Embrace Diversity and Inclusion in Academic Makerspaces with a Network of Tutors (Work in Progress)

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Abstract

The Tam Wing Fan Innovation Wing [1] (a.k.a. the HKU Inno Wing) of the Faculty of Engineering at the University of Hong Kong hosts an academic makerspace aimed at fostering interdisciplinary hands-on learning among undergraduate students. Its user population has grown from 931 to over 2,800 students within two years after its launch. Such growth brings more diversity to the workspace in terms of study focuses, study years, skill levels, and cultural backgrounds. It also induces challenges to the accessibility and inclusion of the makerspace.

The effectiveness of the makerspace depends on its commitment to embrace diversity and inclusion to create an open and welcoming environment that stimulates innovative ideas. This practice paper documents the challenges and opportunities we have encountered due to the inadequacy of diversity and inclusion in the center since its launch and our progress after two years of operation with the help of tutors. We also present the formation of a tutor network, which is designed to be diverse in terms of academic background and culture. An evaluation of the impact of our approach on makerspace diversity, inclusion, and equity is presented through the analysis of statistics and reflections from the tutors involved in the initiative. The study shows that our proposed tutor network can effectively serve as a role model for fostering diversity, equity, and inclusion in academic makerspaces for undergraduate students.

Background

The University of Hong Kong's Faculty of Engineering has established the Tam Wing Fan Innovation Wing [1], also known as the HKU Inno Wing, at a prominent campus location. This state-of-the-art facility spans 2,000 square meters, showcasing the university's commitment to innovation and technological advancement. The Inno Wing hosts an academic makerspace and aims to foster collaboration among undergraduate students in interdisciplinary teams for hands-on projects in engineering and technology. Since the launch of Inno Wing in December 2020, it has encountered both challenges and opportunities stemming from the inadequacy of diversity and inclusion within its premises. To gain a comprehensive understanding of the demographics of the workspace, it is crucial to examine statistical data. Such information provides valuable insights into our challenges and opportunities in terms of diversity and inclusion. In this section, we present relevant background that supports the strategic focus of the proposed tutor network.

1. Resource unfamiliarity for newcomers

Figure 1 illustrates user access to the makerspace during its inaugural year in 2020/21. Despite starting with around 810 registered users, the actual utilization was very low, averaging about 50 daily users in the space, considering the makerspace's theoretical capacity for 420 users. Despite the challenges posed by the pandemic, newcomers faced difficulties navigating available resources that hindered their physical access. In response, implementing inclusive access policies is crucial, with frontline assistance from our tutor team playing a leading role. Figure 2 presents

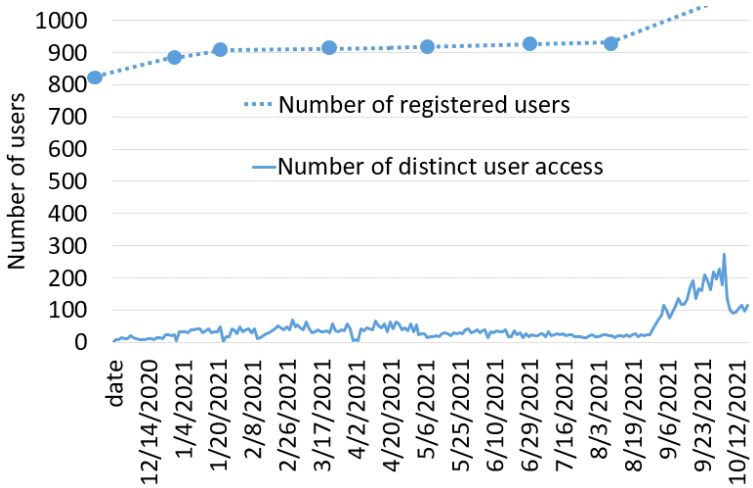


Figure 1: The number of registered users and their access patterns during the 2020/21 academic year, excluding dates of center closure.

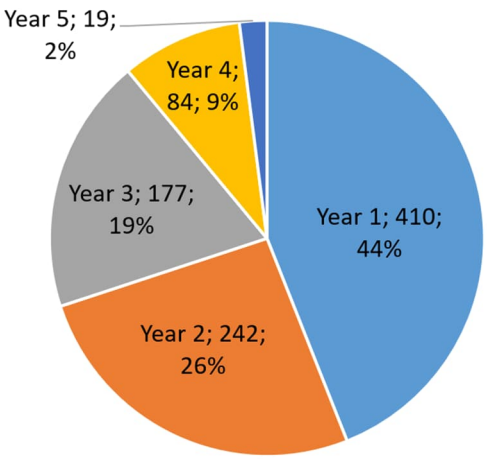


Figure 2. A breakdown of registered users based on their study years by the end of the 2020/21 academic year.

the distribution of study years among registered users by the end of the 2020/21 academic year, indicating that 44% of users are first-year students. Given their unfamiliarity with the center's resources and their anticipated usage for their upcoming four years, tutors should prioritize onboarding these students and fostering an inclusive working environment.

To approach this challenge, the tutor network focuses on the inclusion of new users, aiming to eliminate access barriers for newcomers and ensure a smooth integration process, providing a positive experience for those joining the community. They also train students in maker skills and contribute to uplifting their technical competencies, enabling them to bring more engineering innovation ideas into implementation. The results section demonstrates that these efforts have contributed to the growth in the number of registered users, as well as increased frequency of their access and equipment usage in the makerspace.

2. *Narrow academic backgrounds*

Regarding academic diversity, the makerspace implements a two-phase strategy. In the first phase, which took place in 2020/21, we encountered the challenge of limited familiarity among students from various engineering fields. Since there had been no interdisciplinary workspace like the Inno Wing for engineering students before, students were not well acquainted with each other. Figure 3 illustrates that when the center commenced in December 2020, there were 826 engineering users, accounting for only approximately 33% of the total population of undergraduate engineering students. Consequently, the primary focus for tutors during this phase was to foster interdisciplinary collaboration among students from different engineering disciplines.

Moving into the second phase (2021/22), the makerspace expanded its emphasis to include cross-faculty collaboration. Figure 4 illustrates the breakdown of users by engineering and other faculties at the end of the 2020/21 academic year, with only 3% of users being from other faculties. This low representation from other faculties signals a need for the makerspace to

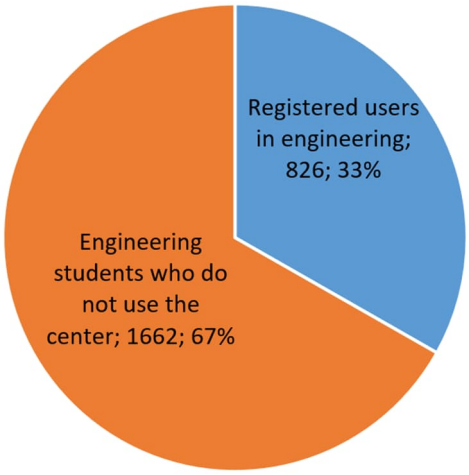


Figure 3. The proportion of engineering undergraduates utilizing the makerspace as of December 2020.

