What Comes Next After Making GenAI Tools Available in Academic Makerspaces?

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Abstract

Providing engineering students with access to Generative AI (GenAI) tools, such as online resources for Large Language Models (LLMs), application programming interfaces (APIs), and the computational power of graphics processing units (GPUs), is an essential first step in fostering innovation within academic makerspaces. However, access alone is not enough to ensure these tools are used effectively, especially when students are tasked with solving complex and interdisciplinary problems. Addressing real world challenges requires more than technical proficiency; students must also learn to contextualize GenAI tools for specific applications, overcome infrastructure limitations, and thoughtfully navigate ethical considerations.

This work-in-progress paper investigates the problem of how to support students in effectively utilizing GenAI tools in academic makerspaces beyond simply providing access. It presents preliminary results from the first step of a study involving a group of expert users. 22 undergraduate students accomplished several impressive projects, including a simulation chatbot for social work training, a legal information assistant, and a moot court advocacy simulator. These projects highlight not only the potential of GenAI tools to address real-world challenges but also the significant achievements students can accomplish when given access to advanced tools and proper support. The work demonstrates how students can adapt GenAI to specific domains, overcome technical and infrastructure limitations, and collaborate across disciplines while learning valuable technical and problem-solving skills.

Through surveys, students shared their first-hand experiences with utilizing AI tools in academic makerspaces, highlighting common challenges and opportunities. They also provided insights into the steps academic makerspaces could take to better support students. Notably, while students ranked ethical awareness as the “least challenging” aspect compared to technical skill-building, they emphasized the importance of teaching ethics alongside technical topics to make it more actionable and relevant. Embedding ethical discussions into technical workshops, such as those focused on bias mitigation or the societal implications of AI, could help ensure that ethical considerations are directly connected to practical, real-world applications.

In addition to these observations, the survey highlights emerging trends in AI development for academic makerspaces, such as retrieval-augmented generation (RAG), multimodal AI, vision-language-action models, and multi-agent orchestration. These trends reflect students’ interest in advancing beyond foundational AI tools to tackle increasingly complex and hardware-integrated problems.

The findings propose a plan for academic makerspaces to transition from being mere access providers to becoming ecosystems of support. Recommendations include building resilient infrastructure, expanding access to advanced AI tools, fostering interdisciplinary collaboration, and offering structured training and mentorship opportunities. By adopting this plan, academic makerspaces can empower students to create innovative, contextually relevant, and socially responsible solutions to pressing societal challenges, equipping them with both technical expertise and ethical awareness to make a meaningful impact.

Introduction

Academic makerspaces have traditionally been vibrant hubs for creativity, hands-on learning, and innovation. Equipped with tools like 3D printers, laser cutters, and electronics kits, these spaces have enabled students to develop prototypes and bring their ideas to life. In recent years, makerspaces have begun to incorporate advanced digital technologies, including Generative AI (GenAI). These tools, which include open-source models like Llama and Qwen, API access to closed-source models such as GPT and Gemini, and GPUs for fine-tuning, allow students to experiment with AI-powered solutions and tackle real-world problems. By integrating GenAI into the academic makerspace environment, institutions are unlocking new opportunities for interdisciplinary innovation.

Yet, simply providing access to GenAI tools is not enough to ensure their effective use. Students often struggle to apply these tools to complex, interdisciplinary challenges due to a lack of technical expertise, domain-specific knowledge, and ethical awareness. Without structured guidance, GenAI tools risk being underutilized or misapplied, leading to solutions that fail to address the nuanced needs of real-world contexts. This work-in-progress paper explores how academic makerspaces can evolve into ecosystems of support to help students overcome these barriers. By examining three case studies of student-led projects, it identifies the challenges faced by students and the structured interventions that enabled them to achieve successful outcomes.

Related works

Academic makerspaces serve as an infrastructure for fostering innovation, interdisciplinary collaboration, and hands-on prototyping in higher education [1][2], exemplified by Stanford's d.school [3] and UC Berkeley's Jacobs Institute for Design Innovation [4], which integrate project-based learning with access to cutting-edge tools and mentorship to bridge theory and practice. Recent developments have expanded their focus to emerging technologies like artificial intelligence (AI), with initiatives such as AI-focused workshops and programs at Georgia Tech [5] and similar centers [6] enabling students to explore generative AI, machine learning, and robotics through student-led, passion-driven projects. These spaces lower barriers for non-technical students, promote human-AI interaction, and support novel applications, though further research is needed on their pedagogical impacts and institutional integration.

