



Service-learning in microbiology during the pandemic: A Malaysian perspective

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ABSTRACT

Aims: During the Covid-19 pandemic, adaptation, flexibility and creativity is paramount in conducting Service-Learning courses. The study aims to evaluate the feasibility of a hybrid mode service-learning in Microbiology course conducted over a semester which involved undergraduate students being strewn all over the country, with highly diversified conditions varying from local movement control laws and availability of facilities such as internet access.

Methodology and results: A cohort of undergraduate students conducted the course from the comfort of their own homes to teach underprivileged school students. The undergraduate students engaged school students in the proximity of their location, then conducted STEM activities over the course of a few weeks either via face-to-face, online or hybrid mode. Microbiology activities included microscopy using a Foldscope (paper microscope), isolation and growth of microbes, preparation of microbe-related food and others. Surveys were conducted with school students pre- and post-programme, parents and the undergraduate students conducting the programme. While the school students benefitted from highly engaging STEM modules, the undergraduate students underwent a steep learning curve, mentoring school students in STEM whilst juggling challenges presented by the pandemic but finally achieved all learning outcomes.

Conclusion, significance and impact of study: Service-learning for life sciences subjects can be conducted efficiently during a pandemic when flexibility and freedom is given to students to achieve the learning outcomes.

Keywords: Service-learning, STEM, Covid-19 pandemic, hybrid

INTRODUCTION

Service-learning is a form of experiential learning where students extend their formal education obtained in classrooms to community-based service. It is different from community service as it encompasses an academic element and is designed in such a way where learning occurs for both the service provider as well as the recipient (Furco, 1996). While some courses such as Medical courses traditionally possess the service-learning element incorporated in their courses since the training of medical doctors involve providing medical care to patients, many courses do not require students to engage with the community at all. This includes Life Sciences courses such as Microbiology, Biotechnology and Biochemistry, where students would spend more time isolated in the laboratory doing research instead. As such, service-learning is a useful exercise which encourages students to engage in real world problems with the community and links cognitive development with personal and affective development.

Many benefits of service-learning have been reported including increased academic performance, improved teamwork and public speaking skills (Cain, 2013), increased social skills (Cartwright, 2010; Celio *et al.*, 2011) and moral-reasoning scores and better attitude towards self, learning and civic engagement (Celio *et al.*, 2011; Lies *et al.*, 2012; Webb, 2017). In a review by Webb (2017) on service-learning in microbiology, the type of service performed can be largely divided into two categories which are education and research. Education service-learning would involve activities like teaching microbiology to elementary or high school students (Abrahamsen, 2004; Mika *et al.*, 2012; Webb, 2016), educating the public through educational materials or hosting an informational booth at a health fair (Larios-Sanz *et al.*, 2011; Vrentas *et al.*, 2011; Cain, 2013). Research-based service-learning, on the other hand, would involve examples such as analysis of water quality from a local community (Abu-Shakra, 2012), a survey of the awareness level of a community on a microbe-borne diseases such as Legionnaires' disease (Cutucache *et al.*,

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2014) or optimizing experiments for citizen science programmes such as the Small World Initiative (SWI, <http://www.smallworldinitiative.org/>) and Tiny Earth (TE, <http://tinyearth.wisc.edu/>) (de Groot *et al.*, 2019). These programmes allow participation of citizens such as high school students in real experiments such as isolation of novel antibiotic-producing microbes from self-taken soil samples to increase societal awareness on antimicrobial resistance.

During this Covid-19 pandemic period, many Service-Learning courses have steered to non-direct community engagement such as preparation of education materials like infographics and videos which can be easily done by students in isolation. However, the practical aspect of certain learning outcomes especially in life sciences subjects including Microbiology is not applied in these types of activities. In addition, the students may never be in contact with any community at all when performing this kind of service-learning activity, which defeats the purpose of service-learning.

