, students have demonstrated a good understanding of one of the critical activities in the histopathology department, indicating that the learning objective has been successfully achieved. On top of that, students' creativity has been boosted as evidenced by the various human tissue mimics that have been used in this home-based laboratory activity, including the use of edible meat and plasticine clay.

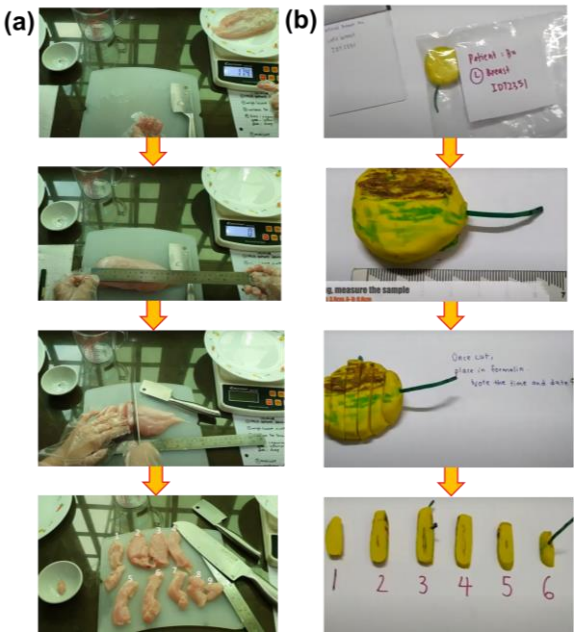

Fig. 4. Representative snapshot images extracted from tissue processing videos submitted by students using (a) chicken breast meat and (b) plasticine clay to mimic the human tissue.

Most participants found that the activity is very informative and resourceful. The adoption of HoHLE can be an important tool to tackle the training challenges faced in some developing countries with insufficient content delivery, increasing material costs and decreased access to physical facilities due to the pandemic [16]. More importantly, HoHLE provides an important and interactive learning opportunity for students during the pandemic.

D. Lab Simulations

Labster simulation is a virtual laboratory with scientific simulations that uses gamification and storytelling approaches to engage students in a case study-based scenario. For the e-practicum, three different Labster simulations (Lab Safety, Antibodies and Hematology) with main key laboratory skills were selected and introduced to the students (Table I). For the simulation, supplementary materials were also provided as students had to answer each quiz question correctly to be able to move to the next step (Fig. 5).

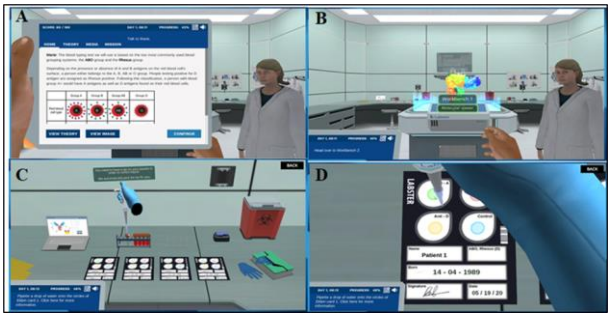

Fig. 5. Screenshots of the "antibodies" virtual lab simulation from Labster. (https://www.labster.com/simulations/antibodies/).

TABLE I: KEY LABORATORY SKILLS OF THREE IMPLEMENTED LAB SIMULATIONS IN E-PRACTICUM

(A) Lab Safety	
No.	Key laboratory skills
1	To understand the importance of personal protective equipment (PPE) in the lab
2	To understand the rules (do's and don'ts) in a laboratory
3	To learn proper use of lab safety equipment's
4	To understand the danger and standard operating procedure (SOP) to react in an emergency situation
(B) Antibodies	
No.	Key laboratory skills
1	To understand the structure and function of antibodies (different isotypes and parts of an antibody)
2	To understand the formation of the antibody-antigen complex
3	To recognize four major blood types (phenotypes) in the ABO system
4	To understand the principles of blood typing using Eldon cards
5	To understand about rhesus incompatibility and hemolytic disease
(C) Hematology	
No.	Key laboratory skills
1	To understand the different functions of each type of blood cell
2	To understand the principle and operate an automatic hematology analyzer to analyze complete blood counts
3	To learn proper skills to prepare peripheral blood smears
4	To learn different Giemsa skills to identify different blood cells

The status of completion and quiz score achieved by students in three Labster simulations was shown in Fig. 6. There was 100% completion for all simulations except Hematology (97.1%) as one student stopped the simulation at 56% completion (data not shown). Overall, students achieved very high scores (>90%) for all simulations. The highest score was achieved for Antibodies simulation (96.2%), followed by Lab Safety simulation (95.7%) and Hematology simulation (92.5%). The Labster simulation allowed students to learn at their own pace and to plan and repeat the content whenever required..

