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A Case Study on How Outreach Programmes Form and Develop the Biomedical Engineering Community in Hong Kong

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***Abstract*—**Biomedical engineering (BME) is an interdisciplinary subject where knowledge about biology and medicine is applied to novel applications, solving clinical problems. This subject is crucial for cities such as Hong Kong where the burden on the medical system is rising due to reasons like ageing population. Hong Kong, who is actively boosting technological advancements in recent years, sets BME, or biotechnology as a major category, as reflected in the 2018-19 Budget where biotechnology was one of the four pillars for development. Over the years, while resources in terms of money and space have been provided, there has been a lack of talents, expressed by both the academia and industry. While exogenous factors, such as COVID-19, may have hindered talents from outside Hong Kong to come, endogenous factors should also be considered. In particular, since there are already a few local universities offering BME programmes, their curriculum or style of education requires to be reviewed to intensify the network of the BME community and support post-academic career development. It was observed that while undergraduate (UG) studies focus on knowledge teaching with some technical training and postgraduate (PG) programmes concentrate on upstream research, the programmes are generally confined to the academic sector and lack connections to the industry. In light of that, a "Biomedical Innovation and Outreach Programme 2022" ("B.I.O.2022") was held to connect students and professors from academia with clinicians and engineers from the industry, serving as a comparative approach to conventional education methods (UG and PG programmes from tertiary institutions). Over 100 participants, including undergraduates, postgraduates, secondary school students, researchers, engineers, and clinicians, took part in various outreach events such as conference and site visits, all held from June to July 2022. As a case study, this programme aimed to tackle the aforementioned problems with the theme of "4Cs" (connection, communication, collaboration, and commercialisation). The effectiveness of the programme is investigated by its ability to serve as adult and continuing education, and the effectiveness of causing social change to tackle current societal challenges, with the focus on tackling the lack of talents engaging in BME. In this study, B.I.O. 2022 is found to be able to complement the traditional educational methods, particularly in terms of knowledge exchange between the academia and the industry. With enhanced communications between participants from different career stages, there were students who followed up to visit or even work with the professionals after the programme. Furthermore, connections between the academia and industry could foster the generation of new knowledge, which ultimately pointed to commercialisation, adding value to the BME industry while filling the gap in terms of human resources. With the continuation of events like B.I.O. 2022, it provides a promising starting point for development and relationship strengthening of a BME community in Hong Kong, and shows potential as an alternative way of adult education or learning with societal benefits.

***Keywords*—**Biomedical engineering, adult education, social change, comparative methods, lifelong learning, innovation, professional community.

I. Introduction

BME is a field which includes the study of biology, medicine, and engineering. As an interdisciplinary subject, it focuses on developing novel diagnostic and treatment methods, bridging between scientists who discover knowledge and surgeons who perform the medical treatment. Therefore, BME plays a vital role in solving real-life medical problems. In Hong Kong, which is transforming to a smart city in recent years, the government encourages STEM advancements, and has set biotechnology/BME as one of the main developing areas. In order for the industry to prosper, talents are needed, and there are multiple universities in Hong Kong offering a BME programme to nurture aspiring prospects. After years of development and capital investment, it has been reflected by the industry that there is still a lack of talents to engage in the BME field.

In Section II, some government policies and university programmes would be reviewed to investigate any shortcomings for the current situation. Regarding this, a "Biomedical Innovation and Outreach Programme 2022" ("B.I.O. 2022") was offered as an out-of-class experience, aiming to supplement the shortcomings conventional tertiary education approaches. Surveys on both professionals and students were done after the programme to collect their feedback on how the B.I.O. 2022 serves as an alternative educational approach. The details of the B.I.O. 2022 and the feedback survey are elaborated in Section III, while the results are explained in Section IV. Finally, as an outlook, opinions were also collected on how to improve the programme to better act as an alternative educational approach and to help develop a wider BME community, which would be explained in Section V.

II. Background

BME is being rapidly developed in the recent years in Hong Kong, where many resources are provided into the field. Also,

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various universities are launching BME programmes to nurture BME talents, helping students to develop their career as scientists, engineers, or researchers, working in hospitals, research institutions, or medical companies. Below, some government policies, together with the university programmes, are reviewed. This could show what progress has been made, and what gaps are remained to be filled.

