Overseas Team Building for Student Leaders in Academic Makerspaces

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Dr. Chun Kit Chui serves as the Director of the Tam Wing Fan Innovation Wing in the Faculty of Engineering at the University of Hong Kong (HKU). The Innovation Wing aims to unleash students' creativity by entrusting them to spearhead ambitious innovation and technology projects that will shape the future. This iconic facility is situated at the heart of the campus, offering 2400m2 of space with state-of-the-art resources and a supportive environment to enhance hands-on and experiential learning for undergraduate students.

In addition to his role as Director, Dr. Chui holds the position of Assistant Dean (Teaching and Learning) in the Faculty of Engineering at HKU, responsible for driving curriculum reform and active learning activities. His research interests include database and data mining, as well as pedagogical research in engineering education.

Dr. Chui has been the recipient of several prestigious awards, including the University Distinguished Teaching Award (Individual Award) at the University of Hong Kong for the 2024-25 academic year, the University Outstanding Teaching Award (Individual Award) at the University of Hong Kong for the 2015-16 academic year, and the Faculty Outstanding Teaching Award (Individual Award) in the Faculty of Engineering for the 2023-24 and 2012-13 academic years. Additionally, he has been honoured with the Teaching Excellence Award in the Department of Computer Science for the academic years 2011-12, 2012-13, 2013-14, 2014-15, and 2015-16. Furthermore, he was a shortlisted candidate for the UGC Teaching Award (Early Career Faculty Member).

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Mo Kei Yiu is a Senior Technical Assistant at the Tam Wing Fan Innovation Wing in the Faculty of Engineering at the University of Hong Kong. He graduated with a Bachelor's degree in Mechanical Engineering from HKU in 2024 and is currently pursuing a taught postgraduate degree in the same field.

During his studies, Mo led the Design, Build and Fly team, where he oversaw the design, manufacturing, and testing of a scaled unmanned aerial vehicle. He has developed hands-on expertise in 3D printing, laser cutting and engraving, and 3D modeling.

Mo is committed to supporting innovative projects and creating a collaborative learning environment within the Innovation Wing, contributing to the growth of fellow students and the advancement of engineering education.

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Ryan Chan Chun Kit is a Mechanical Engineer with a Bachelor's degree in Mechanical Engineering from the University of Hong Kong. During his experience working in Tam Wing Fan Innovation Wing, Ryan has demoonstrated a diverse skillset and rich teaching experience in the field of engineering.

Throughout his academic journey, Ryan has excelled in various engineering projects and research endeavors. He has been actively involved in designing workshops on cutting-edge technologies such as embedded systems, ROS and IoT. Additionally, Ryan has led a undergraduate student research team on robotics, developing various types of smart robots.

Moreover, Ryan has been contributing to the community of Robotics through volunteer means. He has served as an Adviser for BREED and Nestspace at HKU, where he offers consultation and guidance on various projects. Ryan's technical proficiency includes 3D Printing, robotics, 3D modeling and mechanical machining.

With a passion for creating a better learning environment for fellow engineers, Ryan is dedicated to enhancing his skills and contributing to the advancement of mechanical engineering.

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Overseas Team Building for Student Leaders in Academic Makerspaces

Abstract

This practice paper discusses the design, implementation, and outcomes of an overseas team-building program organized by the Tam Wing Fan Innovation Wing (HKU Innovation Wing) at the University of Hong Kong. Established in December 2020, the center has actively supported Student-Initiated Interest Groups (SIGs) focused on technology exploration and development among undergraduate students [1]. In the 2023-2024 academic year, the center had expanded to accommodate 22 active SIGs with over 300 student participants, fostering an interdisciplinary, project-based, hands-on learning culture within the University of Hong Kong.

Despite the growth of SIGs, several issues have surfaced. Primarily, silos exist among the SIGs, hindering effective interactions and collaboration. Additionally, some SIGs have started contending for resources, particularly project space, leading to escalated conflicts. Moreover, a redundancy in training topics among various SIGs for new members has been noted, resulting in duplicated workloads for newcomers.

In the 2024-25 academic year, we implemented an overseas team-building program for student leaders to address these challenges. Following the Tuckman Team Model, we introduced five incentives to boost engagement. The program aims to unite leaders into a cohesive ambassador team, enhancing their understanding of academic makerspaces' educational value. By immersing them in global makerspace activities, they learn best leadership practices to bring back and foster a collaborative culture within the Innovation Wing.

In September 2024, fourteen leaders representing seven SIGs took part in the pilot program. They engaged in ice-breaking activities to dismantle silos, brainstorming sessions to strategize how their SIGs could enhance the HKU Innovation Wing, goal-setting discussions to define outcomes for their involvement in an overseas makerspace symposium, presentations to share their insights, and knowledge-sharing sessions to disseminate experiences and conclusions to other makerspace members.

Surveys and analysis of written reflections from the team leaders indicate that the overseas team-building program effectively dismantled silos, enhanced collaboration, and promoted personal growth among student leaders. These leaders showcased a shift in perspective when offering recommendations for the improvement of the Innovation Wing. Comparing them with the 2023/24 cohort of leaders, these individuals displayed a more proactive approach to enhancing the overall functionality and effectiveness of the makerspace for one another, rather than solely focusing on the benefits of their individual SIGs.