In Malaysia, many universities have adopted a programme called SULAM (Service-Learning Malaysia-University for Society) spearheaded by the Ministry of Higher Education which incorporates a Service-Learning course into the formal curriculum at the undergraduate level (<https://sulam.mohe.gov.my/web/>). As such, students undertaking the Bachelor of Science Microbiology with Honours programme, at Universiti Putra Malaysia, are required to take a course called Service-Learning in Microbiology which is a compulsory course. Typically, the course coordinator arranges for the university students undertaking this course to visit a community like a school or a village where the students run STEM activities which raises interest and awareness on issues related to microbiology such as hygiene, sexually transmitted diseases and vaccines.

However, in 2020, due to the Covid-19 pandemic, universities students were mostly back in their hometowns all over the country undergoing a fully online mode of study when the service-learning course was to be undertaken. There were many pandemic-related restrictions in conducting the course. Depending on the states the students were in and the local pandemic situation in those states, there were different level of restrictions and Standard Operating Procedure which the students had to maneuver whilst carrying out the service-learning activities. For example, some students were strictly homebound as they had to undergo home quarantine due to close contact to a Covid-19 positive case when they were supposed to run the programme and some had a 10-km radius travel restriction. In addition, the university students came from different economic backgrounds; some lived in city centers while others lived in reclusive villages with little internet access or availability of electronic devices. As such, a lot of flexibility had to be given to the students to undertake the course successfully whilst still achieving the learning outcomes of the course which was to adapt theoretical and practical microbiology knowledge while engaging the community and to show affective attributes such as

commitment, professionalism and leadership qualities.

MATERIALS AND METHODS

Course design

The Service-Learning in Microbiology course is a one credit (0+1) course for third year BSc. Microbiology with Honours undergraduate students (called Microbiology students henceforth) which is assessed through continuous assessments. For this cohort, students were requested to run a programme entitled “Evoking an interest in STEM through the mysterious world of the unseen”. Assessment included proposal presentation (oral and written), course coordinator evaluation, community evaluation and a final report which included all the activities they have conducted and a reflection on the experience while carrying out the programme.

Participants

Forty Microbiology students took this course during the pandemic. They were required to engage at least one targeted community in close proximity which were underprivileged school children (mostly those coming from low-income families) from ages 10-17 years old. A total of 72 school children participated in this programme with a minimum contact hours of 20 h over the course of several weeks.

Activities

Microbiology students were required to conduct three compulsory activities with the school children, which were Foldscope activity, micrograph competition and bacteria culture experiment. Foldscope is an affordable paper microscope (www.foldscope.com) which the users have to fold like origami before using. It can magnify specimens up to 140x and is useful for viewing self-prepared specimens from the environment which can also be recorded using a mobile phone camera. In conjunction with this activity, school students were encouraged to join a micrograph competition by submitting their best Foldscope images via Padlet (Padlet.com). The foldscopes were co-sponsored by the Malaysian Society for Molecular Biology and Biotechnology (MSMBB) and Foldscope Malaysia and were sent to the Microbiology students by the course coordinators via postal mail together with the nutrient agar powder for the bacteria culture experiment. However, some students chose to prepare their own nutrient agar using household items as part of the activity conducted with the school children.

Apart from these compulsory activities, Microbiology students were given the freedom to come up with other STEM activities focusing on microbiology, taking account materials they can find as well as the financial implication of those activities which was either borne by themselves or using the money raised by them. However, for every experiment, the Microbiology students had to propose it to the coordinators beforehand to ensure feasibility and

scientific accuracy. Students also had to prepare the protocols and optimize the experiments before conducting the activity with the school children. Brief explanation of some of the activities conducted is as follow:

Bacteria culture experiment – Many variations of this experiment were performed. Some conducted hand-washing experiments where school students were asked to imprint their hands on nutrient agar before and after washing their hands. Some cultured swabs from the environment like the floor, shoes, pets and etc. Some isolated luminescence bacteria from squid. Bacteria culture was observed the next day after incubation.