A. Government Policies

With the goal to transform Hong Kong (HK) into a smart city, the HK government has taken several measures to accelerate the development in STEM, providing both space and financial resources. For instance, the Hong Kong Science and Technology Parks (HKSTP), set up by the HK government since 2001, are attracting more and more biotech companies and start-ups in recent years, providing funding and helping with incubation. Also, the government has set up the Innovation and Technology Bureau (ITB, now known as the Innovation, Technology and Industry Bureau, ITIB) since 2015 for further development on innovation and technology. Through the Innovation Technology Commission (ITC), which is under the Bureau, a number of schemes have launched through the Innovation Technology Funds (ITF) to promote STEM development. Some of the key subsidising programmes are listed in Table I [1].

TABLE I
SOME FUNDING PROGRAMMES PROVIDED BY THE ITF

Name of the Funding Programme	Aim	Description
Innovation and Technology Support Programme (ITSP)	Supporting R&D	Supports theme-based mid-stream researches and encourages collaboration with leading research institutions local and worldwide.
Research Talent Hub (RTH)	Nurturing technology talent	Funds engagement of talents in innovation and technology to take on R&D projects in HKSTP, Cyberport, or other technology companies.
STEM Internship Scheme	Nurturing technology talent	Provides allowance to UG and PG students who are studying STEM programme in local universities to short-term internship.
Technology Start-up Support Scheme for Universities (TSSSU)	Supporting technology start-ups	Supports groups from local universities to translate their R&D results to business products solving real-life problems.
Patent Application Grant (PAG)	Fostering an innovation and technology (I&T) culture	Encourages capitalisation of intellectual work, especially for inventions with technology elements, through patent application.

This list only shows the programmes more related to support to academia. There are more programmes which aim at supporting R&D, facilitating technology adoption, nurturing technology talent, supporting technology start-ups, and fostering and I&T culture.

Among the various aspects of STEM, the government has also set its focus on the BME/biotechnology field. According to ITF statistics [2], however, it appears that the support on biotechnology is not as substantial as expected. As seen in Table II, throughout the years, the proportion of support in biotechnology over total support in all industrial sectors in terms of funding amount is 5.32% whereas the percentages in terms of the number of approved projects is 2.14%. Eyeing 2021 alone, the percentages are at 5.97% and 1.05% respectively.

TABLE II
AMOUNT OF SUPPORT THROUGHOUT ALL YEARS (TOTAL AND ON BIOTECHNOLOGY)

Total	Biotechnology	Proportion
$29458.8M in funding	$1568.3M in funding	5.32%
34057 approved projects	728 approved projects	2.14%

The approved projects come from various ITF funding programmes, such as ITSP, Partnership Research Programme, Midstream Research Programme, General Support Programme, and so on.

Therefore, after reviewing the funding programmes and the allocated amounts, there are still some gaps that need to be addressed. Firstly, from Table I, it shows that most programmes are supporting companies or start-ups, with fewer ones supporting students by offering them opportunities to experiences such as internships. Secondly, even though biotechnology is one of the areas being supported by the government, the proportion of resources can be further increased, as shown in Table II. With a gap in student support policies, it is also worth investigating the university curriculum and study its effectiveness in BME student development.

B. University Curriculum

In light of the development of BME, there have been more universities offering BME education. Currently, there are five institutions providing 4-year BME programmes, namely, the University of Hong Kong (HKU), the Chinese University of Hong Kong (CUHK), the Hong Kong University of Science and Technology (HKUST), the Hong Kong Polytechnic University (PolyU), and the City University of Hong Kong (CityU). Table III shows the curriculum overview for each BME programme.

It is worth noting that hands-on experience is emphasised in Table III. This is because BME is a subject about applying the knowledge of biology and medicine to real-life problems. It is crucial that students get sufficient engineering sense and practical experience before they graduate and work in the industry. The more hands-on experience they get during the university stage, the more experienced and confident they can be when they work in the future, be it in the industry or research. From the table, however, it is seen that the proportion of hands-on experience offered in each university's programme is limited (the remaining proportion is mainly knowledge-based). Therefore, there is a need to offer students more opportunities to experience current novel technology first-hand, and even better, a chance to develop on their own. Together with the problems observed in Part A, where there is not enough support between industry and students, an outreach event called "Biomedical Innovation and Outreach Programme 2022" ("B.I.O. 2022" or "B.I.O.") was proposed. It aimed to act as an alternative to traditional education approaches (i.e., undergraduate study, as reflected in Table III), as well as to tackle societal challenges in expanding the BME community in HK to further accelerate the BME development.