Keywords Team-building, academic makerspace, leadership, study tour, international

Introduction

The emergence of Student-initiated Interest Groups (SIGs) within academic makerspaces has demonstrated itself as a successful strategy in cultivating technology exploration and development among undergraduate students [1]. At the Innovation Wing at the University of Hong Kong, as of

March 31, 2024, the Innovation Wing has effectively drawn in over 3,400 registered members, with approximately 8% from non-engineering disciplines. Additionally, twenty-two affiliated SIGs have been formed, collectively engaging over 300 team members. However, with the expansion of these SIGs, a number of issues have raised.

Isolation and silos

Most SIG teams tend to operate in isolation, leading to ineffective interactions and a notable lack of collaboration among them. Figure 1 illustrates the breadth of student interests within the SIGs during the 2022/23 academic year, showcasing a diverse array of contemporary topics such as AI, robotics, VR/AR, smart technologies, blockchain, and more. This diverse range of expertise presents a significant opportunity for synergy among the SIGs. For instance, the collaboration potential between a robotics SIG and an artificial intelligence SIG to develop intelligent robots - an opportunity that remained unrealized during the initial three years of the center's operation.

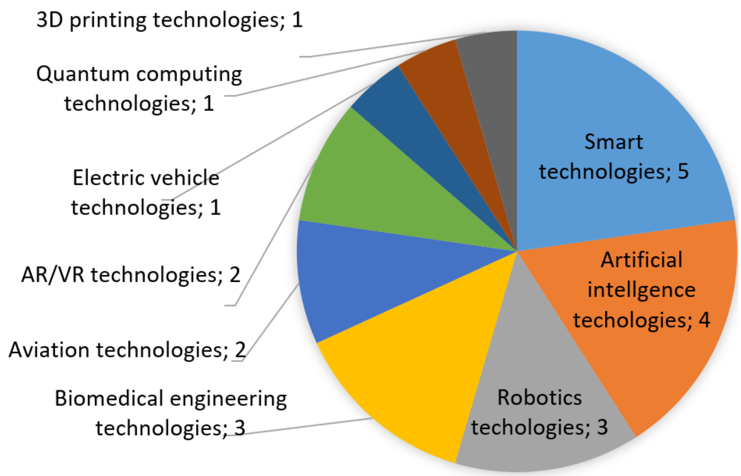

Figure 1. Technology topics of the 22 SIGs in 2024/25.

Compete for resources

The SIG teams have started requesting dedicated resources specific to their projects. For example, a significant number of SIGs have indicated the need to acquire their own sets of 3D printers to ensure exclusive access rather than sharing this equipment with other teams. Additionally, some teams have gradually accumulated their supplies and tools, most of which are already available in the shared machine shop and assembling space in the makerspace. This internal focus has nurtured a more insular culture within each team, leading to a shared aspiration among all SIGs to establish their dedicated facilities within a private working area. This shift signifies a noticeable departure from the collaborative and sharing culture typically observed in academic makerspaces.

The situation has grown more intricate concerning space utilization within the center. While the optimal approach for space utilization involves promoting shared usage among teams, encouraging collaboration by having teams prepare spaces for subsequent users after prototyping and testing, this spirit of sharing has not been embraced by the SIGs. Instead, teams are requesting additional space and longer usage periods that exceed their actual needs. Consequently, new project teams encounter resistance from existing SIGs, who are worried about potential reductions in the space resources allocated to them.

Redundancy in activities

A significant issue arises from the redundancy in the training programs provided by different SIGs for their new members. For example, Table 1 illustrates a student-initiated course from the 2021/22 academic year. Numerous robotics-oriented SIGs independently created training workshops covering introductory robotics courses, electronics, software, and operating systems (ROS). This duplication of training efforts poses challenges for new members of the Innovation Wing. Given that it is common for a new member to join multiple SIGs in their first year, having to invest repeated time and effort in learning the same subject matter across various SIGs results in unnecessary duplication of learning and places undue strain on freshmen. There is a significant opportunity for these training sessions to be streamlined and optimized through collaboration among the SIGs, thereby enhancing the talent acquisition process across the SIGs.

Table 1. The student-initiated courses offered in 2021/22 with overlapping and redundency on training topics

SIG	**Student-initiated courses**
Robotic team	Design and manufacture of robotics
Robotic team	Electronic systems and software design in robotics
Robot combat team	Software in robotics
Robot combat team	Hardware in robotics
Underwater robotics team	Introduction to robotics
AI robotics team	AI and robotics: An introduction
Blockchain team	Introduction to web3

The three critical issues outlined above are rooted in the insufficient interactions and coordination among SIGs, a deficit in shared responsibility for promoting interdisciplinary collaboration, and a lack of a collective sense of ownership of the workspace. It is crucial for the various SIGs to perceive themselves as part of a cohesive community of enthusiastic innovators, all dedicated to advancing hands-on learning initiatives within the academic makerspace.

Related works

Academic makerspaces have emerged as versatile hubs that foster innovation, collaboration, and hands-on learning experiences among students and faculty members in numerous universities. [1] presented an exemplar case on how these infrastructures can significantly drive innovation education through nurturing student-initiated interest groups for technological exploration in the University of Hong Kong. Other examples include the Jacob Institute for Design Innovation at the University of California, Berkeley [2]; the d.school and the Product Realization Lab at Stanford University [3][4]; the Center for Engineering Innovation and Design (CEID) at Yale University [5]; TechSpark at Carnegie Mellon University [6]; the Sears think[box] at Case Western Reserve University [7]; the HIVE Makerspace at Georgia Tech University [8]; and the project Manus at the Massachusetts Institute of Technology [9]. These creative spaces provide a unique setting where individuals from diverse disciplines converge to ideate, design, and prototype projects that transcend traditional academic boundaries [10] [11].