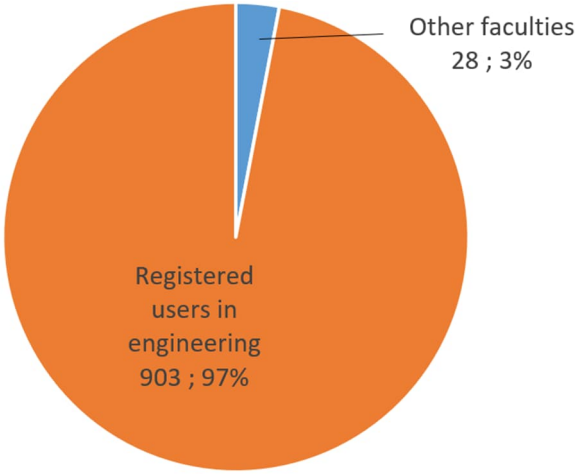


Figure 4. The breakdown of users by engineering and other faculties at the end of the 2020/21 academic year.

proactively foster more cross-disciplinary collaboration. Recognizing that effective technology applications often require collaboration between engineers and experts from various fields, the tutor team aims to bridge this gap. In response, tutors actively supported users from diverse academic backgrounds, including Science, Law, Business and Economics, Architecture, Social Sciences, Education, Dentistry, and Medicine, in getting acquainted with the workspace.

To approach this challenge, we assemble a tutor team with diverse academic backgrounds in engineering. This diverse team makes two contributions: firstly, they assist students from their respective disciplines onboard to the center, and secondly, they encourage cross-disciplinary collaboration by offering diverse perspectives in their consultative services, thereby empowering students in addressing problems with a wealth of cross-disciplinary viewpoints. The results section demonstrates that these efforts have contributed to a significant growth in the number of engineering users, as well as mild increase in non-engineering students joining the community.

3. Cultural diversity and gender equity

The Inno Wing is known for its internationalization efforts, welcoming students from diverse nationalities. In the 2021/22 academic year, 28.3% of the 4,513 new undergraduate student intakes were international students [2]. Among these students, there is a significant representation from mainland China (66.7%), other Asian countries (20.4%), Australia, and New Zealand (1.6%), European countries (5.5%), North American countries (4.3%), and other regions (0.6%). This diverse cultural mix creates a dynamic environment for cross-cultural exchange, fostering creativity and problem-solving. To promote inclusivity, the tutor team actively engages in collaborative work within open teams, ensuring a welcoming environment for all cultures.

In terms of gender ratio among undergraduate students at Inno Wing, the ratio stands at 0.8 males to 1 female. When considering the demographic gaps among users in the makerspace, it is important to note that all engineering students have become users since 2022/23. The gender gap in the makerspace aligns with the gap between STEM subjects and other subjects. In 2018/19, the proportion of female first-degree graduates across all subjects was 54%, whereas in STEM

subjects, the proportion was 32%. Creating an equal, inclusive and welcoming working environment, free of discrimination and harassment, remains crucial.

To approach this challenge, we deliberately assemble a more culturally diversified tutor team and embrace differences in language and culture. We also make a strategic effort to incorporate female expertise, actively contributing to the makerspace's commitment to gender equity through routine critiques of the workspace ecosystem. In the results section, we will highlight the outcomes of these efforts in terms of the latest demographics. Additionally, we will share reflections from the tutors on their observations of diversity, equity, and inclusion in the workplace, particularly regarding students from different cultures and genders. The tutors will also provide insights on their role in upholding these values in the makerspace.

Related works

In recent years, various approaches have been explored to promote diversity, inclusion, and equity in academic makerspaces. By examining the literature, we have identified five main categories contributing to these goals: reviews and practices, activities and workshops, operational measures, mentoring and peer support, and hardware setup.

Studies by Keller et al. [3], Donna et al. [4], and Richard and Giri [5] have highlighted the importance of inclusive design, collaborative projects, and diverse academic backgrounds in fostering inclusion and diversity in makerspaces. [3] conducted a needs and opportunity assessment to design an inclusive and accessible makerspace, suggesting factors such as one-logo branding, a catalog of makerspace capacities, and shuttle bus services to promote inclusivity. Accessibility was interpreted in various ways, including longer operation hours, training workshops to balance safety and flexibility, and creating a welcoming atmosphere through colorful interior design and a welcome desk.

Donna et al. [4] reviewed six makerspace practices in promoting diversity, such as shared memberships and events to promote socio-economic inclusivity and building accessible sites for people with diverse abilities to ensure diversity of ability. These studies highlight various strategies and best practices that can be employed to foster diversity, inclusion, and equity in academic makerspaces. Richard and Giri [5] found that utilizing collaborative projects and inviting students from diverse academic backgrounds to work on common engineering tasks can promote inclusion and diversity. These projects help students perceive computing and engineering positively and appreciate diverse applications, integrating engineering into their areas of interest and expertise.

To further promote inclusion and diversity, it is important to incorporate activities such as workshops and talks [6] [7]. Hira et al. [6] emphasize the importance of broadening the context of engineering activities to increase inclusivity and accessibility, allowing students to work on personally meaningful projects. Similarly, Noel et al. [7] emphasize the importance of incorporating art and engineering workshops as a means to foster inclusion and build confidence within makerspaces. By integrating artistic elements into engineering projects, these workshops encourage students to tap into their creativity and explore the diverse applications of engineering. This interdisciplinary approach not only enhances their technical skills but also broadens their perspective and promotes inclusivity.

Operational measures such as the implementation of a "Maker Grant" program can also contribute to promoting diversity and inclusion [7]. The Maker Grant program provides financial support for approved project proposals, ensuring that students from diverse backgrounds have equal opportunities to participate in the makerspace community. By removing financial barriers, this program promotes inclusivity and encourages students to actively engage in hands-on learning experiences.

Mentoring and peer support play a crucial role in fostering an inclusive and supportive environment within makerspaces [8] [9] [10]. Davishahl [8] suggests the use of mentoring programs and peer-led workshops to build community, social support, and an inclusive atmosphere, particularly for students with less technical skills. Kellman et al. [9] describe how some makerspaces, such as Middle Atlantic University and South Central, intentionally hire underrepresented student groups to onboard new users and support them through equipment training, promoting a sense of belonging and encouraging inclusivity. These institutions also cultivate an inclusive social space and non-stereotypical first impressions through decorations, such as inspirational quotes featuring diverse representation. Pines et al. [10] found that, at the Aggie Innovation Space at New Mexico State University, while 3D printing initially attracted students, peer mentoring and services offered were crucial for continued use.

