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AI literacy training for K–12 learners: Community-led non-formal education practices in China

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Abstract

Introduction. Artificial intelligence (AI) literacy has become increasingly important in K–12 education, yet its implementation in community-led, non-formal settings remains underexplored. This study examines how community-led AI literacy training for K–12 learners are implemented in non-formal community settings in China, with a specific focus on the motivations and challenges faced by university-student volunteer instructors.

Method. Data were collected through semi-structured interviews with eight university-student volunteers serving as instructors and field observations of ten training sessions across five urban communities in summer 2025.

Analysis. Interview transcripts were thematically coded and triangulated with observational data, using an adapted version of Detlor et al.'s framework for community-led digital literacy training.

Results. Three dimensions—volunteer engagement, learning environments, and program components—shaped AI literacy training program. While volunteers' intrinsic motivation and disciplinary background facilitated instruction, challenges such as inconsistent funding, limited equipment, and fragmented curricula constrained the perceived effectiveness and sustainability of the training program.

Conclusion(s). Community-led initiatives can complement formal schooling in promoting AI literacy, but their sustainability and scalability depend on systematic support, adequate resources, and stronger organisational coordination.

Introduction

The rapid advancement of artificial intelligence (AI) technologies has intensified academic and policy discussions about society's readiness for the future, particularly regarding the cultivation of essential digital competencies among the younger generation (Selwyn, 2022). The integration of AI curricula into K–12 education systems is accelerating globally, aiming to enhance students' adaptability for future academic and professional readiness (Eguchi et al., 2021; Miao & Shiohira, 2022).

In this context, the notion of AI literacy has gained prominence, evolving from an early emphasis on specialised skills to a foundational cognitive framework that extends beyond mere tool usage (Ng et al., 2021). The latest framework defines AI literacy as a comprehensive set of competencies (Long & Magerko, 2020), encompassing four domains—technology, work practices, human–machine interaction, and learning abilities (Cetindamar et al., 2024).

Nevertheless, research explicitly linking community-led, non-formal education to the cultivation of AI literacy remains limited, underscoring the need to investigate how such contexts contribute to AI literacy. In these non-formal settings, unlike schools with tenured staff, university student volunteers often act as the primary agents of delivery. The quality and sustainability of such initiatives are directly determined by their adaptability, motivation, and interpretation of curricula. Therefore, examining the lived experiences of volunteer instructors is crucial for understanding how community-led AI literacy initiatives are enacted, sustained, and constrained in non-formal settings. This study examines AI literacy education for K–12 learners by foregrounding the perspectives and practices of volunteer instructors in community-led, non-formal learning spaces. Drawing on Detlor et al.'s (2022) community-led digital literacy training framework, the study employs semi-structured interviews and field observations with eight university student volunteers acting as instructors (hereafter, volunteer instructors). This research provides a preliminary exploration of a community-driven AI literacy education model for K–12 groups within China's unique sociocultural context. The findings extend the applicability of Detlor et al.'s (2022) conceptual framework across cultural contexts, elucidate enabling factors and persistent challenges, and offer actionable recommendations for optimising community-supported AI literacy practices. Specifically, this study addresses the following research questions (RQs):

RQ1: What factors influence volunteer instructors in offering AI literacy training for K–12 learners?

RQ2: What challenges arise during the implementation of such AI literacy training?

Literature review

In recent years, the concept of AI literacy has evolved significantly, expanding beyond technical skills to encompass a broader competency framework (Chiu et al., 2024; Long & Magerko, 2020). This framework includes the core abilities required to engage critically with AI technologies (Velander et al., 2024). As rapid technological advancements reshape social structures, integrating AI into education systems has become a key strategy (Wang & Lester, 2023). With growing global recognition that AI literacy is an essential component of modern education, governments, educational institutions, and communities worldwide are actively developing strategies to empower the younger generation to thrive in an AI-driven future (Chiu et al., 2021).