Within the makerspace ecosystem, teamwork plays an essential role in orchestrating successful project outcomes by enabling participants to leverage complementary skills, share knowledge, and collectively tackle complex challenges [12] [13]. By encouraging collaboration and fostering a culture of mutual support and idea exchange, makerspaces cultivate not only technical expertise but also essential soft skills such as communication, problem-solving, and leadership, crucial for holistic personal and professional development [14] [15] [16] [17] [18]. Scholarly studies have delved into the dynamics of team building [19], exploring how factors like team composition [20], communication strategies [21], trust, conflicts [22], and various other factors [23] influence project outcomes. Team-building models such as Tuckman's model of team development [24] and its variations [25] [26] [27] have been an effective standard for team building in various disciplines.

However, while there is a rich body of literature on team dynamics within an engineering team, little attention has been given to identifying best practices for facilitating collaborations and knowledge sharing among various established teams in academic makerspaces [28]. This gap presents an opportunity for further research and exploration in understanding how to optimize team interactions and foster a culture of collaboration in these innovative spaces.

In the context of overseas team-building initiatives, there is a growing interest in exploring how international collaborations can enhance team dynamics and foster a global perspective among students [29]. Overseas team-building programs offer a unique opportunity for students to engage with peers from different working environments, constraints, and cultural backgrounds to exchange ideas. Studies have demonstrated the positive impact of international team-building experiences on developing students' intercultural competence and adaptability [30].

In the context of team-building among team leaders in academic makerspaces, the focus shifts from single project development to a collective drive to boost cross-team collaboration to nurture a supportive, sharing, and collaborative maker community. This represents a new topic in the field of team-building that is of pressing need in many academic makerspaces. This paper presents our implementation of an overseas team-building program, designed using the Tuckman Team Model, for team leaders of the academic makerspace at the Innovation Wing, University of Hong Kong.

Overseas team-building program with the Tuckman Team Model

To tackle the three identified issues among the SIG teams, we propose taking the SIG leaders on an overseas team-building program. This program aims to unite these leaders, forming a cohesive ambassador team that deeply understands the educational importance of academic makerspaces. By immersing them in the global academic makerspace community, they will be exposed to best practices in leadership and management within academic makerspaces. They will then bring back this insight to their workplace, fostering a supportive, sharing, and collaborative culture within the Innovation Center.

We have adopted the Tuckman Team Model into our initiative. Figure 2 displays our design that incorporates Tuckman's Stages of Group Development, one of the most renowned theories of team development. It outlines five key stages that teams typically navigate: forming, storming, norming, performing, and adjourning [27]. This model provides a comprehensive framework for understanding the dynamics of team evolution and the challenges that teams may encounter as they strive towards optimal performance and cohesion. Additionally, we introduced five core incentives that we used to ensure the successful implementation of the program and the active engagement of the SIG leaders (the outer circle in the figure).

Commencing with the Forming stage, we engage SIG leaders in ice-breaking activities, introductions, and sharing sessions to forge connections and foster a supportive atmosphere. This foundational phase aims to cultivate camaraderie and unity among leaders, laying a solid groundwork for effective collaboration.