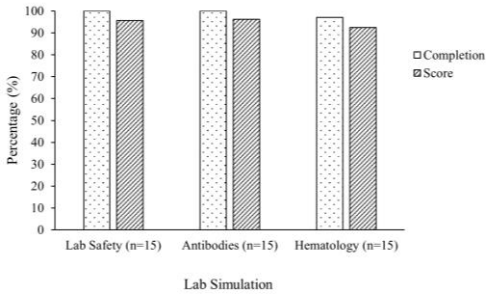

Fig. 6. Status of completion (%) and quiz scores (%) achieved by 15 BM students in three lab simulations implemented in the project (A) Lab Safety, (B) Antibodies and (C) Hematology.

E. Student Feedback regarding e-Practicum

The feedback from students demonstrated a good connection between the e-Practicum and the actual hospital laboratory practices. Even though the e-Practicum was not able to replace the hands-on experience given by the physical hospital attachment, it was still a good alternative to provide significant exposure to students during the pandemic.

"The discussion sessions with HoDs and professional MLT really provide a good opportunity for students to have an idea on daily routines in the lab and able to know latest development in the field." (Student A)

"Activities, like Labster, quizzes, virtual meetings, were really interesting and informative." (Student B)

"Although E-practicum is still lacking when compared to the physical practicum, it's without doubt that I gained a deeper understanding on the theory behind the tests through various online activities prepared by the department supervisors. It has equipped me better before going to actual work scenarios." (Student C)

"Very grateful for the alumni sharing their experience of working in SunMed, gives a lot of clarity of what the scope would be." (Student D)

Some studies found that participants' extrinsic and intrinsic motivation was lower in online education when compared to face-to-face education. Researchers have reported the lack of interaction with peers and lecturers as the reasons for low motivation in online courses [17]. However, this was not observed in this student potentially due to the high level of teaching staff and student engagement throughout the e-practicum.

IV. CONCLUSION

In summary, Biomedical Science students have been rotated to different laboratory departments through the

simulation of an actual hospital laboratory rotation. The exercise managed to achieve intended outcomes such as acquisition of discipline-specific knowledge, collaboration, communication and more importantly, experimental methods and laboratory practices that empowered the students to translate virtual observations into interpretations, similar to actual clinical placements in hospitals.

As the pandemic continues, we envision that this Biomedical Science e-practicum concept can be applied for the teaching of Biomedical Science-related courses using simulated laboratory settings as well as the opportunity to scale it to other health science-related programs. This can be helpful to all higher learning institutions who are planning to adopt an online teaching and learning approach for clinical placement in the near future. The delivery of practical skills and its assessment can be further improved in view of future situations that might impede the practice of physical practicum placements. Once the pandemic situation eases, clinical instructors can be trained to improve on the executional delivery for practical skills.

This research highlighted the experiences of both instructors and students undergoing clinical placement during the COVID-19 pandemic. Although some techniques used in this research has its limitations such as the lack of clinical hands-on skills, students still managed to gain other important skills and knowledge through these simulated experiences. In the future, other forms of delivery like augmented reality and/or virtual reality can be incorporated into the simulated clinical setting to enable students to gain hands-on experience.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

All authors contributed in designing and analyzing the data of this virtual practicum – e-practicum; Ooi YY, Teoh ML, Lee SH, Tang YQ, Chua LL, Looi CY, Ng WK, Tor YS conducted the research and coordinated by Ooi YY; Ooi YY, Chia AYY, Teoh ML, Lee SH, Tang YQ, Chua LL, Looi CY, Ng WK, Yong PVC wrote the paper; all authors had approved the final version.