Winogradsky column – This is a bottle/long container with sediment and water containing different types of nutrients thus creating a mini ecosystem in the container which favours the growth of different types of microbes depending on its ability to utilize the nutrients provided. For example, one bottle contained no nutrients, one bottle contained eggshells as carbon source and egg yolk as sulfur source, and the last two bottles contained only either of the nutrient source. The bottle was observed weekly for different coloration indicating presence of difference types of microbes.

Yeast fermentation – In this activity, students mixed baker's yeast in water which can be supplemented with sugar in a bottle which is capped with a deflated balloon on top. As the yeast ferments the sugar, it releases carbon dioxide which inflates the balloon. Different amount of sugar or types of sugar can be used to vary the balloon inflation.

Food microbiology – Students prepared various types of food containing microbes such as growing edible fungi, making yoghurt and a local delicacy called "tempeh" which is a soyproduct fermented with fungi.

Other activities include making microbe models such as the structure of a virus capsid using origami and playing microbe-theme online games and quizzes. In all activities and experiments, Microbiology students explained the scientific theory they have learned from their own university courses and impart the pertinent roles microbes play in our daily lives to the school children.

Mode of delivery

While most of the Microbiology students planned the activities and submitted their assignments for assessments in groups, the actual programme with the school students were conducted individually due to logistics. Most of the Microbiology students chose to conduct the activities with school children living nearby their homes, allowing them to do face-to-face activities. A few of the Microbiology students were stuck in hostels, homebound due to quarantine after being in contact with Covid-19 positive cases or had chosen school children to engage which were physically far from them. These Microbiology students conducted the programme fully online or by hybrid mode. For activities which were done online, the school children were either sent the materials needed or asked to prepare the materials using easily available items and the online programmes were mostly

conducted in groups to allow interaction between the school students. The Microbiology students then conducted the experiments alongside the school children via video conferencing.

Survey

A total of four different surveys were conducted during the course of the programme. Two surveys were answered by the school children pre- and post- programme to understand their level of understanding on microbes and their interest in STEM before and after the programme. In addition, a survey was also filled in by the parents to indicate the impact the programme had on their children. Finally, a survey was conducted on the Microbiology students themselves to get their feedback on their experience when conducting the programme.

RESULTS

Achieving the learning outcomes

The proposal conducted by the Microbiology students showed that they were able to critically plan and design short experiments that can be carried out at home with limited materials, was suitable to engage schooling age children and was able to maintain Covid-19 SOP at the same time. Their proposal included protocols of the experiments they had proposed to carry out to ensure feasibility in terms of materials and time while their final report included results for the experiments conducted which showed that the experiments were successfully performed due to optimization of the protocols beforehand (Figure 1). These are important learning outcomes for Microbiology students as they have been trained for years in the programme to critically plan, optimize and report experiments in an unbiased manner in the lab which they have brought to the community through simplified experiments and activities. While some experiments can be very simple, like the yeast fermentation experiment which main objective is to show that fermentation produces gas as indicated by an inflated balloon, the Microbiology students attempted to translate knowledge and training gained from their formal studies by designing more complex experiments. For example, this can be done by varying the types and amount of sugar used and ensuring proper controls are included which is translated to varying degrees of balloon inflation. In addition, since the Microbiology students had to mentor younger school students through a span of several weeks, they had to show excellent leadership qualities to ensure the school students would stay committed to complete all the activities planned which was not an easy task to achieve since the involvement of the school students were voluntary and not part of a school-organized programme. In addition, the Microbiology students had to balance professionalism whilst maintaining a close, friendly relationship with the school students to encourage continued interest and engagement by the school students.