The physical setup of makerspaces also plays a role in promoting accessibility and inclusion [11] [12]. Yi and Bauman [11] emphasize the importance of a central location for physical accessibility and inclusion, which prevents associating the makerspace with a specific department. They also stress the importance of having diverse tools and supplies, various purposes of usage, and adaptable training styles to accommodate a diverse population. Compeau [12] utilized a mobile makerspace as an outreach method, promoting public understanding of makerspaces in schools and delivering workshops, which contributed to increased diversity by exposing students to the STEM field.

Our approach is influenced by insights from various perspectives, ranging from operational measures (including workshops, talks, and the Maker Grant) to considerations related to hardware setup (such as equipment and tools), as well as insights into mentoring and peer support. Our study focuses on establishing a mature, diverse, and multicultural tutor network with the goal of fostering inclusion, diversity, and equity in the academic makerspace.

Promote inclusion and diversity with a network of master tutors

We implemented an Innovation Tutorship Training Scheme (ITTS) [13] in the Inno Wing. This initiative systematically recruits and trains students in master's programs, cultivating a mature, diverse, and knowledgeable supportive network of tutors. This tutor network receives backing from all engineering departments, which allocate funding for their MSc students to actively participate in the ITTS. The engineering faculty further supports the scheme by funding a full-time tutor responsible for managing and training these MSc tutors within the Inno Wing. At the onset of each academic year, new tutors are recruited and undergo comprehensive training, committing to a one-year service term. During their service period, tutors undergo a 3-month probationary assessment of their technical competencies and performance in five duties as presented as follows.

1. Conducting comprehensive orientation tours and safety/access inductions

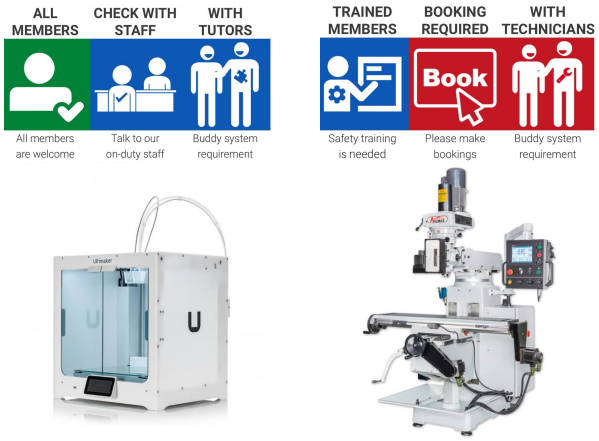


Figure 5. Machine's signages for 3D printers and CNC milling machines.

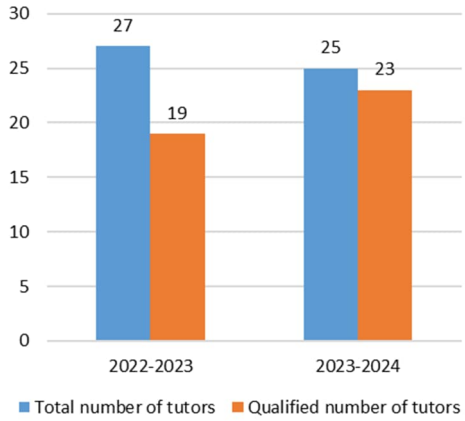


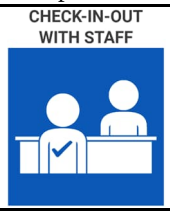
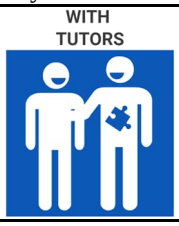
Figure 6. The total number of tutors and those who became qualified to host inductions.

A common misconception about academic makerspaces is that the space is exclusively for highly technical and skilled users, which could be intimidating to newcomers. While this may be true for some high-risk machinery, many of the equipment is safe for exploration when proper guidelines are followed. Therefore, the first step in eliminating access barriers for newcomers is to define clear operational guidelines, supported by easy-to-understand signages, that all makerspace users adhere to. Tutors serve as frontline staff responsible for introducing and enforcing these guidelines in the workspace.

The guidelines articulate three crucial aspects for each resource in the makerspace: 1) Who can use it, 2) What to do before using it, and 3) The buddy system during use. For each aspect, a three-level color code of restrictions, ranging from less restrictive (green) to median (blue) and more restrictive (red), is employed. Table 1 illustrates the signage designed for the access protocol for the resources. For example, as shown in Figure 5, the PLA 3D printers are 'Green, Blue, Blue,' indicating that they are available for all members (green), walk-in use is allowed (blue), and the printers should be operated with a tutor/technician (blue). As another example, the CNC milling machine's signage is 'Blue, Red, Red,' signifying that it is available for trained users only (blue), requires prior bookings before use (red), and needs to be operated with a technician (red). With clear signage for all resources in the makerspace, all users would understand how to access the resources safely.

All tutors first undergo training to become proficient in presenting detailed guidelines to makerspace equipment, training programs, safety protocols, existing SIG projects, and available activities. As shown in Figure 6, there are 23 out of 25 tutors qualified to host induction tours in 2023/24. Subsequently, these qualified tutors organize orientation tours for every new user of the makerspace and administer a safety quiz to qualify new users. The orientation tours also emphasize the inclusive culture of the workspace by introducing the tutor network, which provides consultation and assistance when users encounter difficulties in accessing resources in the makerspace.

Table 1. The signages designed for the access protocol for resources in the makerspace.

	Less restrictive	Median	More restrictive
Who can use?			
	Feel free to use when it is unoccupied.	The equipment/facility is available only to users who have received respective trainings.	Access permission to this equipment/facility is granted exclusively to staff.
What to do before use?			
	Please serve yourself.	Walk-ins are allowed. Please check in and check out with the on-duty staff before use.	Prior booking and approval are required.
Buddy system requirement during use.			
	Operate with the presence, attention, and assistance of another trained member.	Operate under the on-site supervision of a tutor/technician.	Operate under the on-site supervision of a technician.

2. Providing training to promote maker skills

Guided by equipment usage statistics, we strategically tailor internal training to empower tutors with the necessary skill set for operating machines. The allocation of tutors aligns with the popularity of specific machines, ensuring ample support for the more widely used equipment. As depicted in Figure 7, illustrating equipment usage statistics by type in 2021/22, the PLA 3D printers emerged as heavily utilized resources. Laser cutting and engraving machines, while efficient alternatives for some prototyping tasks, are less familiar to students due to a lack of using experience. Consequently, all tutors in 2021/22 undergo comprehensive internal training and quizzes, qualifying them as both operators and instructors for these PLA 3D printers and laser cutting and engraving machines. Figure 8 showcases the laser cutting session that tutors offer for undergraduate users. These sessions are conducted on a one-to-one basis, emphasizing tutor-student interactions and experience sharing. Additionally, a well-organized roster ensures a consistent on-site presence of qualified tutors, providing maximum support to students.