A related study [7][8] investigates the integration of AI ethics into academic makerspaces through a structured framework that combines technical training in generative AI with interdisciplinary collaborations. This approach emphasizes ethical considerations such as data privacy, intellectual property, and responsible use of AI-generated content. An analysis of student reflections highlights common blind spots, including over-reliance on AI for factual accuracy, limited awareness of global legal and regulatory implications, and insufficient attention to equity and the societal impacts of AI. These findings emphasize the need for embedding ethical education into hands-on AI training and fostering systemic awareness to promote responsible AI development and usage.

The rise of Generative AI has sparked extensive research into its impacts, opportunities, and challenges within the education community, particularly in teaching and learning [9] [10]. In response, many institutions have introduced strategies to prepare students for the rapid advancement of AI technologies [11] [12] [13]. These efforts largely follow a top-down approach, spanning institutional policies, guidelines, AI literacy curricula, and faculty-led initiatives such as workshops and forums. Such structured strategies provide essential support, ensuring that students gain a solid understanding of technical foundations and ethical principles.

However, the fast-paced evolution of AI often outstrips the ability of policies and curricula to keep up [14]. This creates a critical need for complementary bottom-up approaches that harness student-driven ideas to propose innovative tools and measures. These approaches offer the flexibility necessary for agile adaptation and long-term relevance in an ever-changing technological landscape. This work-in-progress paper embraces this bottom-up perspective, exploring its implementation within an academic makerspace setting.

The academic makerspace in this study

Academic makerspaces vary significantly in their organizational structure, function, and services across institutions. While some are embedded within colleges, libraries, or research centers, the subject of this study, the **Innovation Wing** (Inno Wing) at the **University of Hong Kong** (HKU), operates as a centralized, standalone facility managed by the Faculty of Engineering [6]. The Inno Wing is designed to inspire and empower undergraduate students to transform their technological aspirations into reality, providing a uniquely equipped environment to support innovation and interdisciplinary collaboration.

The Inno Wing offers a spacious 2,000-square-meter academic makerspace that fosters creativity, collaboration, and hands-on learning. Since its launch in 2020, it has served as a vibrant platform where students can complement their academic studies with extracurricular projects, bridging the gap between theoretical knowledge and practical application. Hosting over 3,000 students annually from diverse academic disciplines, the Inno Wing creates a multidisciplinary space for exploration, innovation, and teamwork.

Access to the center is open to all students at HKU, with priority given to participants in two signature programs: Student-Initiated Interest Groups (SIGs) and Student-Initiated Courses (SICs) [15]. SIGs enable students to form interdisciplinary teams and collaborate on innovative projects, while SICs empower experienced students to design and teach semester-long courses on specialized topics, such as robotics and artificial intelligence. These initiatives not only provide students with hands-on technical training but also cultivate essential skills in leadership, project management, and teamwork. The center is supported by a dedicated team of academic advisors, technical experts, and peer mentors, who ensure continuous guidance throughout the students' innovation journeys. Funding for the Inno Wing comes from a combination of institutional support and philanthropic donations, ensuring its state-of-the-art facilities, resources, and programming remain accessible and impactful.

In the field of Generative AI, the Inno Wing has established itself as a leading extracurricular learning hub at the institute, nurturing the next generation of technology innovators who are both knowledgeable and ethically responsible [7]. The center complements formal education by providing resources and fostering self-directed, hands-on learning, enabling students to adapt to this rapidly evolving field while embedding ethics into the project development process. During the 2023/24 academic year, the center expanded its infrastructure to include enhanced computing facilities, software tools, and cloud resources, supporting undergraduate students in learning and developing generative AI technologies. Since ethics cannot be effectively taught in isolation, it must be integrated into real-world, hands-on experiences where students can contextualize its relevance and apply it to address the societal impacts of AI technologies. This integration aligns the center's initiatives with HKU's policies on emerging technologies, which emphasize ethics and responsible innovation in both teaching and research.

The pilot projects in this study

This study explored three pilot projects involving 22 undergraduate students who participated using the framework described in [7], highlighting the potential of GenAI tools to tackle real-world challenges while revealing key barriers students face in applying these technologies. These projects were deliberately selected to represent diverse applications of GenAI, ranging from content generation and data analysis to interactive prototyping, and to foster interdisciplinary collaboration among engineering, design, and computing students. While the projects were successfully implemented with tangible AI technologies developed by the participating undergraduates at the Inno Wing, gathering user feedback from these core users proved essential; they reported challenges such as limited technical prerequisites, integration difficulties with existing workflows, and ethical concerns around AI outputs, while suggesting measures like structured onboarding workshops, peer mentoring sessions, and simplified tool interfaces to help future students navigate GenAI more effectively.