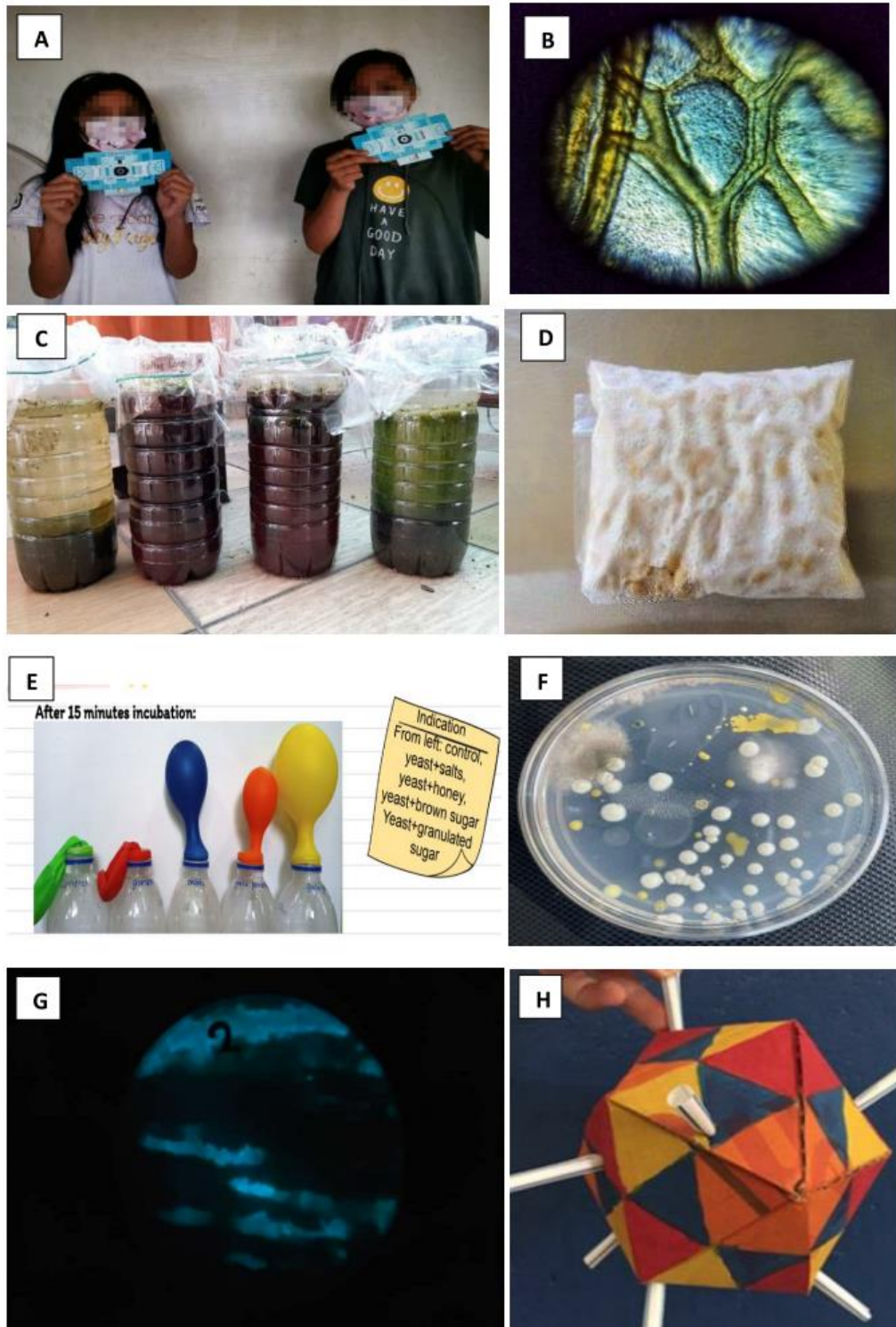


Figure 1: Examples of activities/experiments performed. (A) School students with their folded Foldscope, (B) Image of a fly's wing as viewed using the Foldscope submitted by a student in the Micrograph Competition, (C) Winogradsky column, (D) 'Tempe', a soy based local delicacy produced by fungus fermentation, (E) Yeast fermentation experiment, (F) Mixed cultures of baker's yeast and microbes from the environment, (G) Isolation of luminescence bacteria from squid and (H) Virus icosahedral origami.