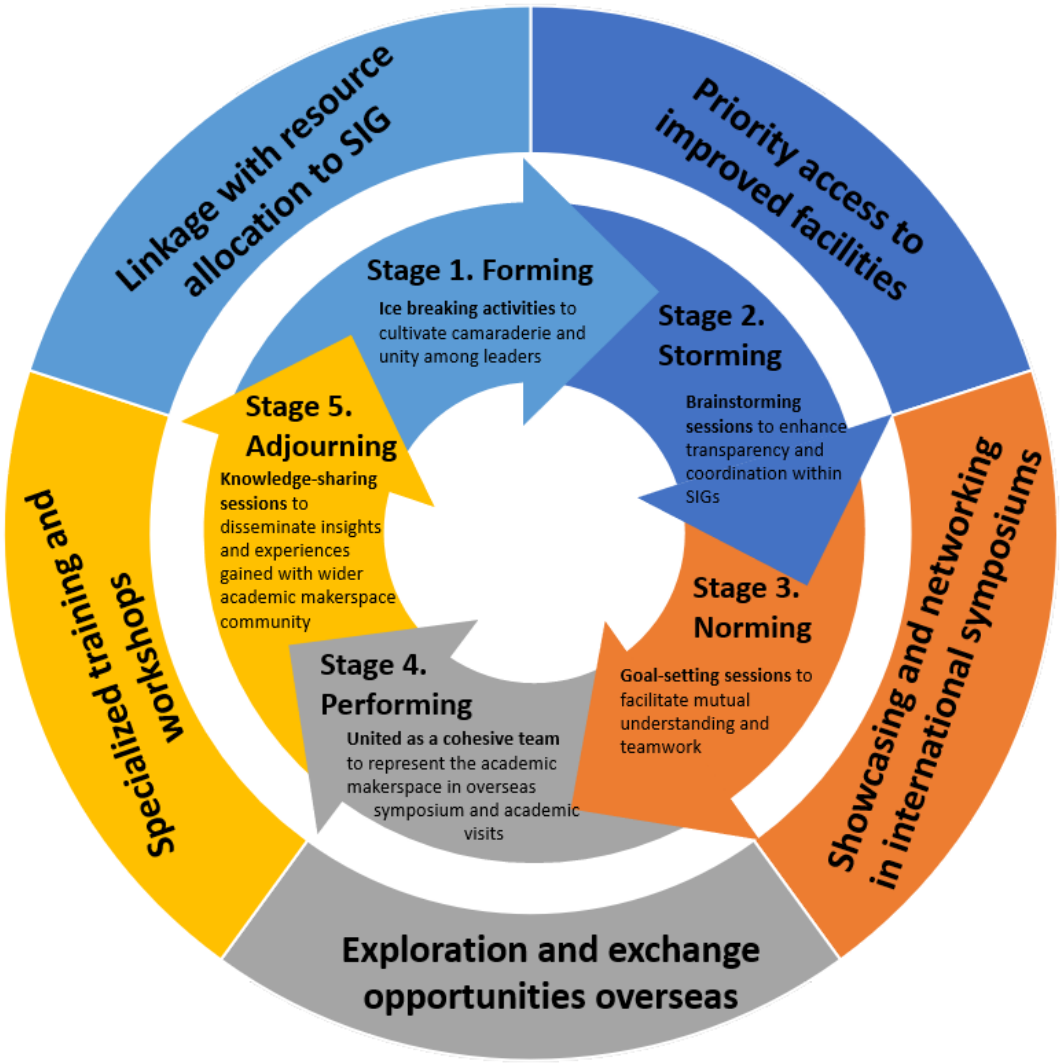

Figure 2. The Tuckman's Stage of Group Development applied in the overseas team-building program for SIG leaders in academic makerspaces and the essential 5 incentives for active engagement.

Transitioning into the Storming stage, we task SIG leaders with engaging in detailed discussions among their respective SIG teams to create technical reports on their projects and innovations. This process instills a culture of structured planning and accountability, encouraging leaders to critically evaluate their projects, establish clear objectives, and strategize for the upcoming academic year. By addressing conflicts and promoting open communication, this phase enhances transparency and coordination within SIGs, effectively navigating challenges and promoting growth.

Moving towards the Norming stage, our focus remains on fostering a purposeful approach to project development and aligning team members towards shared objectives. The technical reports created by SIG leaders aid in streamlining efforts and promoting synergy within the teams. Additionally, goal-setting sessions facilitate mutual understanding and teamwork, guiding leaders towards a collective vision for talent development, promotional activities, and resource utilization.

As we progress into the Performing stage, SIG leaders are united as a cohesive team to represent the academic makerspace at an international symposium and visits to academic makerspaces overseas. This initiative upholds values of collaboration, sharing, and continuous learning, providing leaders with exposure to best practices and innovative strategies from established academic makerspaces. By showcasing their projects and engaging with peers, leaders enhance the learning environment, introduce fresh perspectives, and nurture a culture of ongoing improvement and innovation.

Upon the return from the international symposium, a knowledge-sharing session is hosted as the Adjourning stage to disseminate insights and experiences gained with the wider academic makerspace community. This session serves as a platform for collective growth and learning within the Innovation Center. Subsequently, with a deeper sense of purpose and a strengthened community bond, SIG leaders adjourn back to lead their respective teams for the upcoming academic year. Equipped with enhanced awareness of overarching goals and a shared commitment to collaboration, this transition signifies a renewed focus on collective success and innovation.

The successful implementation of the model hinges greatly on the provision of adequate incentives for the active engagement of SIGs. Five incentives were used in our program. Firstly, there is a direct correlation between SIGs' level of participation and the allocation of resources, including space and funding, to incentivize their involvement. Secondly, priority access to improved facilities is provided to support their projects. Thirdly, opportunities for publication and participation in international symposiums allow them to showcase their work on a global platform. Fourthly, exploration and exchange opportunities with like-minded students, academics, and industry professionals overseas broaden their perspectives and foster collaboration on an international scale. Lastly, specialized training and workshops tailored to their project needs enhance their skills and project outcomes. Additionally, individual leaders gain opportunities for personal growth. Engaging in activities such as publishing technical works and public speaking in international experiences not only enhances their technical skills but also broadens their horizons, fostering a more diverse and well-rounded educational experience. These out-of-classroom learning activities enrich their skill sets and contribute to a broader and more holistic educational experience.

Piloting the program

Fourteen student leaders representing seven Student-initiated Interest Groups (SIGs) were selected to participate in the program at the commencement of the academic term. The initiative commenced by outlining the educational objectives of the academic makerspace, emphasizing the advancement of hands-on and student-driven learning within the field of engineering.

Following this introduction, the SIGs delved into in-depth internal discussions aimed at exploring how their respective teams could actively contribute to the overarching educational mission of the center. These discussions centered around leveraging their technical expertise and aligning their team's vision in engineering technology with the broader goals of promoting hands-on learning and student-driven initiatives within the academic makerspace.

Figure 3. The SIG leaders aim at presenting their technical reports and project innovation to the academic makerspace community at an international symposium.