III. METHODOLOGY

The B.I.O. 2022 was organized during June to July 2022,

hosting over 100 participants including UG and PG students, researchers, engineers, and clinicians in the biomedical field. During the two-month programme, several events were held. The details of the events are shown in Table IV.

TABLE III
BME PROGRAMMES OF HONG KONG UNIVERSITIES

University	Proportion of Hands-on Teaching	Example of Hands-on Teaching Courses
HKU [3]	12.5%	Engineering Training Integrated Project Biomedical Engineering Laboratory Professional Training (Internship) Final Year Project
CUHK [4]	11.4%	Year 1 Summer Training Introduction to Engineering Design Biomedical Engineering Laboratory and Hospital Experience Medical Instrumentation and Design Engineering Internship (Work-study) Final Year Project
HKUST [5]	13.3%	Laboratory for General Chemistry I Academic and Professional Development Bioengineering Laboratory Bioengineering Capstone Design/Thesis Research/Industrial Project Engineering Seminar Series
PolyU [6]	20.8%	Introduction to Innovation and Entrepreneurship Engineering Design & Biomechatronics Biomedical Engineering Innovation for the Community Biomedical Engineering Industrial Internship Capstone Project Digital Design and Fabrication for Healthcare Services
CityU [7]	18.8%-28.0%	Bio-sensors and Bio-devices Robotic Technology in Healthcare Final Year Project Industrial Attachment Scheme/Co-operative Education Scheme/Overseas Internship Scheme

Hands-on Teaching includes laboratory, project-based courses, and internships.

TABLE IV
LIST OF EVENTS IN B.I.O. 2022

Event	Date	Description
Conference	Jun 18-19	Hybrid Mode (In-person + online) on tripod focused themes (medical, engineering and outreach)
Site Visits	June 13, 21, 28, July 22, 28	In-person visits to laboratories, enterprises, hospitals, research centres, etc.
Research Presentation Clinic (RPC)	June 9, 10, 11	Online interactive workshop for developing written and oral skills for academic publications and presentations
Mentor Chat Room (MCR)	June 7, 11, 14, 28, July 22	In-person/online small group chat room

Figs. 1-4 are a few picture highlights of the B.I.O. 2022 programme.

After the programme, five students and seven guest speakers from the conference were interviewed to gain their feedback. For speakers (who are professors and clinicians), they were mainly asked about the opinion to the conference and the BME industry, while for student participants, the questions revolved around both BME education and the B.I.O. programme in general. From the feedback from both students and speakers, conclusion could be made on whether the B.I.O. programme can fill in the gaps elaborated in Section II.

Fig. 1 Conference

Fig. 2 Site Visit

Fig. 3 Research Presentation Clinic

Fig. 4 Mentor Chat Room

IV. Results

From Section III, it is mentioned that the feedback from the students and speakers would reflect the results of the effectiveness of the B.I.O. programme. In this section, their feedback will be categorised into three parts. The first two parts are about the views on BME education and the industry, provided respectively from the perspective of students and speakers. The third part focuses on the views of B.I.O., which shows how it serves its purposes in 1) providing students with more hands-on experiences, 2) connecting academia and industry for more collaboration opportunities, and 3) complementing traditional education methods.

A. Expectation in BME Education

Although BME may not be the first choice for all the student interviewees at first when they apply for university, they all agreed that BME is an interdisciplinary subject, where the collaboration between biology, medicine, and engineering makes this subject interesting. Some also saw the potential of this programme, where they could make use of the broad range of knowledge gained in the programme to deal with real-life medical problems. As most of them foresaw themselves to work in the field doing research in the near future, they expected the programme curriculum to have a lot of hands-on experiences to sharpen their practical skills. However, partly due to the pandemic, these opportunities were largely reduced. Therefore, one of the expectations from the students was to have more hands-on experience. One student added that current hands-on experiences provided by the university curriculum mainly revolves around biomedical device research, hence laboratory experiences in a broader range of biomedical fields, such as biomolecular studies or engineering metabolic pathways, would be also encouraged. Another gap from the curriculum raised by the interviewees was about the discipline electives. Taking HKU BME programme as the reference, it offers courses similar to other engineering disciplines in year 1 study, with only one course on biology and chemistry specific for BME students. Some introductory courses are being taught in year 2 and year 3, while in year 4, students have to choose electives courses. However, some interviewees pointed out that the gap between was large, as the elective courses were too advanced because they had only learnt the basic knowledge from a broad range of fields in the previous years. Some mentioned that there was not enough guidance on which stream (e.g., biomaterials, biomedical imaging, biomechanics) to choose as they have not figured out their research interest yet. This links to another problem that they do not have enough exposure to different fields of research during their early years of university study. Therefore, one student suggested that apart from the compulsory internship they had to take in year 3, an internship in earlier years should also be encouraged and supported by the university to gain exposure as early as possible.