Table 1: Pre-programme survey for 72 school students before commencement of the programme.

Question	Yes (%)	No (%)
I know about the existence of microbes.	88.9	11.1
I am aware that microorganisms are actively related with my daily activities.	77.8	22.2
I know there are good microbes that can be useful in our daily lives.	65.3	34.7
I know there are bad microbes that can cause diseases.	98.6	1.4
I understand the importance of personal hygiene and am able to explain why it is important in the prevention of foodborne illness.	76.4	23.6
I know how to view microbes.	62.5	37.5
I have experience observing microbes under microscope/foldscope.	35.7	64.3
I love science subjects.	61.1	38.9
I want to explore more about microbes.	91.7	8.3

Table 2: Post-programme survey of 55 school students after commencement of the programme.

Question	Yes (%)	No (%)
I have learned a lot of new things about microbes through this programme.	92.7	7.3
I can connect this programme with what I learned at school.	92.7	7.3
I enjoy learning science through this programme.	100	0
The activities in this programme evoke my interest to science subjects.	98.2	1.8
This programme helps me to understand more about microbes and how they associate with our life.	92.7	7.3
Would you recommend this programme to others in the future?	100	0
The lessons given by the Microbiology students about microbes are informative and effective.	92.7	7.3
The Microbiology students have presented the lessons confidently.	92.7	7.3
This programme has increased my interest to study science in the university.	98.1	1.9

Effect of the programme on the school students

Based on the pre-programme survey (Table 1) answered by all 72 school students, majority of them are aware that microbes play a role in their daily lives, whilst almost all of them (98.6%) associated microbes with diseases and only 65.3% were aware of beneficial/good microbes. Apart from that, only 35.7% have had an opportunity to view microbes under a microscope before. Lastly, only 61.1% was inclined towards science but almost all of them (91.7%) was interested to learn more about microbes.

For the post-programme survey, only 55 out of 72 participants answered the survey (Table 2). Almost all respondents (>92%) have said that the programme had increased their knowledge and interest on microbes and the Microbiology students did a good job conducting the programme. In addition, 100% of them said they enjoyed learning science through this programme and would recommend the programme to other people.

Effect of the programme on parents/guardians

Fifty parents answered the post-programme survey for parents/guardians (Table 3). In general, the score for all questions were good and above 4.00. According to the survey, the highest scores (>4.80) showed that parent strongly agreed that their children learned more about microbes from this programme, benefitted from being mentored by university students and would recommend the programme to other people. In addition, majority of the parents also agreed that their children have an

increased interest in STEM after the programme or continued to use knowledge learned in the programme such as using the Foldscope and increasing hygiene practices. However, 4% of the parents disagreed that Microbiology was a suitable field for their children to enroll in in the future while 30% was neutral about it. Only 26% strongly agreed (scale 5) that it was a suitable career choice for their children. This question had the lowest score obtained (4.16) from the scale of 5 compared to all other questions.

Effect of the programme on the Microbiology students

Forty students were involved in this Service-Learning course. Survey of the impact of the project on these students clearly shows that it has successfully brought various positive impacts to the students as all questions scored above 4 from a total of 5 points (Table 4). It successfully improved students' skills in various aspects such as creativity (4.70/5.00), group work skills (4.43/5.00), communication skills (4.53) and social skills (4.65). Higher self-confidence was also successfully gained through the implementation of this project through interaction in conveying information to the community (4.60). In addition to gaining positive motivation for themselves in imparting knowledge to the community, students were also very happy in the success of this project, as well as teaching students to better appreciate the knowledge gained in the field of Microbiological Science (4.78/5.00).