Beyond training, tutors are tasked with the design and development of new training materials. Identifying underutilized equipment from previous years, tutors concentrate their efforts on creating targeted training materials for the current year. For instance, recognizing the potential of new VR equipment in 2022/23, tutors have introduced “VR tasters”, offering students an

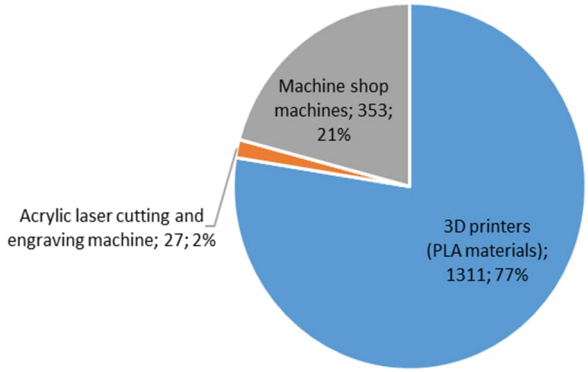


Figure 7. Equipment usage breakdown by equipment types in 2021/22 academic year.

Figure 8. One-to-one equipment training offered by master tutors

introduction to various VR gadgets. Recent initiatives include the development of training materials for embedded systems to enhance the usage of electronic workbenches in 2022/23 and generative AI walkthroughs in 2023/24 to encourage the use of multimedia equipment and image/video editing facilities in the podcast studios in the makerspace.

3. Offering diverse academic perspectives in consultative services

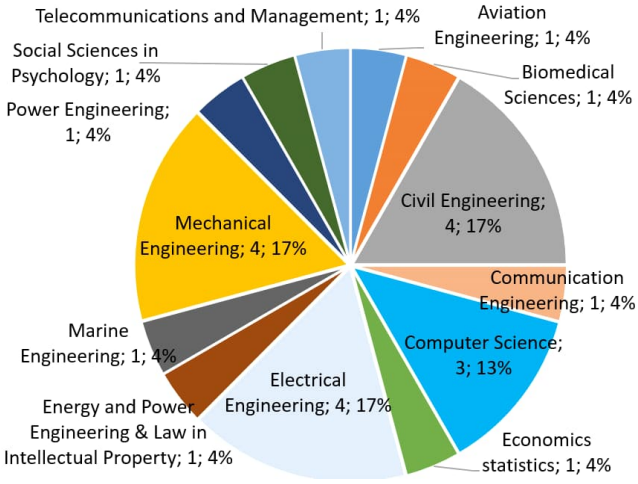


Figure 9a. Number of tutors break down by academic backgrounds in the 2023/24 academic year.

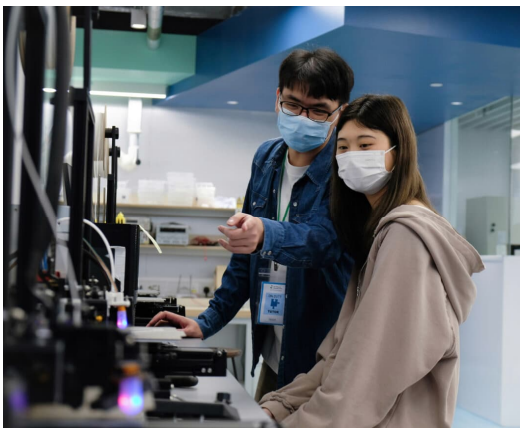


Figure 9b. On duty tutors are available to provide consultation services to students.

Tutors serve as a driving force in supporting interdisciplinary initiatives, strategically recruited with diverse academic backgrounds to provide consultative services for undergraduates from all faculties. Figure 9 illustrates the diverse academic backgrounds of the tutor network, which can promote undergraduate diversity in two significant ways. Firstly, it enables the specialization of induction and equipment training for users from various academic backgrounds. Secondly, it encourages students to engage in more cross-disciplinary work by providing a wider spectrum of perspectives in consultative support. For instance, tutors from electronic engineering and computer science can collaborate to offer comprehensive advice on an IoT project that requires knowledge in sensors and computing, thereby driving student projects toward greater diversity.

4. Exploring innovation through cultural diversity

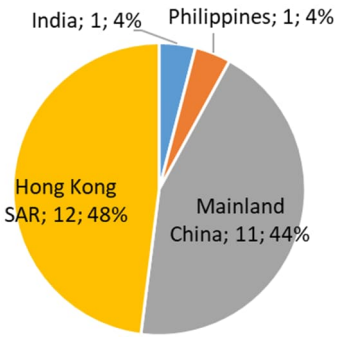


Figure 10. Breakdown of tutors by countries of residence (as of January 1, 2024).

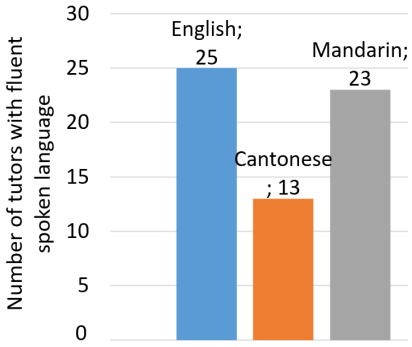


Figure 11. Breakdown of tutors by spoken languages (as of January 1, 2024).

As the university's demographics evolve towards greater internationalization and cultural diversity, our goal is to cultivate a more culturally diversified tutor team and embrace differences in language and culture. Figure 10 illustrates our progress, showing that the tutor network has begun to include master students from China, catering to 66.7% of international students from this area. We have also recruited two tutors from India and Philippines, matching the two other large foreign communities in India and Southeast Asia within the institution.

Additionally, active efforts are underway to enhance language diversity in 2023/24. As depicted in Figure 11, the tutor team is fluent in English, Cantonese (the local language), and Mandarin, enabling us to provide multilingual support in our inductions, training, and daily interactions with students. This initiative also provides an opportunity for the tutor network to host brainstorming sessions for students, facilitating the active sharing of challenges and opportunities across various geographical landscapes. Such diversity serves as a catalyst for inspiring student innovation and for exploring the application of solutions and innovative ideas in a global context.

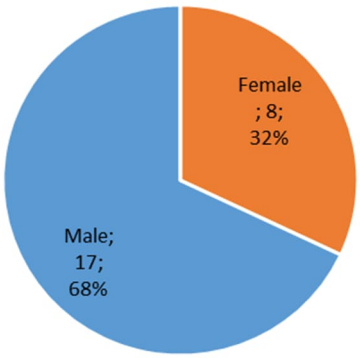


Figure 12a. Gender ratio of tutor team (female, male and others) in the 2023/24 academic year.