Specifically, preliminary research on AI literacy education for K–12 populations has encompassed systematic reviews (Casal-Otero et al., 2023; Gu & Ericson, 2025), pedagogical models based on specific AI competencies (Chai et al., 2020; Wu et al., 2024; Yue et al., 2022), and curriculum design and instructional tool development for K–12 learners (Lee et al., 2020; Mannila et al., 2025; Van Brummelen et al., 2021; Zhang et al., 2024). However, most current K–12 AI literacy education remains focused on school environments and classroom settings (Zhou et al., 2025). In contrast, community-led or community-driven AI literacy education requires further investigation. There is a particular lack of a theoretical basis for how communities can serve as vital information grounds for non-formal AI education aimed at cultivating youth AI literacy (Zhu et al., 2020). While there have been commendable attempts globally, differences in sociocultural contexts limit the direct adoption or transplantation of successful models. Additionally, the fragmented nature of existing case studies indicates that the practical implementation of AI literacy education for K–12 populations require further research (Micheuz, 2020). This includes leveraging theoretical frameworks to design targeted, situated, participatory, and experiential pedagogical approaches for K–12 learners. To date, little existing research has paid attention to non-formal education contexts such as community learning centers and memory institutions—such as libraries—that also play educational roles in society (Tadimalla & Maher, 2024).

While research directly addressing AI literacy training in non-formal contexts remains scarce, relevant insights can be drawn from the broader body of work on digital literacy initiatives. Studies of digital literacy programs in libraries, community centers, and other organised out-of-school environments demonstrate the potential of non-formal spaces to support learners' technological engagement (Tinmaz et al., 2022). For instance, Meyers et al. highlighted the role of community centers and memory institutions in fostering lifelong digital skills (Meyers et al., 2013), while Belete et al. discussed how community learning centers function as organised non-formal education spaces that provide literacy, skills, and community development opportunities (Belete et al., 2022). Together, these studies suggest that non-formal contexts can serve as important complements to formal schooling, particularly for populations with limited access to digital resources.

Method

Research context and the training program

In response to China's call to improve citizens' AI literacy, XXX University (omitted for double-blind review) launched an outreach program offering AI literacy training for K–12 students in collaboration with neighborhood communities where the university is located.

From June to August 2025, the project team recruited 20 university students as volunteer instructors. They were trained in course preparation and instruction by an expert in the information sciences discipline. The volunteer instructors then decided which content would be covered in the K–12 program and which teaching methods would be used. As of August 31, 2025, ten training sessions had been held across five communities, with a total of 200 K–12 students attending at least one session. Participants were aged 7–16, with most from primary school (Grades 4–6). Training topics included AI basics, generative AI, and barriers and challenges of AI. As community centers were equipped only with basic multimedia (e.g., projectors) and lacked computer labs, a '*Bring Your Own Device*' (BYOD) model was adopted, supplemented by instructors' demonstrations on their own laptops.

Data collection

This study employed semi-structured interviews and field observation to investigate the attitudes and behavioral responses of volunteer instructors when interacting with K–12 learners in community-led, non-formal learning spaces, with a specific focus on AI literacy training.

Semi-structured interviews were used to elicit participants' lived experiences and perspectives and to uncover the meanings these experiences hold in specific contexts (Alon & Krtalić, 2024). The interview protocol was designed to address the research questions by focusing on three key themes: motivations for participation and disciplinary influences; instructional practices, including content preparation, classroom interaction strategies, and pedagogical adjustments; and perceived barriers related to resources, infrastructure, and organisational support in the non-formal setting. Field observation, in turn, was conducted to capture behaviors directly and non-intrusively, thereby generating reliable and contextualised insights into teaching practices and learner engagement (Kumar & Sharma, 2023). Figure 1 presents snapshots from observations of the program.

Figure 1. Field observation of AI literacy training session in a community.

Between August 19 and September 8, 2025, eight university students who had served as volunteer instructors were interviewed. Pre-screening was used to ensure diversity in interviewees' characteristics, including gender, age, disciplinary background, and number of sessions taught. Interviews were conducted online via video conference, each lasting at least 60 minutes. Each participant received an honorarium of 50 RMB at the end of the interview. Details of participants' backgrounds are provided in Table 1.