B. Expectation in BME Industry

After learning the expectations from the student perspective, this part focuses on the perspective from professors and clinicians. Since they were the speakers from the conference, their feedback was focusing on the conference experience. Apart from the conference, they also shared their views on the current industry and what is lacking in the BME community.

1) Views on the Conference

All of the speakers expressed their excitement about the conference, especially because it could be done as a face-to-face event. Many events in Hong Kong during the past two years were either cancelled or changed to online due to the pandemic. They were glad to see that in this face-to-face format, different participants, including students, industry, engineers, and clinicians, could come together and discuss the journey in innovation. Being able to communicate, whether during the presentation and forum section, or from further discussion during breaks, was crucial to connect participants from different fields, which could open opportunities to collaborate or even commercialise the products from the collaboration, bringing value to the BME community. They saw the significance and also the inter-relationship between communication, connection, collaboration, and commercialization (the 4Cs, i.e., the theme of this event) when working out solutions to solve biomedical problems.

2) Views on the BME Industry and Community

The speakers interviewed are working at different places, from universities to hospitals to start-ups, representing diverse career pathways in the BME industry or community, and their combined view would be comprehensive enough to conclude current situation in HK BME environment. Firstly, they agreed that the government has been working hard to boost the BME development as one of the strategic focuses. It devotes resources in terms of funding or space, such as the HKSTP or Cyberport. However, they still saw a lack of talents. For example, one professor whose research focuses on AI applications in orthopaedics mentioned the difficulty in recruiting programmer or BME talents working in AI area. Others suggested with an increased financial support, platforms could be set up to foster the linkage between students, clinicians, and entrepreneurs. This showed that currently students in universities do not have an easy platform to get to know the industry, which matches to the findings in part A (students' perspective) where students do not have sufficient exposure to different BME fields. Therefore, in part C, it would be shown that how B.I.O. can bridge the two.

C. How B.I.O. Serves Its Purposes

As the participants of the B.I.O. programme, students' feedback about the different events of this programme would reflect whether B.I.O. served its purposes well. Regarding the theme of B.I.O., i.e., the "4Cs" (connection, communication, collaboration, and commercialization), they all agreed on the importance of this theme on BME research and development, and also believed that it was well emphasized in the programme. With that in mind, their opinions proved the effectiveness of the B.I.O. 2022 programme, specifically in the following three areas.

1) Providing Students with More Hands-on Experience

Although the B.I.O. was unlike a capstone project which lasts for a year, it provided knowledge that usual classes could not teach through another format of hands-on experience. When asked about any memorable moments during B.I.O., some students who joined the site visits mentioned the visit to an MRI machine company where they invited participants to try on their MRI machine directly while explaining how the machine worked and how the images were analysed. They believed that instead of learning and remembering the hard facts of MRI during classes, looking at a real MRI machine and the internal components, or even trying on the machine, could make them understand better on how an MRI machine works, helping them remember better this particular knowledge about MRI. These site visits did not require students to build a medical device from scratch, still it could offer hands-on experiences in another way. This is because through looking at and trying on a realistic product, they mentioned they could know more about the technical details and any specific points to note in practice, and thus they really enjoyed this kind of out-of-classroom experience.

2) Connecting Academia and Industry for More Collaboration Opportunities

In part A, it was mentioned that some students required guidance on which research direction to choose. In conference and site visits, they were able to get to know the latest technologies in various fields, such as biomedical imaging and orthopaedics, to name a few. In particular, they learnt both the knowledge in paper and in practice on these different fields of research. This gave them a clearer look on how it was like to work or do research in specific fields, such that they could make a more informed choice when they are finding internships or choosing topics for capstone project. With a research interest confirmed, they could then reach out to professors or companies to seek for opportunities to work in their labs. As an example, one of the interviewees applied a research assistant position at an orthopaedics group after visiting their labs in a hospital site visit. Hence, B.I.O. can serve as the platform suggested by speakers as reflected in part B, to connect students from academia to companies in the industry. Recalling the 4Cs, the students believed that communicating with professors or clinicians through these outreach events could bring up connections that they would not easily form normally, such that there could be opportunities to collaborate. Some interviewees even thought all the way through the research cycle where research ideas were translated into products that could be put into market to deal with real-life medical problems, fulfilling commercialization.