1. Social work simulation chatbot. The first project, a social work simulation chatbot [16], was designed to address the shortage of field instructors and the ethical complexities of real-client interactions in social work training. Utilizing LLM APIs and GPU resources, students developed a chatbot capable of simulating dynamic client interactions, incorporating demographic attributes, emotional states, and counseling progressions. Collaboration with social work faculty was integral to ensuring the chatbot aligned with training standards. However, this project also highlighted challenges related to domain immersion and the critical need for interdisciplinary support.

2. Community legal chatbot. The second project, a community legal chatbot, aimed to assist laypersons in navigating complex legal information. Students developed a retrieval-augmented generation (RAG) system by leveraging over 2,000 pages of legal documents. This system combined topic prioritization with inline citations and bias mitigation to provide users with relevant, accurate, and comprehensible legal information. The project required students to adapt generic AI tools to meet jurisdiction-specific legal standards, exposing significant challenges in contextualization and technical implementation.

3. AI moot court simulator. The third project, an AI moot court simulator, addressed the resource-intensive nature of traditional moot court exercises. Students created a scalable platform powered by multi-agent LLM orchestration, enabling virtual advocacy practice. The platform included structured advocacy phases, such as submissions and rebuttals, and employed the IRAC framework for evaluating legal arguments. This project demonstrated the potential for generative AI tools to enhance experiential learning but also revealed barriers related to technical expertise and interdisciplinary communication.

4. Other diverse applications of AI. Beyond the three flagship projects, the group applied similar techniques to address challenges across various fields. Examples include developing an AI historian in collaboration with the University library, creating AI tools for museum curation, and designing an AI chatbot to assist a subway company with its maintenance handbook and policies. These projects highlight the versatility of generative AI tools and their ability to solve real-world problems across diverse domains. They also show the importance of interdisciplinary collaboration in maximizing the impact of academic makerspaces.

Methodology

This preliminary study focuses on gathering feedback from students in the pilot projects. They are expert users in the sense that they possess foundational technical skills to use the GenAI tools and are firsthand users as the first batch to engage with the GenAI facilities at the Inno Wing. As for the recruitment of students in the GenAI projects, an open call was conducted, and applicants went through an interview process to demonstrate both their foundational understanding of GenAI and their passion for the projects. A total of 22 non-final-year undergraduate students were recruited. These students had foundational technical proficiency in machine learning and natural language processing, which they had acquired through computer science courses. This technical background enabled them to effectively engage with the GenAI tools and resources provided by the makerspace, making them ideal participants for the initial evaluation.

To gather detailed feedback, a survey was designed with three key objectives: 1) to identify the challenges students faced when utilizing AI tools, 2) to uncover opportunities for enhancing the support provided by the makerspace, and 3) to collect recommendations for developing effective support mechanisms that would improve the overall student experience. The survey incorporated both qualitative and quantitative components, providing a comprehensive understanding of the students' experiences and feedback.

The survey was structured into three sections. The first section collected factual data about the participants, including their academic programs, years of study, project teams, and the specific AI facilities they had utilized, such as API access or GPU resources. The purpose of this section was to establish the context of their engagement with the AI facilities and to provide background information for follow-up analysis.

The second section explored the challenges students encountered while using the AI facilities. This part of the survey combined open-ended qualitative questions and Likert scale quantitative measures. Students were asked to describe the most significant challenges they faced and to explain how they addressed these challenges. These open-ended responses offered rich qualitative insights into their personal experiences. Additionally, students were presented with a series of Likert scale statements, which measured their level of agreement with specific challenges commonly associated with AI tools. These statements covered areas such as technical barriers, including prompt engineering and model fine-tuning; contextualization, such as adapting generic AI models to specific fields; ethical concerns, including bias, fairness, and transparency; and collaboration gaps, such as difficulties in accessing field experts. The Likert scale ranged from 1 (Strongly Disagree) to 5 (Strongly Agree).

The third section of the survey focused on gathering actionable recommendations from the participants. Students were asked to provide open-ended suggestions on how the Inno Wing could better support them in their AI projects and propose measures to help new students effectively utilize the AI facilities. This section provided valuable qualitative feedback, highlighting opportunities for improvement and practical strategies to enhance the usability and accessibility of the resources.

The data collected from the survey was analyzed using a systematic thematic analysis approach. Two researchers independently coded the qualitative responses, allowing key patterns and themes to emerge from the open-ended data. This iterative process ensured a comprehensive and reliable understanding of the qualitative feedback. The Likert scale responses were analyzed quantitatively to determine the prevalence and severity of specific challenges faced by the participants.