Characteristics	Code	No. of participants
Gender	Male	3
	Female	5
Age	18-22	2
	22-25	6
Disciplinary Background	Information Management	6
	Computer Science	1
	Artificial Intelligence	1
No. of Sessions Taught	1	2
	2-5	3
	5+	3

Table 1. Details of participants' background.

In addition, three observers from the research team conducted on-site field observations in ten community teaching sessions, focusing on teaching practices, learner responses, and interactions among volunteer instructors, students, and community staff. Ten pieces of field notes were produced and supplemented with informal conversations with parents and community administrators, providing a richer account of the learning environment.

Data analysis

The analysis proceeded in two stages, combining inductive coding of interview transcripts with triangulation from field observations:

First, interview transcript coding. Interview transcripts served as the primary data source, given their capacity to reflect participants' direct narratives and meaning making. Initial codes were derived from recurring phrases and expressions and then aggregated into higher-level categories. For example, the excerpt '*Lesson preparation is generally the responsibility of an individual. Since a single class typically has only one lecturer, lesson preparation is carried out on an individual basis. (P5)*' was coded as Solo Preparation, further categorised under Knowledge Sharing, and ultimately incorporated into the construct Learning Environment. Coding discrepancies between researchers were resolved through discussion, leading to the development of a preliminary codebook.

Second, framework refinement with field data. The coding framework was then refined by incorporating insights from field observations and informal conversations with students, parents, and community staff. This process provided corroborating evidence and enriched the thematic structure. The refined analytical framework is presented in Figure 2.

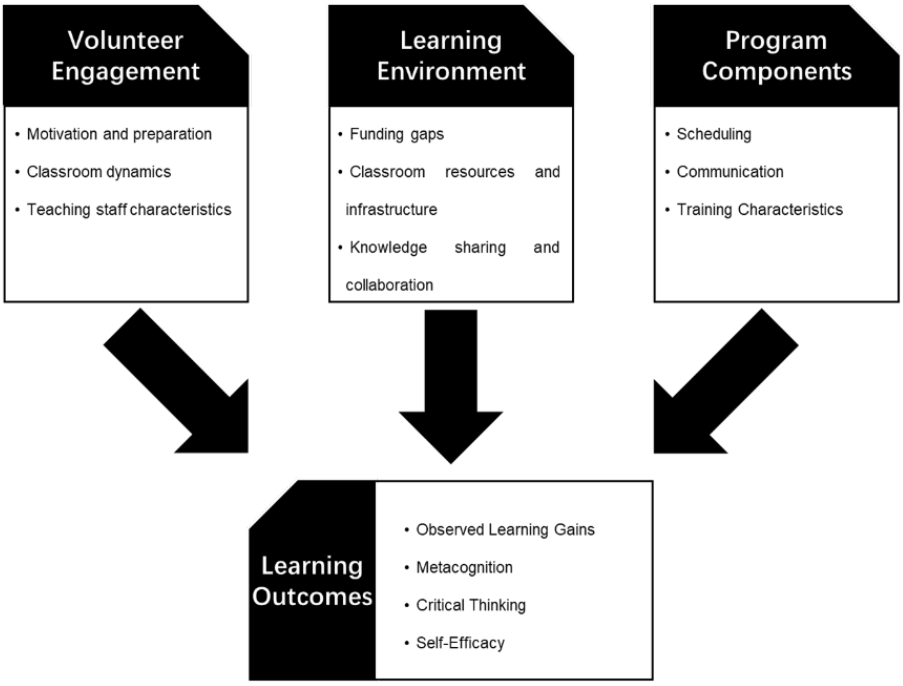

Figure 2. Refined analytical framework.