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Adeline Chia Yoke Yin completed her PhD studies at Monash University, specialising in the field of translational medicine. Her primary research interest is on understanding the mechanism of actions and role of carbohydrates and lipids in diseases as well as molecular modeling analogues to target metabolic disorders, with specific interest in disorders of the reproductive system and aging. She has secured many grants nationally and internationally and published various international peer reviewed journals. She also serves as an international ambassador of the Biochemistry Society (UK) and the Royal Society of Biology while being a lifetime member of the Malaysian Society for Biochemistry & Molecular Biology (MSBMB), Young Scientist Network-Academy of Science Malaysia (YSN-ASM) and many more. In recognition for her research effort, she has won several awards such as the Merck Young Scientists Award (Bioscience category), IUBMB Women in Science Travel Grant and Young Scientist Award Observer Fellowship IUBMB. Assoc. Prof. Dr. Adeline is currently teaching Biochemistry courses at School of Biosciences, Taylor's University and has a passion for teaching and her innovative approach had won her the Taylor's University Exemplary Meritorious Academic Staff Award, Vice-Chancellor's Award Most Cited Academic, Gold Award for Innovative Module Site, President's Award and Anugerah Fasilitator e-Pembelajaran Terbaik Nasional.

Teoh Ming Li obtained her BSc (hons) in biomedical technology and PhD in algae biotechnology both from the University of Malaya. Dr. Teoh is a phycologist with more than 20 years experience of working on microalgae, especially those from the Polar Regions. Her primary research interest is on the response and adaptation of microalgae to climate change. She is also interested in researching bioactive compounds derived from microalgae which have commercial values in the pharmaceutical, cosmetic and food industry. Her other research interests include the toxicological effects of heavy metals and emerging contaminants on microalgae. In recognition of her expertise, Dr. Teoh has recently being appointed as Short-term Visiting Professors at the School of Science, Mae Fah Luang University in Thailand where she conducted specialized lectures and laboratory practical in the areas of microalgal cultivation and algal biotechnology innovations for undergraduates students between November and December 2019. Dr. Teoh is currently teaching Toxicology and Pharmacology courses at School of Biosciences, Taylor's University. Besides research, Dr. Teoh also won awards in various national and international university carnival on e-Learning. She believes that the self-paced method allows students to design their own learning experience, not only at their own pace, but according to their own interests and learning preferences.

Lee Sau Har received her BSc biomedical science in 2009 and was conferred her PhD degree in 2013. With her excellence in research, she was selected to attend the Nobel Laureate meeting in 2010. After that, she joined Tsinghua University, Beijing in 2014-2015 as a postdoctoral fellow, under the support of Centre for Life Sciences (CLS) Postdoctorate Fellowship. During this period, her research interest expands into the cancer stem cell field and she was awarded two national grants from the China government. Prior to joining Taylor's University as a Lecturer, Dr Lee served as a Senior Research Scientist in Cell Genesis Sdn Bhd. Dr Lee's current research interest encompasses discovery of potent anti-cancer compounds from peptide and plant sources, followed by mechanistic studies of those potential compounds. Besides, she is also exploring the use of miRNAs in the regulation of cancer cells growth, as well as how these compounds can be specifically delivered to the target cells. She is currently a member of multiple research associations, including MACR, MSBMB, OWSD and an affiliate of the YSN-ASM. Upon joining School of Biosciences, Taylor's University in 2017, Dr Lee has been experimenting with various teaching and learning strategies for her teaching modules as she acknowledges the learning difficulties that some of the students may face with and she had won a Silver award in IUCEL competition 2019.

Tang Yin Quan received his bachelor degree in biomedical science and PhD in cell biology. Prior to joining the Faculty, Dr. Tang has accumulated four years of postdoctoral experience in multidisciplinary biomedical research fields (Cancer Pharmacology, virology, regenerative medicine, vascular biology) in the University of Malaya, Johns Hopkins School of Medicine, U.S, and ICGEB, Trieste, Italy. The significance of his works had been recognized in a number of scholarly publications, conferences, and awards including the Best Presenter in Young Scientist Program (YSP) and Travel Award in KSBMB International Conference, South Korea, Travelling Award to First Croucher Summer Course - Precision Genome Engineering by CRISPR by Hong Kong University as well as the IUBMB Early Career Grant and YSP Observer Fellowship in IUBMB Seoul. He is also a member of the Royal Society of Biology (UK). Currently, Dr Tang is teaching Cell Biology, Biomedical Instrumentation, Clinical Genetics, and Bioinformatics modules at Taylor's University. He utilized various interesting teaching method including personalized learning to meet different student needs in learning, and being recognized with several teaching awards: International e-Learning Carnival & Conference 2019 and Putra InnoCreative Competition 2018. In addition, he is also one of the advisors of our "Taylor's University School of Biosciences, TUSOB" club.