Figure 12b. A gender-balanced team of tutors in the 2023/24 academic year.

5. Fostering gender equity and inclusion in makerspace

The tutor network is strategically assembled to incorporate female expertise, actively contributing to the makerspace's commitment to gender equity through routine critiques of the workspace ecosystem. Their insights hold significant value for the makerspace, addressing operational blind spots and ensuring that inductions and training sessions are universally

inclusive, with a specific focus on reaching out to female students. Figure 12 shows the gender ratio of the tutor team in 2023/24, which has achieved 32% of female tutors in the network, a comparable ratio to the female students in STEM subjects in the institution.

All tutors, irrespective of gender, undergo training with a specific focus on their responsibility to maintain a workspace free from discrimination and harassment. As the makerspace nurtures a student-centered culture, on-site staff support serves as an additional layer of protection during conflicts involving such incidents. The center has experienced challenges, with a user reporting instance of physical harassment. While hardware measures like CCTV contribute to workspace security, timely assistance from mature tutors plays a crucial role in aiding students in need. As we recognize, a tutor network emphasizing gender equity not only serves as a role model but also educates undergraduates on the importance of cultivating an inclusive and respectful workspace.

Results and discussion

Methodology

We assess the impact on makerspace diversity and inclusion using both quantitative and qualitative methods. Firstly, we compile statistics to reveal shifts in user demographics concerning facility access, resource utilization, and academic diversity. Data is extracted from three sources: the Moodle Learning Management System (LMS), managing user registration, orientation tours, safety quizzes, and equipment training; the RFID access system, tracking user accesses to the workspace; and a facility usage system recording the purpose of each equipment usage. The data spans from December 2020 to August 2023, covering two-thirds of the 2020/21 academic year and the full 2021/22 and 2022/23 academic years.

Secondly, we analyze written reflections gathered from a network of tutors during 2023/24. A total of 17 tutors provided written reflections on three topics covering makerspace inclusion for diverse academic backgrounds, diverse cultural backgrounds, and gender equity. Their written reflections were analyzed using a coding scheme described in [14]. No predetermined themes were set in the analysis, and the uncovered themes emerged from the data itself. The initial coding process was an open exploration, and the data were subsequently annotated. Words and sentences under each criterion were unitized and labeled as mutually exclusive categories [15]. Subsequent readings allowed for the emergence of themes and observations.

Limitations

When interpreting the statistics, it's essential to consider that the center commenced operations in December 2020. Consequently, the statistics for 2020/21 only cover the period from December 1, 2020, to August 31, 2021, which is three months less than the statistics for 2021/22 and 2022/23. Another important factor is the impact of the pandemic, which led to operational limitations in 2020/21 and Semester 2 of 2021/22 (with no face-to-face learning from January 2021 to May 2021 and a pause in hands-on activities at the center). In addition, while tutors’ reflections presented in this section serve as frontline feedback on the makerspace's inclusivity, insights from the users' perspective via survey study are currently a work-in-progress and are not included in this paper.

Statistical analysis

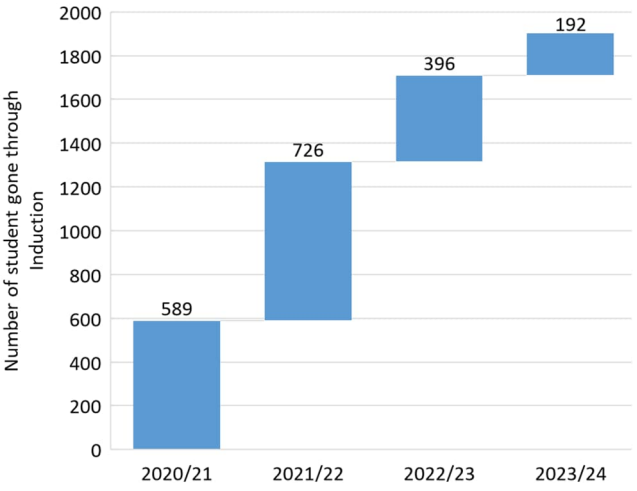


Figure 13. The number of students gone through induction and passed the onboarding quiz (up to January 1, 2024).

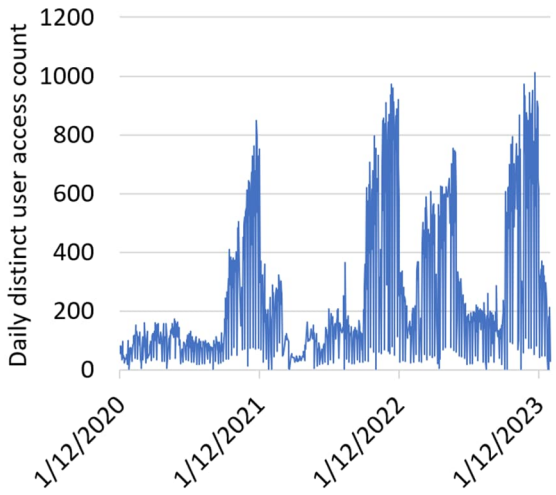


Figure 14 Number of daily user access to the makerspace (up to January 1, 2024).

Regarding the impact of orientation tours and safety/access inductions led by tutors, Figure 13 displays the number of newcomers who have undergone orientation tours and passed the safety/access inductions led by tutors. As of January 2024, more than 1,991 students have successfully completed the onboarding quiz, accounting for 71% of the entire user population. The outcome of these orientation activities is evident in the increased access to the makerspace, as familiarity with resources and the tutor team has fostered greater utilization. As illustrated in Figure 14, access to the makerspace began to surge in 2021/22, with the average daily access changing from 89 in 2020/21 to 196 in 2021/22, reaching 334 in 2022/23.

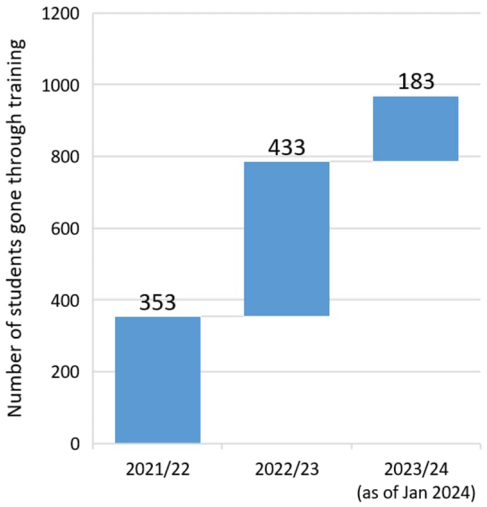


Figure 15. The number of students gone through equipment training (as of January 2024).