Figure 4. The SIG leaders aim at connecting with like-minded overseas students, academics, and professionals and bring back fresh ideas to improve their projects.

Table 2 provides an overview of the specific focuses of each SIG and the topics of their respective technical reports. The technical reports show that the majority of SIGs commenced by reimagining a simplified, beginner-friendly iteration of their projects, transforming them into hands-on workshops tailored for new students in the 2024-25 academic year. These workshops serve a dual purpose: not only do they foster a culture of hands-on learning driven by students, but they also facilitating the exchange of skills and expertise among the SIGs. Furthermore, these training sessions are extended to members of other SIGs, promoting collaboration and skill-sharing across different interest groups within the makerspace.

Table 2. The topics of the techincal report and structured planning of SIGs in the pilot run.

SIG team's focus	Topics of the technical report and structured planning for 2024/25
Generative AI	Fostering AI Makerspace: A Journey through Introductory Hands-On Workshop
Synthetic biology	Students as Partners: Building the Biomakerspace Together
Aviation technology	Exploring Aviation Innovation Through Simulation and Fabrication: Round-The-Pole Flying
Electric vehicle technology	Interdisciplinary Making Outcomes: The HKU Racing Team's Journey in a Collaborative Makerspace Environment
Upcycling in engineering	Upcycling Keyboards to Make Affordable Do-It-Yourself (DIY) Video Game Controller Kits
3D printing technology	Kooler: An Innovative 3D Printing Learning Kit for 3D Printing
Robotics	Multi-disciplinary Training for Undergraduate Students participating the Annual Robocon Hong Kong Contest

In the subsequent phase of the program, student leaders engaged in goal setting activities designed to enhance collaboration and interaction. Ten specific goals were outlined for this overseas team-building trip, as detailed in Table 3.

Table 3: Ten intended goals established with the SIG leaders for the overseas team-building trip and the corresponding average scores of n=14 (all participants) reflecting their achievements in each of the goals

	Intended goals established with the SIG leaders	**Average scores reflecting their achievements**
1	Presenting project works and demonstrating prototypes to industry professionals, students, and academics from other institutions to receive feedback and suggestions for improvement.	4.79
2	Learning about the operations and management of academic makerspaces overseas.	4.86
3	Understanding the challenges and opportunities present in overseas academic makerspaces.	4.79
4	Participating in hands-on workshops during the makerspace symposium.	4.57
5	Identifying and interacting with student teams from overseas institutions who share common interests or are working on similar projects within their SIG.	4.71
6	Exploring and understanding the maker culture of overseas institutions to identify best practices that can be implemented to enhance our innovation center.	4.71
7	Acquiring fresh ideas in project management and leadership through networking and engaging with professionals in the field.	4.43
8	Collaborating with international counterparts on a small-scale project to apply the knowledge gained during the symposium.	4.43
9	Acting as an ambassador of the Innovation Center and introducing its educational mission, values, and activities to others.	4.79
10	Hosting a knowledge-sharing session upon return to share insights and experiences with the rest of the academic makerspace community.	**4.21**

The 14 SIG leaders then consolidated their roles as ambassadors for the innovation center, embarking on an overseas team-building expedition. Amidst the pilot initiative in 2024, they seized the opportunity to present their work at the 2024 International Symposium on Academic Makerspaces hosted at the University of Sheffield in the United Kingdom. This global event brought together educators, industry experts, and students from around the world, facilitating the exchange of knowledge, experiences, and inspiration to enrich student learning experiences and promote alumni success.

The team engaged in thorough planning and debriefing sessions, assessing their goal achievements through active participation in seminars and presentations sessions depicted in Figure 3, demonstration sessions illustrated in Figure 4, and workshop sessions in Figure 5. Additionally, some SIG leaders conducted impromptu visits to overseas academic makerspaces, facilitated by connections established during the symposium. Subsequent to their involvement in the event, the team forged connections with the academic makerspaces at University College London (UCL) Engineering. They then participated in a post-symposium activity to exchange ideas and gain insights into makerspace operations, facilities, and student programs, as depicted in Figure 6.

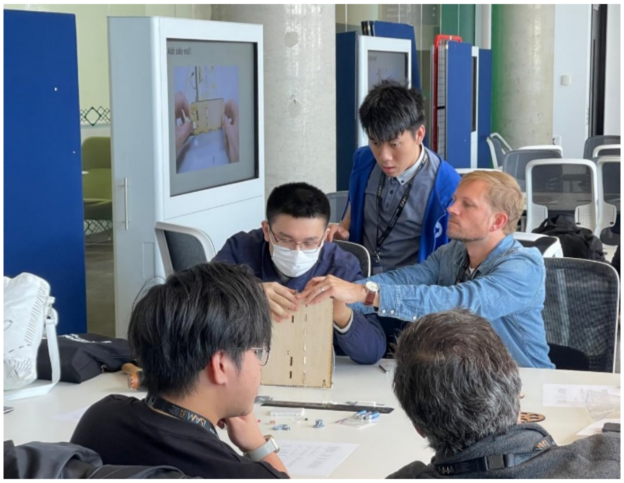

Figure 5. The SIG leaders engage in hands-on workshops to interact with makerspace practitioners and immerse themselves in the maker culture abroad.

Figure 6. The SIG leaders visit various academic makerspaces to gain insights into their operations, management, challenges, and opportunities.