Preliminary findings

This study adopts an analytical framework inspired by Detlor et al.'s (2022) work on community-led digital literacy education (Detlor et al., 2022), which is adapted and extended to suit the context of this research. As illustrated in Figure 3, the adjusted analytical framework includes three dimensions that affect the learning outcomes. Among them, learning environment and program components are obtained from Detlor et al.'s framework, whereas volunteer engagement is added for this project since volunteer instructors play key roles in this community-led training program.

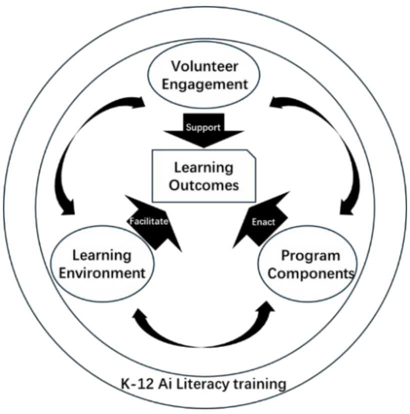

Figure 3. Adjusted analytical framework.

Volunteer engagement

The analysis revealed that volunteer instructors' engagement played a vital role in shaping both the effectiveness and the challenges of AI literacy training. Three interrelated factors emerged from the data: motivation and preparation, classroom dynamics, and teaching staff characteristics.

Motivation and preparation. Driven by disciplinary identity and intrinsic motivation, participants viewed the program as an opportunity to bridge the digital divide using their academic background. As P5 remarked, '*Information management serves as a link between technology and the target population□□ I wanted to apply our advantages to popularise complex technology for the general public.*' This sense of purpose drove them to invest effort in course design.

In terms of preparation, volunteers adopted active adaptation strategies to bridge the gap between complex technical concepts and K-12 learners' cognitive levels. For example, P6 described a process of '*filtering and translating*' complex technical knowledge: '*I utilised generative AI to convert technical definitions into metaphors that children could understand…… then adjusted the depth based on their age.*' Similarly, P5 reported pre-designing embodied activities prior to instruction, transforming abstract protocols into physical simulations (e.g., modeling network data transmission through coordinated gestures). These examples illustrate that preparation involved deliberate pedagogical transformation aimed at prioritising accessibility over technical density.

Classroom dynamics. Maintaining order proved a persistent challenge in non-formal, interest-driven settings. Multiple participants (P3, P4, P5, P6, and P8) emphasised that disruptive behaviors could derail practical sessions. P4 observed that '*before the activity started, some students were already playing on their own.*' Volunteer instructors also stressed the need to balance friendliness with authority. For example, P8 remarked, '*With primary school students, you need to be strict at times to hold their attention.*'

Teaching staff characteristics. Instructors' disciplinary backgrounds (e.g., AI, computer science, information management) and prior teaching experience also shaped classroom outcomes. Less experienced instructors often struggled with discipline management (P5), whereas those with more experience were more successful in maintaining order and encouraging participation (P3). Importantly, several instructors perceived the program as an opportunity for personal growth and skill development, which, in turn, reinforced their motivation and teaching confidence.

Learning environment

The second dimension concerns the learning environment, encompassing both material resources and the social infrastructure that supported or constrained the effectiveness of AI literacy training. Three themes emerged: funding gaps, classroom resources and infrastructure, and knowledge sharing and collaboration.

Funding gaps. Inconsistent—and often insufficient—funding across communities was a significant obstacle. Field observations indicated that some community centers lacked human resources; instructors sometimes had to seek remote assistance when technical issues arose with the projector, disrupting the class and reducing opportunities for learner engagement. By contrast, other communities offered stronger support. At these sites, staff conducted pre-class equipment checks, reimbursed teaching materials (P2, P3), and maintained institutionalised arrangements. As P2 noted, '*community staff helped manage classroom discipline*,' and observations confirmed that staff provided timely assistance when technical difficulties arose.

It is also noteworthy that, in addition to the community centers, the training program received financial support from the university. This covered essential costs such as teaching materials, equipment maintenance, transportation subsidies, and small stipends to offset teaching-related expenses for volunteer instructors. This institutional support provided a critical safety net, ensuring program stability despite uneven community-level support (P1, P5).