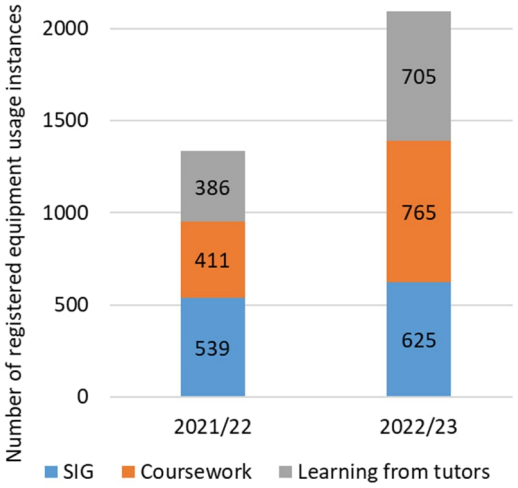


Figure 16. Equipment usage count (in terms of registered equipment usage instances).

On the tutors' effort to enhance less technically proficient users with essential maker skills, Figure 15 shows the number of users who have undergone equipment training offered by the

tutors. These regular equipment training sessions cover PLA 3D printers, laser engraving and cutting, electronic works and embedded systems, as well as generative AI software walkthroughs, which are essential to assisting less-experienced users in navigating and utilizing the facilities in the makerspace. As highlighted in Figure 15, around 950 students have successfully completed training sessions since the commencement of the training sessions in September 2021. This initiative not only enhances the skills of individual users but also fosters increased utilization of these key equipment pieces, supporting both coursework and student projects. The outcome of these training sessions can be seen in the increased equipment usage shown in Figure 16. In particular, we observed a significant rise in equipment usage for prototyping coursework projects, from 411 usage instances in 2021/22 to 765 usage instances in 2022/23. Transitioning from equipment-based training, as a work-in-progress in 2023/24, tutors will offer task-based training sessions for users, thereby further stimulating the creative potential of students in building solutions to solving real-life problems.

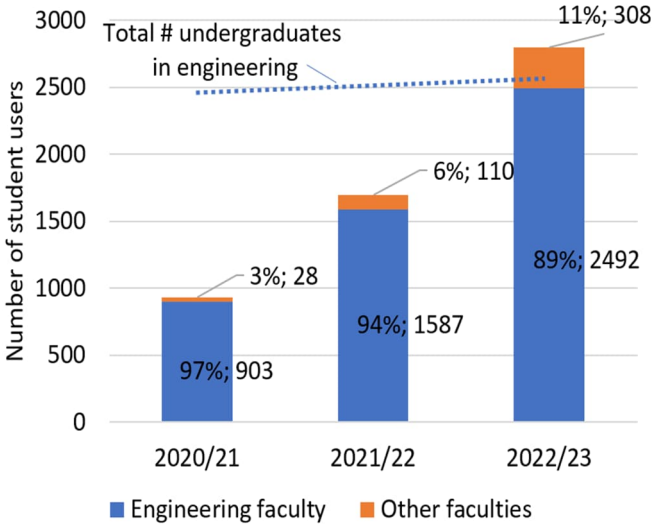


Figure 17. Number of users break down by engineering faculty and other faculties.

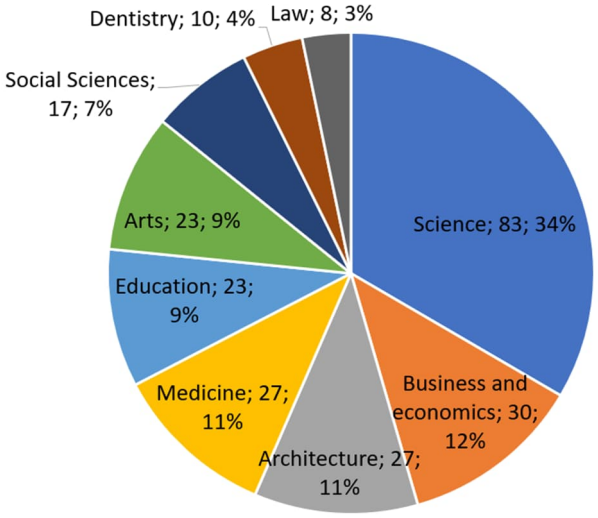


Figure 18. Breakdown of the non-engineering users by study programs (as of January 1, 2024).

On the aspect of academic diversity, Figure 17 illustrates two progressions. Regarding the promotion of the makerspace to all engineering students, encouraging results are observed in 2022/23, with the number of engineering users reaching 2,492, covering over 95% of the engineering undergraduate population. The tutor network, rich in engineering backgrounds, is well-matched to the academic background of these undergraduate users. In terms of promotion to users from other faculties, small progress is observed. As of 2022/23, non-engineering students accounted for 11% of the total registered users, up from 6% in 2021/22. Figure 18 further illustrates the diverse background of non-engineering users in the makerspace as of January 2024, with Science students being the majority of non-engineering users. This trend emphasizes the increasing importance of tutors' service to non-engineering disciplines. In response to this trend, the orientation tour and equipment training are being reviewed to assess their suitability for these non-engineering users. As a work-in-progress, the tutor network will reach out specifically to the non-engineering groups and understand how the makerspace service can be further improved to create an inclusive working environment for these user groups.

On the aspect of cultural diversity, as an academic makerspace in Hong Kong, 86% of users are from local (Hong Kong), Macau, and mainland China, with 14% of the user population coming from other countries, as shown in Figure 20. Figure 19 further breaks down the international students by their countries of residence (excluding mainland China). As observed, the makerspace has successfully attracted users with diverse cultural backgrounds, with three largest international groups from Korea, Indonesia, and India. The gender ratio of the user population by January 2024 is illustrated in Figure 21. Female users account for 21%, and compared with 32% female students in STEM subjects in the Inno Wing, there is still room for improvement.