Table 3: Post-programme survey of 50 parents of school students who underwent the STEM programme.

Question	Scale (where 1= strongly disagree and 5 is strongly agree)/No. of parents					Total score
	1	2	3	4	5	
My child shows some interest in learning STEM and would like to learn more about it.			5	21	24	4.38
My child has started to develop the skill of using Foldscope and observed the environment using it.			7	20	23	4.32
My child is taking good care of their hygiene better than before.			5	15	30	4.5
My child starts to ask and share things about science.			9	21	20	4.22
Microbiology is a suitable field for my child to enroll in the future.	1	1	15	20	13	4.16
My child could relate the importance of microbes into our daily life better.			5	26	19	4.28
My child learned more about microbes through these activities.				12	38	4.76
My child benefited from having university students conducting activities during school break.				7	43	4.86
Overall, how would you rate this programme from a scale of 1-5 with 5 being the best score?				6	44	4.88
How likely would you recommend this programme to others in the future?				7	43	4.86

Table 4: Survey of the impact of the service-learning in Microbiology course on 40 university students.

Attributes	Scale (where 1= strongly disagree and 5 is strongly agree)/No. of students					Total score
	1	2	3	4	5	
The programme helped me to improve my creativity.			1	10	29	4.70
The programme helped to develop my outreach talents by coaching, questioning and engaging the participants.				9	31	4.80
I feel teaching others helped me to learn as well, and made me feel like I was having a positive.			2	12	26	4.60
The programme helped me to increase my confidence level.			3	9	28	4.63
The programme helped to improve my communication skill.			3	13	24	4.53
The programme helped to improve my teamwork skills.	1			19	20	4.43
The programme helped me to improve my social skills.			2	10	28	4.65
The programme helped me to identify how coursework relates to the real-life scenario.		1	2	9	28	4.60
This programme helped me to appreciate BSc in Microbiology with Honours program more.				9	31	4.78
I enjoyed doing this programme.			3	8	29	4.65

Challenges encountered

In the final report submitted by the Microbiology student, a reflective essay was also included to detail the challenges faced by the Microbiology students when conducting the programme. One of the most common challenges faced by the Microbiology student was finding a suitable time to conduct the programme with the school students as both the Microbiology students and the school students had on-going online classes. Another challenge faced was getting the commitment of the school students to finish the programme. Since the school students' involvement was voluntary, the Microbiology students had a huge challenge in ensuring the school students were committed to the whole programme. In fact, some of the Microbiology students had to find new school students to engage even before they start running the programme as

some of the school students who agreed to join the programme pulled out at the last hour. Another challenge was finding a conducive environment to conduct the activities. Since most of the activities were performed at home, they had to make do with materials found at home, limited space and interruption from younger siblings. Even worse, some states at that time were affected by heavy flooding due to the monsoon season which interrupted the plans and activities of some students, thus they had to look for alternatives such as postponing some activities, planning simpler activities that can be conducted online, changing the location or the student engaged (if it was the school student which was affected). Other challenges included conducting activities and experiments which were age-appropriate as some Microbiology students wrote in their reflections that the activities prepared were either too sophisticated or too easy for their school

students which then was reflected by a lack of enthusiasm from the school students. Most of the Microbiology students have never had any teaching experience, so they were unsure how to approach school students, which were much younger than themselves, effectively.

DISCUSSION

The Covid-19 pandemic has brought about a new term called the “new normal”. Everything, from how we eat, shop, work, learn and even breathe have all taken a new meaning. Here, we present an experience on how a Service-Learning course was conducted for the Microbiology subject during this pandemic. To date, there is only a handful of reports on the implementation of Service-Learning in Microbiology-related courses involving hands-on activities and none reported in Malaysia, as far as to our knowledge. In a rather elaborate programme involving 43 Biology college students engaging with 146 high school and middle school students from five different schools (but only 106 students answered the survey) as well as eleven of their teachers, it was reported that this “Learning Partnership” benefitted all three parties (Abrahamsen, 2004). However, only four questions were asked per group of participants and there were a small percentage of respondents (~10%) who gave negative answers including that they would not have remembered the content of the lessons better than studying it for an exam and that the program was not worth their time (for teachers).