Achievement of the intended goals

To assess the SIG leaders' achievement towards the intended goals, we conducted an online survey study. Following the program's completion, the SIG leaders were asked to evaluate their achievements for each goal using a 5-point Likert scale, ranging from "Strongly disagree" (1) to "Strongly agree" (5). All 14 SIG leaders participated in this assessment. The average scores derived from their responses are detailed in the last column of Table 3.

The outcomes of the Likert scale survey reveal that the participants attained high average scores, reflecting their accomplishments across various aspects of the program. Activities such as presenting project works and demonstrating prototypes (4.79), acting as ambassadors for the Innovation Center (4.79), learning about the operations and management of academic makerspaces overseas (4.86), and understanding the challenges and opportunities in overseas makerspaces (4.79) garnered notably high scores. These results signify successful outcomes in exposing SIG leaders to global makerspace standards and challenges, cultivating their comprehension of the significance of academic makerspaces from a global standpoint.

While SIG leaders have effectively engaged in hands-on workshops (4.57) and interacted with student teams from overseas institutions (4.71) during the symposium, they have encountered more challenges when it comes to acquiring innovative ideas in project management and leadership (4.43) and establishing collaborations with international counterparts (4.43). SIG leaders also recognize the need to enhance their language and social skills to facilitate more active and in-depth exchanges of ideas.

However, it is essential to note that hosting knowledge-sharing sessions upon their return received the lowest score (4.21). This observation implies that while many SIG leaders committed to sharing their knowledge with the makerspace community, some showed decreased activity post-trip. To address this issue, it may be beneficial to introduce additional incentives or establish prior agreements to maintain engagement levels and ensure the dissemination of knowledge and experiences within the community.

Written reflections of the SIG leaders

Besides the survey, the SIG leaders were also tasked with providing written reflections detailing how the program influenced their personal development and the operational culture within their respective SIGs and the academic makerspace. Their written reflections were subsequently analyzed using a coding scheme as outlined in reference [32]. The analysis process did not entail pre-established themes; rather, themes surfaced organically from the data itself.

The initial coding phase involved an open exploration, during which the data were systematically annotated. Words and sentences within each criterion were unitized and categorized as mutually exclusive groups [33]. Through subsequent readings and review, overarching themes and insightful observations emerged from the coded reflections, shedding light on the impact and effectiveness of the overseas team-building program on three categories: the understanding of the educational value of academic makerspaces, the development of SIGs, and the participants' personal growth.

1. On the understanding of the educational value of academic makerspaces

Three major themes emerge regarding the enhanced understanding of the role of academic makerspaces in education. Firstly, all participants articulated a deepened appreciation for the educational value of academic makerspaces, particularly in cultivating an environment that encourages creativity and interdisciplinary collaboration. One participant expressed, "*I witnessed firsthand how fields such as engineering, design, and the arts converge in meaningful ways to create solutions that address technical challenges while incorporating social and artistic dimensions.*" Another noted, "*I was inspired by talented students and their amazing initiatives, which showcased creativity and innovation in a hands-on way.*" This increased understanding among SIG leaders of the educational value of the HKU Innovation Wing will guide their SIGs towards aligning with the center's overarching goals, thereby mitigating potential silos among them.

A significant 71% of participants highlighted how the hands-on and innovative atmosphere of the makerspace deeply resonated with them, instilling a profound sense of mission to uphold these core principles. As one participant reflected, "*The experience taught me that makerspaces are not just about tools and machines, but about fostering a mindset of curiosity, creativity, and resilience - qualities that I aim to incorporate into my personal and academic life.*" This deepened insight further reinforces the SIG leaders' grasp of the educational significance of the hands-on workshops conducted by their SIGs. Beyond technical skills, the emphasis on inspiring curiosity and fostering innovation emerges as the ultimate goal of these initiatives.

Moreover, an overwhelming 78.6% of participants acknowledged the Innovation Wing's invaluable support for their team-building initiatives, emphasizing the significance of giving back to the community through active engagement. A participant shared, "*After interacting with students from various universities, I gained a deeper appreciation for the operational efficiency and diverse facilities offered by our innovation center. Yet, I also identified certain initiatives implemented by* *other universities that could further enhance our educational impact.*" Another participant noted, "*This experience has inspired me to believe that every small effort in fostering creativity made by my team can make a significant difference in Inno Wing.*" This collective realization has prompted the SIG leaders to unite with a shared sense of purpose, collaborating as a cohesive force to support the enhancement of the Innovation Wing as a common objective.

2. On the development of SIGs

Three themes have been observed that influence the development of the SIGs. Firstly, 92.9% of participants expressed that they have strengthened connections and bonding with other SIGs. "*We also had the chance to get to know the people we were traveling with much better. We also learned a great deal about what other SIG projects in Inno Wing were about,*" and "*listening to what other SIGs are working on is extremely inspiring and completely different from my normal thought processes in Inno Wing. Additionally, I also made friends with my tripmates and have a better understanding of what they do.*" Beyond merely being aware of what others are doing, the overseas team-building program also successfully instilled a supportive and collaborative mindset among the teams. "*The relationships we've built will create a supportive network for us, allowing us to seek advice and collaborate as we move forward.*" These understandings resonate with the center's culture. In fact, numerous collaborations among SIGs were confirmed during the trip, addressing the problem of resource competition and reducing redundant activities through enhanced SIG communication and collaboration.