3) Complementing Traditional Education Methods

Traditional education methods, although do include hands-on experience and internships, are mainly comprised of knowledge-based classes. While they are important, as emphasized by some of the students, there could still be more hands-on and outreach activities. B.I.O. programme could complement the gap. As mentioned from students' feedback, B.I.O. could provide them with more hands-on experience, while giving a platform for communication and connection provided them the outreach they needed. Furthermore, in other events of the B.I.O., research presentation clinic (RPC) taught aspiring researchers on how to present their ideas and work in both writing and speaking, while in mentor chat room (MCR), students gained precious sharing from mentors of different fields in the industry. One MCR participant particularly remembered one of the mentors shared on the advice in patents, with the mentor even sharing some experiences where he failed to apply one. This kind of knowledge transfer was very valuable for students when they pursue their future in either research or industry, especially when they would not be taught in normal classes. Therefore, B.I.O. effectively served as a complementary educational approach to traditional teaching methods.

V. Outlook

In the previous section, the effectiveness of the B.I.O. 2022 has been investigated with promising results, encouraging the hosting of future B.I.O. programmes. For further improvements, opinions from student participants were gathered on how to further improve such that B.I.O. can better serve its purposes.

A. Future Improvements of B.I.O.

Since most of our interviewees foresaw themselves to be doing research in the near future, they shared some comments on future improvements to better help with their research path. One lower year participant thought B.I.O. can provide even more guidance on how to choose research direction, hence a workshop on how to start a topic would help. Another interviewee with more research experience suggested an event similar to an MCR, but with focus on mentors sharing how to plan a research study, because often times when students begin to plan, they may not have a clue on whether the idea is feasible or innovative. Apart from research-related suggestions, there are also some feedbacks about scaling up the programme, including involving more companies or universities labs to visit, collaborating with more faculties such as biomedical sciences, and promoting to more participants, be it UG, PG, or even secondary school students. Furthermore, when holding more and more events, one participant also suggested these events could be split throughout the whole year, providing more time flexibility for more students to join, so as to expand the platform for the BME community.

B. Other Suggestions for Further Development of BME Community

Apart from the B.I.O. programme, there are also some suggestions on current policies and university curriculum to help further develop the BME community. As mentioned in the background section, there is insufficient student-related policies. Besides funding internship opportunities, there can be also more support on spinoff companies from universities. As these companies usually have good ties between academia and industry, it will be easier to draw in talents who may already be working in laboratories in the universities. As for university

curriculum, even though it may not be easy to introduce a lot more semester-long hands-on courses suddenly, universities can offer some short-term out-of-classroom experiences to students, and it is better if these experiences happen in the early years of the university programme. For example, HKU has a short-term lab shadowing programme where year 1 students visit and take part in some of the work in two different laboratories, while CUHK offers two-week summer training at hospital also for year 1 students. In the future, hopefully when the pandemic is over, the usual lab sessions in various courses can return normal, such that the hands-on experience for students can be maximized, helping them shape their research interest and future development in the BME community.

APPENDIX

In the methodology section, it is mentioned that five students and seven speakers were interviewed. Some of their details are listed in Tables V and VI. For certain anonymity, their names are only revealed as initials.

TABLE V
STUDENT INTERVIEWEES

Name	Year and Major	(If any) Research Interest/Project
B.Q.	Year 2, HKU BME	Ultrasound imaging
H.L.	Year 4, HKU BME	/
J.C.	Secondary school student	/
K.L.	Fresh graduate, HKU BME	Microfluidics, synthetic biology
R.L.	Fresh graduate, HKU BME	Medical visualisation for orthopaedics/pre-surgical diagnostics

TABLE VI
SPEAKER INTERVIEWEE

Name	Affiliation
A.S.	HKU
C.L.	HKU
E.C.	CUHK
J.C.	HKU
R.C.	Gense Technologies (a medical imaging device company)
S.Y.	Time Medical (an MRI machine company)
T.W.	HKUST

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