In another service-learning in Microbiology project performed by Webb (2016), the benefits reported were similar to those obtained in the current project. However, only six undergraduate student volunteers were reported, while the effect of the programme to the elementary students were answered by the teachers (n=13) and not the students. Interestingly, ~20% of the undergraduate students disagreed that the experience made them consider a career in microbiology or teaching which had a similar pattern to the current programme, although the question was answered by the parents in this case. A more recent Service-Learning programme with some Microbiology element was conducted by the students in the Bachelor of Biology, University of Neuchâtel (Switzerland) (Faton *et al.*, 2021). However, in this programme, only qualitative data collection and no quantitative survey was performed. In addition, in the service-learning in Microbiology programmes carried out by Larios-Sanz *et al.* (2011) and Cain (2013), the undergraduate students did not perform hands-on activities with the targeted communities; instead, they conducted education-based service-learning such as designing and distributing educational brochures and displays. This kind of programme was similarly reported during the Covid-19 pandemic (Adkins-Jablonsky *et al.*, 2021; Linares *et al.*, 2021).

Due to the Covid-19 pandemic, a one-suits-all teaching plan was not suitable as students had different limitations, may it be geographical, financial or facilities

limitations. As such, students were given loose guidelines and were free to choose the community to engage and the activities to be conducted which would suit their own limitations. At the end of the day, 100% of the Microbiology students achieved the learning outcomes, as they were able to show that they had critically plan activities and conducted them in a professional manner with the community. Some students did exceptionally well, coming up with elaborated experimental manuals for the activities while other students chose simpler experiments.

While the service-learning in Microbiology course was successfully conducted with many clear benefits including engagement with the community as well as industrial partners and non-profit organisations as sponsors, the challenges faced by the students in this time of pandemic should also not be overlooked. Other than physical challenges already presented thus far when conducting the programme, the mental health of these students should also be investigated. According to a study conducted by Son *et al.* (2020), a study of 195 university students in the United States show a whopping 71% indicated increased stressed and anxiety where 82% of students showed increased concerns on academic performances. As such, when designing the teaching plan for courses, a flexible approach such as presented here, especially for courses such as Service-Learning, should be given to students so they can achieve the learning outcomes according to their own capacity. However, one of the disadvantages of the programme may be the workload for the Microbiology students as they have to prepare the materials for the experiments by themselves since they cannot work in groups for this. This could also be the reason one undergraduate student said that he strongly disagreed that this programme improved his teamwork skills.

Finally, service-learning for Life Sciences courses like Microbiology is important to increase scientific communication with the public and also to change the perception of the public towards science. This Service-Learning programme had provided an excellent platform for science communication training as most scientists are bad communicators as they cannot discern between jargon and everyday talk and lack training in communication, although they may be experts in a field (Brownell *et al.*, 2013). In addition, parents were quite opposed to allowing their children enroll in a Microbiology course in future. However, in a study conducted in Malaysia, parents play the most important influence other than a person's own decision in choosing a career path (Kamsi *et al.*, 2019). In the same study, accounting students said they chose accounting over STEM programmes as they believe it would provide them with better future prospects and high salary. As such, the scientific community have a huge task to play in making science desirable again.

CONCLUSION

In conclusion, the service-learning programme “Evoking

an interest in STEM through the mysterious world of the unseen" was successfully conducted during the pandemic and was shown to benefit both Microbiology students conducting the programme as well as school students from the community who joined the programme. At the end of the day, the Microbiology students transferred knowledge gained from their university studies to their local community which is the ultimate aim of service-learning.

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