Classroom resources and infrastructure. The adequacy of venues, digital equipment, and learning materials had a substantial impact on student engagement. In well-equipped settings, smooth demonstrations encouraged interaction; by contrast, poor acoustics, inadequate seating, or malfunctioning equipment hindered participation. As P4 noted, '*Hardware limitations or sudden breakdowns made it hard for students to concentrate.*' Parents also emphasised during field observations that under-resourced environments risked discouraging children's interest. Compared with public cultural institutions (e.g., public libraries), community venues generally lacked comparable digital infrastructure. For AI practice-oriented sessions, students were often required to bring their own devices, which instructors then used for teaching purposes (P3, P4, P5, P8). However, this arrangement introduced new challenges for classroom management.

Knowledge sharing and collaboration. Beyond material resources, the social environment shaped how knowledge circulated among instructors. Most sessions relied on a single instructor, limiting opportunities for collaborative curriculum design. Exchanges were often informal and dependent on personal initiative. For example, P8 noted, '*I act as a bridge within the team. If I participate in the team's collaboration, communication goes smoothly; otherwise, there is little coordination to speak of.*' Although some instructors emphasised the benefits of peer planning and expert input, structured mechanisms for teamwork remained underdeveloped (P6).

Program components

The third dimension relates to the program's structural and pedagogical components—such as session organisation, communication strategies, and curriculum design—that shape learners' experiences. Three themes emerged: scheduling, communication, and training characteristics.

Scheduling. The length and timing of sessions affected teaching effectiveness and learner engagement. In some communities, classes were compressed into short sessions, limiting practice depth and constraining opportunities for students to internalise concepts. As P6 observed, '*If the one-hour class could be adjusted to allow more time for communication, the effect would be much better.*' In other cases, extended sessions risked losing students' attention, particularly among younger children. Scheduling was often adjusted to accommodate students' ages: P8 noted that for lower-grade students, classes were strictly limited to 45 minutes, whereas for upper-grade students, they could last up to 55 minutes.

Field observations suggested that inconsistent start times—often due to venue preparation delays or late arrivals—undermined the overall learning atmosphere. For instance, a session scheduled for 15:00 was postponed until 15:30, leaving students idle and reducing teaching time. These findings indicate that, while flexibility is necessary in community contexts, the absence of standardised timeframes can cause confusion and reduce participation.

Communication. Program success also depended on how information was communicated to families. Communities primarily relied on WeChat groups, phone calls, and public notices. As P8 reported, '*On the one hand, there is a WeChat group where course recruitment announcements are posted. On the other hand, relevant posts are released through the community's official WeChat account.*' Instructors noted that sessions with higher attendance tended to be those for which community leaders proactively reached out to parents in advance (P2, P8). In contrast, passive or last-minute mobilisation led to poor attendance. Field notes revealed that some parents received notifications only one day—or even the same day—before the session, making timely attendance difficult. Nevertheless, once sessions began, strong interest persisted (P7). Overall, the AI-related theme generated curiosity and parental support, with parents associating it with future career opportunities (P5). However, a lack of detailed communication about program content sometimes produced a mismatch between expectations and reality (e.g., a parent anticipated '*programming or robotics*,' but the actual content was more conceptual), leading to disappointment (P4).

Training characteristics. This theme addresses the pedagogical structure of sessions and the curriculum content. Most instructors adopted a lecture-based approach, supplemented by multimedia presentations; some incorporated interactive elements, flipped classrooms, and short assignments. Other sessions experimented with team teaching or interactive activities, which instructors and learners found more engaging, though these approaches required greater preparation and coordination (P7, P8). Curriculum design emerged as critical. Some courses emphasised broad introductions to AI concepts, linking them to everyday life (e.g., facial recognition on smartphones), which students found relevant and interesting (P1, P2). Others attempted hands-on exercises, but these were often limited by the availability of digital equipment and the short duration of classes (P4, P8). In the absence of a standardised syllabus, teaching depth and focus varied across communities, often depending on the individual instructor's expertise and preparation (P4).