Chua Lin Lin completed her undergraduate and PhD studies at the University of Melbourne, Australia, specializing in the field of Immunology and Microbiology. Her primary research interest is on understanding the role of monocytes and macrophages in diseases. These immune cells can be trained to assist infection clearance and boost general health. At present, she is investigating potential ways to modulate the functions of monocytes and macrophages using natural products and food products. She is also interested in understanding the mechanisms by which prebiotics and probiotics can promote gut health. In recognition for her research effort, she has won several awards such as the Network Researcher Exchange, Training and Travel Award by the Australian Society for Parasitology and Young Scientist Award by the Malaysian Society of Biochemistry and Molecular Biology. Dr. Chua is currently teaching Microbiology courses at School of Biosciences, Taylor's University. She understands that each student may have their own unique learning style, hence she varies her teaching methods to motivate students to learn better and attain success. She incorporates various interesting e-Learning teaching strategies in delivering her courses and has won several awards in national and international university carnival on e-learning.

Looi Chung Yeng obtained his bachelor of biomedical science (hons) degree from University Putra Malaysia. With Japanese Government scholarship, he furthered his Master and Phd in Tohoku University, Japan. He worked as a post-doc in IDAC, Japan before continuing as senior research fellow in University Malaya under Honorary Prof Mohd Rais Mustafa. Currently, he is a senior lecturer teaching Advanced Pharmacology in School of Biosciences, Taylor's University. His area of specialization is on natural product-based drug design and development, cancer or infection immune response. He has published more than 70 papers in indexed journal with a H-index of 29 and total citations of 2232. He also contributed two book chapters and serving as Associate Editor in tier-one journal, BMC Complementary and Alternative Therapies. Before joining Taylor's University, he also involved in world's first immunotherapy Phase 3 multi-centered clinical trial on nasopharyngeal cancer as production scientist in Tessa Therapeutics.

Ng Woei Kean is a lecturer of medical microbiology in School of Biosciences, Taylor's University. His work mainly focuses on the manipulation of antibodies and aptamers in developing diagnostic assays for detection of infections, specifically on methicillin-resistant *Staphylococcus aureus* (MRSA), influenza A, dengue and chikungunya. He aims to transform the diagnostic tests into low-cost, user-friendly yet highly reliable tools for point-of-care purposes. Other than doing research, he also enjoys in teaching. Dr. Ng believes that an academician is not sorely by

teaching the contents or knowledge from the textbooks, but is also to enlighten the future generation to be a better human being to the nation. Dr. Ng completed his Ph.D. in Institute for Research in Molecular Medicine (INFORMM), Universiti Sains Malaysia. He received several awards during his Ph.D. candidature including the best oral presenter in an international conference and Three-minute Thesis Competition.

Tor Yin Sim obtained BSc biomedical sciences and PhD specializing in molecular biology and pharmacology from Universiti Putra Malaysia. Her research focus on basic and clinical epidemiology of cancer. Molecular basis and foundational knowledge are essential to make advancements in the diagnosis, treatment and prevention of cancer. She is currently exploring interferon gamma signaling pathway in regulating Programmed Death-1 Ligand-1 (PD-L1) activation in non-small cell lung carcinoma. And the PD-L1 expression and genetic polymorphisms as prognostic marker in Malaysian NSCLC. Her research interest also includes developing copper complex as a targeted therapy in colorectal cancer. Besides, she is the member of Malaysian Association for Cancer Research (MACR) and Malaysian Society for Biochemistry & Molecular Biology (MSBMB).

Phelim Yong Voon Chen completed his PhD studies and bachelor of biomedical sciences at Universiti Putra Malaysia. His primary research interest areas are on proteomics, cell biology and mycology. He was the associate dean for research and development for School of Biosciences from year 2011 to 2012 and associate dean for learning and quality for School of Biosciences from 2013 to 2017. Currently, he is the head of School of School of Biosciences, Faculty of Health and Medical Sciences, Taylor's University and serve as the Director of Taylor's Centralized Laboratories, Taylor's University.