Secondarily, half of the participants have expressed that they have also learned valuable lessons on adjusting hands-on workshops to cater to students from diverse backgrounds, emphasizing the importance of inclusivity and adaptability within their projects. A leader from the AI SIG shared, "*Some of the most insightful pieces of feedback had to do with the split between theoretical explanations and practical applications in our previous workshops: attendees, especially those without a robust background in Computer Science, felt overwhelmed when there was too much information presented and too few practical examples showing the application of this information. This changed my approach when designing a workshop so that they are more approachable for that kind of attendee.*" This implies that the SIGs are more open to promoting their innovative works to a more diverse audience. This helps to improve the Innovation Wing's effort in promoting diversity, equity, and inclusion within the center, down to the academic activities organized within the SIG communities.

Thirdly, all participants shared insights regarding their leadership in SIG projects, highlighting how the experience inspired fresh ideas and professional insight in development, design, and project implementation.

"*We talked with professionals from different fields. Besides engineering, we spoke with people from education, medicine, and other areas, which helped us build connections and opened up possibilities for future collaborations... This fresh perspective has helped us figure out the directions we might take our project in,*" and "*we met many student representatives from other universities, which allowed me to learn how they use the resources available to develop their projects.*" For more in-depth cross-institutional discussions, the SIG leaders gained understanding about the challenges faced by students from other institutions and shared insights to avoid or tackle them. A leader from our electric vehicle team shared, "*I had the opportunity to connect with students from other Formula*

Student (FS) teams throughout the symposium. These discussions gave me insights into how other teams have tackled challenges, structured their teams, and maintained continuity." The SIG leaders also reflected in his report that he has learned how to integrate new recruits and transfer knowledge effectively. He engaged in deep conversations on sustaining the team and concluded that it requires younger members to be adequately prepared to take over as senior members graduate. Clearly, this demonstrates how the overseas team-building opportunity has assisted the leaders in connecting with like-minded students, academics, and professionals abroad, fostering valuable connections and expanding their collaborative horizons, ultimately guiding them towards informed decision-making for the project's future directions.

3. On personal growth

Two major themes have emerged from the students' reflections in terms of personal growth and leadership development. Firstly, 50% of participants noted improvements in their confidence, presentation skills, and communication abilities. "*I gained valuable experience in public speaking and audience engagement. During the social events and poster sessions, I met people from diverse backgrounds…*" and "*Presenting my work at such a prestigious event significantly boosted my confidence, as I had the chance to effectively communicate my research and its broader implications to an engaged audience. This opportunity honed my presentation and public speaking skills.*" The SIG leaders have also developed an increased awareness of the importance of presenting and showcasing their innovative work collectively to establish a reputation and image of student innovation in academic makerspaces. They recognize that building such reputation can, in turn, attract more talent to the workspace and benefit the future expansion of their SIG project. A SIG leader reflected, "*During the poster session, I learned from students at another institution about how they showcase students' work in an open area of their makerspace. This setup allowed visitors to touch and explore the work, creating a more engaging experience. Reflecting on this, I think it would be beneficial for our center to create a dedicated area for regular project exhibitions, emphasizing transparency and open collaboration.*"

Furthermore, 57.1% of participants regarded this journey as an eye-opening experience that not only inspired their career plans but also heightened their sense of continuous improvement and innovation. "*This trip and the entire opportunity, from the initial conception of the poster until the overseas visit, has shown me a world of infinite possibilities within research and academia for us to explore our interest in STEM education and maybe even beyond,*" and "*…feeling motivated and inspired to pursue innovative research opportunities in the field. I am grateful for the support of my institution in facilitating this trip, which has undoubtedly shaped my future endeavors in materials science and research.*" In fact, many student-initiated projects in academic makerspaces begin as hands-on development projects such as building an AI application, an electric vehicle, and more. Through interactions with academics worldwide, these SIG leaders have come to understand that excelling in their projects involves engaging with the latest developments and research outcomes in their fields, thereby opening the doors to academic research as a potential future pathway for these leaders. Other leaders interested in industrial professional standards have also found inspiration after learning about the possibilities in the industry, thereby strengthening their determination to dedicate their future professional careers to the field.

Adjuring - Improving the Innovation Wing through a shift in perspectives

Upon returning, a knowledge-sharing session was hosted to disseminate insights and experiences with the academic makerspace community. These interactive sessions yielded a series of recommendations as listed as “Top-10 recommendations in 2024/25 after the overseas team building program” in Table 4. In comparison with the shift in perspective, the recommendations obtained from SIGs in 2023/24 are also listed in the table.

Table 4. Top 10 recommendations by SIG leaders for the Innovation Wing in 20232/24 (before the team building program) and 2024/25 (after the team building program).