Observed learning outcomes

The final component of the analytical framework (see Figure 3) concerns learning outcomes, which are influenced by the preceding three dimensions. In this study, the following outcomes emerged from interview and observation data.

Observed Learning Gains. Learners demonstrated tangible improvements in their knowledge of AI, progressing from merely using tools to understanding concepts. Many developed a clearer grasp of complex principles. For instance, P8 noted that older students could comprehend the underlying probability mechanisms of AI hallucinations and even simple encryption algorithms. Field observations corroborated these gains, noting that students transitioned from passive listeners to active creators. As P8 observed, '*Students wanted to stay after class to continue generating content…..researching which prompts would work better.*'

Metacognition. Participation enhanced learners' awareness of their own learning processes. They began to monitor and adjust their interactions with AI. P8 reported that while younger students used prompts directly, older learners proactively refined them to suit their needs, such as asking the AI to link related knowledge points rather than just giving answers. This shift indicates a higher level of information literacy where learners evaluate and direct the tool rather than blindly following it.

Critical thinking. The program encouraged learners to question assumptions and reason about AI in real-world contexts. P3 observed that learners developed a detective mindset towards digital content, actively debating whether a seemingly perfect image was AI-generated by analysing logical inconsistencies. P8 also reported that some learners began to reflect on issues such as information cocoons and monopolised sources, realising the need to diversify their information intake.

Self-efficacy. Learners' confidence grew as they successfully completed tasks. P1 described how a female student who had initially sat shyly at the back and rarely spoken became eager to participate: '*During an algorithm lesson, she sat next to me and actively shared her ideas, transforming from lacking confidence to expressing her thoughts confidently.*' These experiences increased learners' willingness to tackle challenges.

Discussion

The findings emphasise the interdependence of volunteer engagement, learning environments, and program components in shaping AI literacy training outcomes, highlighting the importance of social and organisational conditions that sustain learners' opportunities to engage with AI literacy education.

Motivated instructors, for example, compensated for resource limitations by designing creative activities and providing personalised guidance, while well-structured curricula mitigated challenges arising from inconsistent scheduling or venue constraints. Unlike basic digital literacy training, AI literacy education requires higher computational resources and abstract conceptualisation. Consequently, the '*hardware gap*' in community centers creates a unique bottleneck for implementing hands-on AI practices, forcing volunteers to rely more heavily on pedagogical adaptation than in traditional ICT training. These findings align with prior research emphasising the synergistic effects of human and structural factors in non-formal AI literacy education (Casal-Otero et al., 2023).

Theoretically, this study extends community-led AI literacy training frameworks in broader contexts (Detlor et al., 2022) by emphasising the pivotal role of volunteer instructors in delivering community-led AI programs for K–12 learners. The results suggest that AI literacy models should account for the dynamic interplay of human and structural factors in non-formal educational contexts. Practically, the findings indicate ways to improve community-led initiatives for K–12 populations: systematic training for volunteers to enhance instructional quality; provision of adequate resources (venues, teaching materials, and computer equipment) to support effective instruction; and, at organisational and policy levels, consistent practices, proactive communication, and curricula tailored to community learners to strengthen implementation. Furthermore, value co-creation among volunteers, community staff, and K–12 education experts could enhance the sustainability and scalability of non-formal AI literacy education.

Limitations and future research

This study examined community-led AI literacy initiatives for K–12 learners in China, focusing on volunteer engagement, learning environments, and program components. The preliminary analysis indicates that these three dimensions collectively shape the effectiveness of AI literacy training—particularly for lower elementary school students—highlighting opportunities and challenges in community-led, non-formal AI literacy education.

However, the study is limited by a relatively small sample of volunteers and communities, as well as indirectly obtained learning outcomes. Future research will refine the training program and address the factors identified here. In addition, future programs should measure learners' outcomes through pre- and post-training tests and increase the sample size to improve generalisability. Investigating online or hybrid modes of community-led AI education could also provide insights into scalable models.

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