Limitations: A limitation of this study is that it primarily focused on expert users with foundational knowledge in AI. While this focus provided valuable feedback from firsthand expert users of the academic makerspace, it does not capture the perspectives of general students who may lack technical training or background but are still interested in accessing GenAI tools. However, listening to expert users as a first step is particularly useful because these students are more likely to fully explore the capabilities of the GenAI facilities and identify both strengths and shortcomings that might not be apparent to less technical users. Their advanced understanding allows them to provide in-depth and actionable feedback for optimizing the makerspace's infrastructure and support mechanisms. Once the facilities are better tailored to meet the needs of expert users, future studies can expand to include feedback from a broader range of students, including those with minimal technical expertise, to ensure the facilities are accessible and beneficial to all.

Preliminary findings

A consistent challenge highlighted by the survey was **technical barriers**, particularly in deploying advanced AI models locally or integrating them into complex workflows. For instance, one student working on chatbot project described difficulties in interacting with a locally hosted LLM, which required deploying the model, configuring infrastructure, and managing interactions through Python-based frameworks like vLLM. While some students overcame these hurdles by leveraging tools such as Docker containers, frameworks, and version control systems, others felt that the available resources lacked the necessary infrastructure to simplify these processes. This issue was further compounded by system compatibility challenges, as students frequently encountered errors when migrating projects between operating systems like macOS, Linux, and Windows. These compatibility issues not only delayed project development but also complicated collaborations and workshops, as highlighted by one team's experience of dealing with incompatible CUDA toolkit functions during a migration.

Another recurring theme was the **reliability of AI-related infrastructure**. Several students highlighted that server shutdowns presented significant challenges, particularly during project showcases or evaluations by supervisors. For instance, a student stressed the importance of maintaining a stable server environment, as unexpected shutdowns often led to the loss of unsaved progress and required a complete rerun of hosted applications. Although students implemented temporary workarounds, such as using version control systems and incremental saves, these solutions only addressed the symptoms rather than the root cause. This highlights the pressing need for more robust and reliable infrastructure. Ensuring 24/7 uninterrupted and reliable services remains a major challenge for many academic makerspaces.

Beyond technical challenges, students stressed the importance of **tailoring AI models to specific applications**. Adapting generic LLMs to meet domain-specific requirements, as seen in projects like the legal chatbot and the social work simulation chatbot, demanded significant time and effort. While some students collaborated with domain experts to refine their applications, others expressed frustration over the lack of structured opportunities for interdisciplinary collaboration. This gap hindered their ability to effectively customize AI tools for the nuanced needs of their projects, highlighting the need for better mechanisms to facilitate such interactions.

Interestingly, the majority of feedback on **ethical concerns**, such as bias, fairness, and transparency, suggested that these issues were not perceived as significant challenges by most students. This highlights a concerning gap in understanding, as faculty, staff, and industry stakeholders often regard ethics as a critical issue in AI development [7]. This disconnect should serve as a warning to academic makerspaces, as it indicates that many students may lack awareness of the importance of ethics in AI or dismiss it as a secondary or uninteresting consideration in their projects. However, students working on real-world AI applications, such as the social work chatbot, acknowledged the importance of ethical principles in their designs. They recommended offering additional resources and guidance to help future projects better address ethical considerations.

Emerging trends

The survey in 2025/26 academic year also revealed emerging trends in AI that gained prominence as projects progressed. While many students initially focused on text-based LLMs, the rapid development of open-source models spurred interest in fine-tuning and retrieval-augmented generation (RAG) techniques. For example, students working on chatbot employed RAG to improve contextual accuracy by integrating large datasets into their workflows. As their projects evolved, students began exploring **multimodal AI**, which integrates text, images, and other media into cohesive systems. This shift required students to develop a deeper understanding of multimodal frameworks and tools, which were not readily covered in their formal education or sufficiently supported by the makerspace.

The survey responses also highlighted a growing interest in **vision-language-action models**, particularly among students working on robotics and automation-related projects. These models, which combine computer vision with natural language processing and reasoning capabilities, opened up possibilities for practical applications in autonomous systems. For instance, students envisioned robotics projects capable of visually identifying objects, reasoning about their uses, and performing specific actions in real-world environments. Similarly, there was an emerging interest in **physical AI systems**, where students sought to integrate AI with hardware, such as robotic arms and autonomous vehicles. These trends reflect the students' aspiration to move beyond software-based applications and engage with real-world, hardware-integrated solutions.

Finally, the survey highlighted a growing focus on **model orchestration and agentic AI**, where multiple AI models are integrated into organized workflows to tackle complex tasks. For example, students working on the social work simulation chatbot explored the potential of coordinating separate models for dialogue generation, emotion detection, and scenario adaptation. This trend shows the increasing complexity of AI applications and the need for advanced resources and training to support students in implementing these sophisticated systems.