	Top-10 recommendations in 2023/24 before the overseas team building program	**Top-10 recommendations in 2024/25 after the overseas team building program**
1	[Team X] is facing a critical shortage of tables which is affecting our work, hindering interaction, and stifling collaboration. More tables should be made available for our team, if feasible.	Enhance the makerspace infrastructure to accommodate better tools, projects, teams, and exhibitions, including expanding physical space.
2	The limited space for item storage for [Team Y] is causing significant difficulties and constraints.	Implement a remote queuing and monitoring system for 3D printers to streamline operations, enhance shared use and boost efficiency.
3	There is insufficient space allocated for storing [Team Z]'s project archives.	Engage undergraduate students in teaching and operational roles to foster a culture of knowledge-sharing and hands-on experience.
4	[Team Z] is in desperate need of a spacious area designated for robot testing purposes.	Establish cross-disciplinary mentorship programs and networking opportunities to encourage collaboration and diverse skill development.
5	[Team X] urgently require an upgraded 3D printer and access to materials beyond PLA, particularly materials like carbon fiber.	Upgrade facilities by investing in better equipment such as CNC machines, metal printers, and air filtration systems, while introducing new shared machines like sewing machines, UV printers, and button makers.
6	The center should provide more training on Waterjet machines and CNC machines for [Team Y] and [Team Z].	Enhance access systems to facilities and events, making it easier for new members to utilize resources and participate in activities.
7	Our team strongly recommend the installation of the Ubuntu operating system on all center computers instead of Windows OS.	Lower entry barriers through various methods, such as the creation of Zines and other inclusive initiatives to encourage participation.
8	Applying for project funding is a real pain.	Promote failure-friendly events, improve student leadership, empower interest groups, increase usage through curriculum courses, and emphasize transparency and open collaboration to create a supportive and innovative environment within the academic makerspace.
9	Our team need more time to work and access to facilities, please extend the opening hour of the center or grant special access for our team.	Implement an improved feedback system to gather insights from users and enhance the overall user experience.
10	Reimbursement needs to speed up.	Provide design consultation services to support members in their projects and creative endeavors, fostering innovation and skill development.

Two significant insights highlight the evolving perspectives within the academic makerspace recommendations.

Immediate needs vs. strategic planning. Initially, the focus was on addressing immediate needs and challenges of individual SIG, such as shortages of tables and space constraints, in the 2023/24 recommendations. However, this perspective shifted towards strategic planning and holistic improvements in the 2024/25 suggestions. The transition involved a proactive approach to enhance the overall functionality and effectiveness of the makerspace by emphasizing infrastructure enhancement, new systems implementation, and mentorship program establishment. This shift reflects a broader view that extends beyond short-term fixes to create long-lasting positive impacts on the makerspace environment and its community.

Resource expansion for own SIG vs. operational improvement for everyone. Another key observation involves the change from advocating for resource expansion tailored to specific SIG in 2023/24, to prioritizing operational improvements benefiting all users in the 2024/25. This shift signifies a move towards balancing the needs of various SIGs with enhancing overall operational efficiency and user experience for a more inclusive and equitable makerspace environment.

Focusing on the top-10 recommendations in 2024/25, space allocation (recommendation 1) remains a primary concern among the SIGs. However, a shift in perspective unfolded during the feedback sessions. Rather than viewing space allocation as a competitive and conflicting issue among individual SIGs, there was a growing realization of the collective need to bolster the expansion of the academic makerspace for the benefit of all. This shift aimed to facilitate access to improved shared facilities, projects, and exhibitions beyond the confines of individual groups.

Moreover, instead of advocating for exclusive equipment, such as 3D printers for their respective SIGs in 2023/24, the leaders proposed implementing a more efficient queuing and monitoring system in 2024/25 (recommendation 2). This system would enhance the utilization of shared resources and promote equitable access for all participants.

Additionally, the leaders recognized the significance of involving more undergraduate students in the academic makerspace to enhance hands-on teaching and learning experiences (recommendation 3). This initiative aligns with the educational goals of the makerspace, which prioritize experiential learning and student engagement in engineering disciplines. By incorporating more undergraduate students, the makerspace can foster a more inclusive and collaborative environment conducive to skill development and innovation across disciplines.

Furthermore, the leaders emphasized the importance of cross-disciplinary collaboration and proposed the creation of additional networking opportunities to cultivate such interactions (recommendations 4, 6, 7). The feedback received was notably positive, with all recommendations oriented towards collective benefits rather than individual gains.

Moreover, the leaders also acknowledged the value of promoting a failure-friendly environment within the academic makerspace (recommendation 8). By encouraging a culture that embraces mistakes as opportunities for learning and growth, participants can feel more empowered to take creative risks and explore innovative ideas without fear of judgment. This emphasis on hands-on learning from failures contributes to the development of a supportive and collaborative maker community where experimentation and exploration are highly encouraged.

Conclusion and the way forward

This practice paper addresses the challenges of silos, resource competition, and redundant training topics among various student teams within academic makerspaces. It introduces an overseas team-building program designed to unify student leaders and foster a collaborative culture. The program's outcomes successfully dismantled silos, enhanced collaboration, and promoted personal growth among student leaders. They demonstrated a deep appreciation for the program and expressed their enhanced understanding of the educational value of academic makerspaces, as well as a strong mission to uphold these principles and contribute to the community. The program also strengthened inter-SIG connections, prompted adjustments and increased inter-team collaborations in their training activities, improved communication skills, and instilled a drive for continuous improvement and innovation.

Moving forward, the extension of the overseas team-building program for student leaders across multiple academic makerspaces presents a promising path towards fostering a globally connected and collaborative academic community. Embracing diverse perspectives, cross-cultural interactions, and innovative partnerships will be crucial in driving continued growth, knowledge exchange, and interdisciplinary initiatives within and beyond academic makerspaces. By leveraging the insights gained from these expanded networks and experiences, the future holds great potential for advancing creativity, leadership development, and impactful research collaborations on an international scale.

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