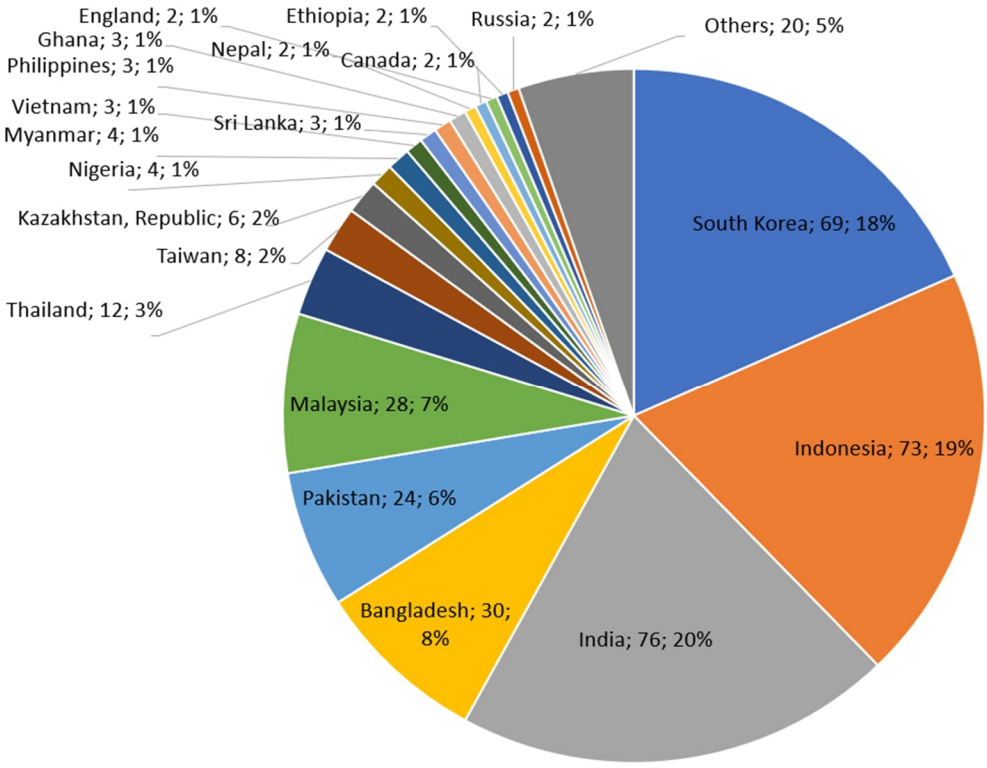


Figure 19. Breakdown of the users by other international countries of residence (a total of 376 users as of January 1, 2024).

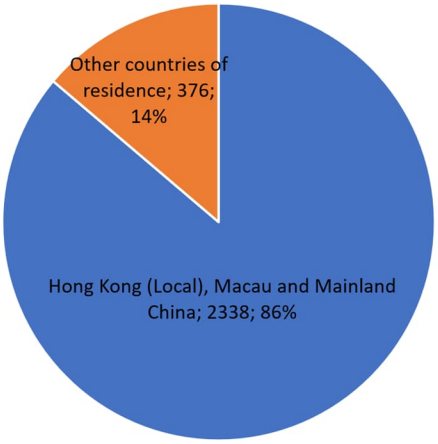


Figure 20. Breakdown of the users by countries of residence (as of January 1, 2024).

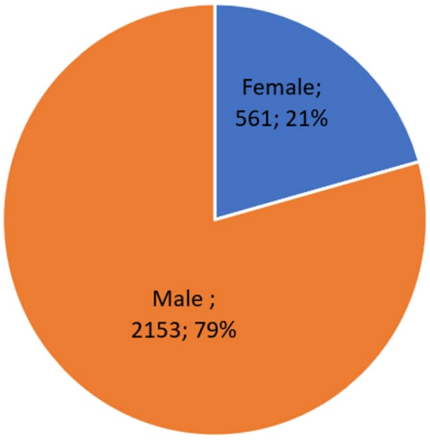


Figure 21. Gender ratio of makerspace users (female, male and others) as of January 1, 2024.

Written reflection on workspace inclusion, diversity and equity

While statistics indicate that the makerspace community embodies diversity in both culture and gender, it is crucial to delve deeper into whether the workspace genuinely fosters inclusivity and caters to various user groups. To gain a more profound understanding, we collected reflections from front-line tutors in the 2023/24 academic year, who have gained extensive experience in daily interactions with users in the makerspace. Each tutor was assigned the task of presenting a personal reflection on a specific aspect related to the diversity and inclusion of the makerspace, as outlined in Table 2. The allocation of these aspects was aligned with each tutor's specialized job duties, ensuring a comprehensive examination of the makerspace's inclusivity.

Table 2. Reflection topics

	Reflection topics	Number of tutors
1	Is the workspace genuinely inclusive for students with diverse academic backgrounds? Reflect on your role in fostering academic diversity within the workspace.	4
2	Is the workspace genuinely inclusive for students with diverse cultural backgrounds? Reflect on your role in supporting cultural and linguistic diversity in the workspace.	6
3	Is the workspace genuinely inclusive for students of all genders? Reflect on your role in upholding gender equity within the workspace.	7

On inclusion for diverse academic backgrounds in the makerspace

The insights provided by tutors emphasize the advantages of assembling teams with diverse academic backgrounds. Firstly, tutors contribute significantly to creating a more inclusive learning environment that caters to the specific needs of their academic disciplines.

In comparison to other engineering disciplines, civil engineering is often perceived as an underrepresented field in makerspaces. This is due to the fact that traditional hands-on civil works involve large-scale structural projects, concrete technologies, hydraulic systems, and other elements that may not be suited for the scale typically accommodated in makerspaces. For civil engineering students, 3D printing is commonly associated with construction applications that extend beyond the capabilities of standard PLA 3D printers. Recognizing this challenge, our tutor, with expertise in civil engineering, has played a leading role in leveraging resources for civil undergraduates. A tutor with civil engineering background emphasized, "*I provided recommendations for the integration of 3D printing and laser cutting into the civil engineering coursework. This approach aims to broaden students' perspectives beyond mere calculations, encouraging them to engage in the creation of tangible prototypes.*" This proactive stance not only enhances the educational experience for civil engineering students but also creates an inclusive learning environment for civil engineering students.

Similarly, another tutor with electronic engineering background recognizes opportunities for students in his field. He aims to inspire and encourage students to take on challenges within the center, stating, "*Most of the work being conducted by undergraduates focuses on robotics... they*

may not be aware of other opportunities related to their major. As an EEE tutor, I share with them my views on the current megatrend, such as Climate Change, to inspire their innovation."

Furthermore, the team's diverse academic backgrounds contribute to the development of more inclusive tutor services. A tutor from social science explains, "*An essential aspect involves using communication skills to create a more inclusive learning environment. This includes incorporating visual aids in workshops and tour guides, as well as posing open-ended questions to stimulate students' interest and encourage their input while assessing their understanding.*"

In addition, tutors provide valuable professional advice on student projects, bringing diverse academic perspectives. A tutor with background in psychology emphasizes the importance of offering varied insights, noting, "*...listening to students' needs and helping them articulate problems. Likewise, my psychology background allows me to approach engineering projects with a user-centric focus, considering usability and accessibility in addition to functionality.*"

As a noteworthy point, having tutors from non-engineering disciplines establishes a role model culture that is inclusive to students beyond the engineering domain. One of our tutors with non-engineering background expresses, "*I believe that my presence as a tutor with a non-traditional background can inspire students from diverse disciplines to pursue their interests, including participation in various Special Interest Groups (SIGs) within the center.*"

On inclusion for diverse cultural backgrounds in the makerspace

The analysis of the reflections on cultural diversity results in three themes. The primary theme highlights that linguistic barriers can hinder the exchange of ideas among students from different cultural backgrounds. The tutor team addresses this aspect with two steps. First, they initiate interactions with students by actively communicating with them in their native language. This is made possible by the rich language proficiency among the tutor team. As one tutor shared, "*We are open to all languages, and communication can be unrestricted by the type of language, creating an interesting environment to discover the cultural characteristics embedded in the language*." Tutors connect students from different cultural and linguistic backgrounds, and in this process, English, with some translation assistance, comes into play. As other tutors elaborated, "*I tailor my approach to meet each student's linguistic needs, ensuring they can express and understand concepts clearly… I converse in Mandarin with students from Mainland China who may not be proficient in English…such interactions often lead to new insights and ideas.*".