What comes next?

Based on the insights gathered from the survey, future planning for AI facilities at academic makerspaces should prioritize adaptability, resource expansion, and interdisciplinary collaboration. This section outlines the key areas of focus for the future development of these facilities, with recommendations directly informed by feedback from students who were the first users of the GenAI facilities. Items 1 to 6 are actionable suggestions derived from the third section of the survey, where participants provided specific ideas for improving the makerspace. Point 7, however, is a proposed strategy for academic makerspaces on the topic of ethics in GenAI, an area that students ranked as “least challenging” for their projects in the Likert scale results from the second section of the survey.

1. Building a reliable infrastructure for AI projects. One of the most pressing needs identified by students is the improvement of infrastructure reliability within academic makerspaces. To address issues such as server shutdowns and system incompatibility, makerspaces should invest in scalable, cloud-based GPU resources and provide access to robust computing environments that are compatible with a wide range of platforms. This approach would reduce disruptions and enhance the overall user experience for students working on demanding AI projects.

2. Expanding access to emerging AI tools and frameworks. To keep pace with the rapid development of AI technologies, academic makerspaces should provide students with access to cutting-edge tools and resources, such as multimodal AI frameworks, vision-language-action models, and orchestration systems. Partnerships with industry leaders and access to API services from providers could further enrich the makerspace offerings, enabling students to explore and experiment with the latest advancements in AI.

3. Enhancing training and mentorship opportunities. Students consistently emphasized the need for structured training programs to help them navigate the complexities of AI development. Academic makerspaces could organize regular workshops, bootcamps, and tutorials on topics such as model deployment, fine-tuning, and multimodal AI. Additionally, mentorship programs pairing experienced students or faculty members with newcomers could provide invaluable guidance and support, particularly for those working on interdisciplinary projects.

4. Facilitating interdisciplinary collaboration. Many students highlighted the importance of collaboration with domain experts to contextualize their AI models for specific applications. Academic makerspaces can foster such interactions by organizing networking events, interdisciplinary hackathons, and project showcases that bring together students from diverse academic backgrounds. These initiatives would create opportunities for knowledge exchange and spark innovative ideas for real-world applications of AI.

5. **Empowering students through peer learning.** Academic makerspaces should encourage students to take on leading roles in organizing workshops, sharing sessions, or collaborative projects. For instance, students who have mastered advanced techniques such as RAG or model orchestration could lead peer-to-peer sessions, helping others develop these skills while reinforcing their own understanding.

6. Developing standardized resources and evaluation frameworks. To streamline the development and evaluation of AI projects, academic makerspaces could create standardized resources, such as Docker images, reusable evaluation frameworks, and comprehensive documentation templates. These resources would not only simplify project development but also enable students to build on each other's work more effectively, fostering a collaborative and efficient learning environment.

7. Integrating ethics with technical context. For ethics, the suggestion is to teach it in conjunction with technical understanding, as ethics without practical context can feel abstract and disconnected. By embedding ethical discussions within technical workshops, such as those on bias mitigation in training data or the societal implications of AI systems, academic makerspaces can ensure that students develop a holistic understanding of AI development and deployment. This integration would not only make ethics more relatable but also prepare students to approach AI projects responsibly and with a broader awareness of their societal impact.

Follow-up of this work-in-progress

As a work-in-progress paper, this study has offered initial insights into the challenges, opportunities, and emerging trends faced by students utilizing AI facilities in academic makerspaces. The proposed strategies, such as improving infrastructure reliability, expanding access to advanced tools, fostering interdisciplinary collaboration, and implementing structured training programs, are currently being actively piloted. These measures aim to address the gaps identified through the survey and establish an adaptive ecosystem to support AI innovation.

Looking ahead, it will be important to broaden the scope of this study by conducting follow-up surveys with a larger group of members. This expanded approach will help examine how participants' diverse competencies in AI develop as the supportive measures are implemented and refined. By tracking their progress, we aim to gain a deeper understanding of the long-term impact of providing access to AI tools and targeted interventions to enhance their learning and innovation experiences.

As we continue to evaluate and adapt our approach, this study contributes to a larger narrative about the role of academic makerspaces in preparing students for the rapidly evolving field of AI. The ultimate goal is to shape the academic makerspace into a dynamic environment that not only provides access to the latest AI technologies but also empowers students to apply these tools effectively, responsibly, and creatively to solve interdisciplinary challenges. This ongoing journey offers an exciting opportunity to explore how academic makerspaces can remain at the forefront of innovation in the age of AI.

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