The second theme delves into understanding the general needs of various cultural groups and providing tailored assistance without falling into stereotypes and biases. The tutor network fosters awareness and sensitivity to the diverse needs of students from various cultural backgrounds. For instance, a tutor from Nepal shared, "*Many students come from different countries with diverse cultures and societies. I myself am a good example of that. I am from Nepal with a Hindu religious and cultural background, which is quite unique…*". Tutors then provide tailored support to assist students from different cultural groups, emphasizing the importance of being free from stereotyping and bias during their tutoring work. As one tutor shared, "*In the workspace, students never feel any barriers or biases but rather celebrate diversity and cultural events and are also encouraged to show creativity.*" and another tutor emphasized "*There is no superiority or inferiority in all cultures in the world. In the current*

globalized society, I believe that the Earth is a big family. The collision and integration of cultures will make the work environment and society more diverse and happy."

The third theme highlights the tutor's role in establishing a positive role model among tutors. They value and cherish cultural diversity, as shared by a tutor, "*… my colleagues not only come from Hong Kong locals but also from mainland China and India. Our language, culture, and diet are not the same, but when we communicate and chat, we use language that everyone can understand. We also strive to integrate into the local culture, which is a manifestation of mutual respect.*" Another tutor stated, "*… willing to learn, teach, and share cultural activities like festivals, foods, typical dress, etc.*" Additionally, friendship is built among tutors in the network, "*I really appreciate our friendship. During working time, we help each other solve problems, when off work, we discover good restaurants and interesting places together. We have diverse educational backgrounds, obtaining our bachelor's degrees in different places, the US, Canada, Hong Kong, and mainland. It is really interesting to know about student life there, discuss culture, environment, and people we have been through.*"

As a consequence, these positive gestures of tutors have demonstrated a strong example of spreading the right attitude to embrace cultural diversity among students. Tutors concurred, "*Inno Wing is fully inclusive of different cultures, where students from mainland China, Hong Kong, and other countries can work together,*" and "*... diverse students are grouped together, the result is a multifunctional team characterized by exceptional performance and ingenuity."*

On gender equity in the makerspace

The reflections on gender equity reveal four themes regarding tutors' approaches to promoting gender equity in the workspace. The first theme emphasizes the significance of the tutors' role in establishing the right first impression for newcomers. Tutors acknowledge that they serve as the initial point of contact for individuals entering the workspace, holding the responsibility of showcasing the best of what the environment has to offer and encouraging newcomers to explore and stay longer. As one tutor stated, "*A tutor is the first contact point for a newcomer, and they are responsible for describing and explaining the location and features",* and *"… if a tutor fails to provide accurate and enthusiastic explanations, newcomers may not comprehend the purpose and benefits of being in the center.*"

The second theme emphasizes the tutors leading equal opportunities for participation. The tutors are aware of their role as mature staff in addressing any discriminatory behaviors that may arise and educating undergraduates on adopting an inclusive, diverse, and equal working attitude. One tutor stated, "*In this workspace, everyone is treated as an explorer, creator, leader, or in many other identifications as they see themselves … No one is labeled or defined by a certain gender in this workspace. Every member has equal access to the same resources.*" Another tutor added, "*My role in upholding gender equity within the workspace involves attentively recognizing the needs of all students, including the more introverted ones, by offering support and assistance to those students so that they feel included and empowered to strive in their projects.*"

The third theme relates to the operational arrangement that ensures the workspace at all time has tutors of different genders, providing timely help to students in need. Tutors also shared that internal training helped individual tutors pay attention to gender equality during their interactions

with students. One tutor expressed, "*Our daily training sessions welcome students of all genders to get involved and develop necessary makerspace skills (e.g., 3D printing). Tutors who host the training are trained to be patient and supportive so that our members, regardless of their genders, have a sense of belonging in the makerspace throughout the training.*"

The fourth theme reveals that the design of the physical infrastructure and workplace atmosphere should take gender equity into careful consideration. The center sets a good example on campus, such as "*no facilities are labeled as gender-specific, including the toilets. Students of all genders, including transgender students, are free to use these toilets which are not divided into male and female.*" Additionally, in the design of documentation, signage, and terms, there is an effort to "*use inclusive language in signage and documentation. Gender-neutral terms or inclusive alternatives to address individuals or groups.*" The workplace atmosphere is described as "*welcoming to all gender. There are no dress codes in the workspace (except in the machine shop, because of safety concerns) … promotes teamwork and collaboration, celebrates contributions from students of all genders.*".

The reflections also affirm that tutors are acutely aware of the importance of building a sense of belonging among undergraduates in the workspace and creating a welcoming environment for all students. The tutors expressed, "*Tutors are always willing to provide guidance and conversation to those in need within the workspace, so that every member will have a sense of belonging in the makerspace.*" and "*It is my responsibility to create a supportive and nurturing environment that fosters equal representation and enables all students to thrive, regardless of their gender. Together, we can build a more inclusive workspace where everyone feels welcomed and valued.*" This commitment reflects their role in subtly promoting the concept of equality and continuously maintaining community harmony. The tutor network's approach contributes to cultivating a respectful, fair, and inclusive working environment for tutors and students of all genders alike.

Conclusion and the way forward

This practice paper addresses three key challenges faced by academic makerspaces in the context of diversity, inclusion, and equity. These challenges include resource unfamiliarity for newcomers, narrow academic backgrounds in the community, and difficulties related to cultural diversity and gender equity. The presented approach, involving the establishment of a mature, diverse, and knowledgeable tutor network, has proven effective in serving as a role model for fostering diversity, equity, and inclusion among undergraduate students in academic makerspaces. This study identifies insights and best practices derived from the tutor network.

Given that the Inno Wing is still in its infancy stage with two years of operation, this paper represents a work-in-progress with some initial positive results. However, continuous monitoring is essential to gain a more comprehensive understanding of the lasting impact of such an approach. An in-depth study is currently underway, focusing on gathering feedback from students and various stakeholders, to further refine and enhance our strategies for promoting diversity, inclusion and equity in the academic makerspace environment.

In future work, the tutor network will prioritize building a stronger sense of belonging among users and harnessing their collective power to promote inclusion, diversity, and equity within the

makerspace. This will involve fostering meaningful social interactions, cultivating relationships, nurturing shared values, and creating a supportive community.

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