Exploring Citizen Science Participation and Challenges in Academic Libraries: A Comprehensive Qualitative Study

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Citizen science, the involvement of the public in scientific research, is a growing trend that presents both opportunities and challenges for academic libraries. This study delves into the realm of citizen science engagement within Malaysian academic libraries, offering a qualitative exploration of participation levels and difficulties confronted by academic librarians.

Drawing upon in-depth interviews, our research unveils the multifaceted landscape of citizen science involvement in Malaysian academic libraries. Key findings underscore the potential benefits and hurdles academic libraries face in fostering citizen science initiatives. Results offer a comprehensive analysis of the present status and prospective development of citizen science initiatives in academic libraries in Malaysia. The study highlights the importance of addressing prevalent obstacles to optimize the advantages of involving the public in scientific research. It also contributes to the evolving field of library and information science by providing evidence of intricate dynamics and possible opportunities for citizen science within the academic library context.

Keywords: Citizen Science, Academic Libraries, Qualitative, Challenges, Malaysia.

BACKGROUND

Open Science is the transparent and accessible knowledge shared and developed through collaborative networks (Vicente-Saez & Martinez-Fuentes, 2018). The European Commission's Open Science policy emphasizes its eight pillars, including citizen science, which allows the public to contribute to scientific knowledge (Ayris et al., 2018). Citizen science refers to the voluntary participation of citizens in different phases of the scientific process, often during the data collection or analysis phase of projects run by scientists (Bonney et al., 2009b). Citizen science is also a method where citizens develop the research design and questions and are involved in the data collection and analysis.

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https://doi.org/10.47657/7566

The collaboration between scientists and citizens may facilitate the collection and analysis of data sets more profoundly than when the scientists act independently (Hansen et al., 2021).Research universities have begun to engage in citizen science through available research within the League of European Research Universities (LERU). The astronomy department at Lund University and the Vattenhallen Science Center has developed a citizen science center. The Universities of Zurich and Leiden are building multidisciplinary Citizen Science Labsto motivate researchers to participate in cutting-edge citizen science projects. Furthermore, a collaboration between the University of Geneva, CERN, and the UN Institute for Training and Research has resulted in the Citizen Cyber lab. It originated from an EU-funded FP7 initiative and aims to encourage citizens and scientists to collaborate in novel ways (LERU, 2016). Citizen science effectively relocates scientific activity into a larger community and provides additional opportunities for society to participate in research. Research communities and libraries generally support it. However, the effectiveness of this support is determined by how empowered such groups feel about participating in citizen science activities successfully. Citizen science also supports implementing sustainable development goals (SDGs) through transformative practices, attitudes, and behavior changes (West & Pateman, 2017). Moreover, citizen science projects help leverage the SDG efforts by applying new methodologies to enhance the quality of such data, thus presenting an opportunity for academic library involvement.

Many academic libraries serve as citizen science centers all over the world. As a national research library, the Slovak Centre of Scientific and Technical Information is a hub for advancing citizen science in that nation. They created the first Massive Open Online Course in Slovakia to provide the opportunity to study the fundamentals of citizen science and accelerate the progress of the field (Stožická et al., 2022). The advantages include giving patrons a compelling reason to use the library, providing an opportunity to learn new skills, connecting library employees with the academic community and enhancing the visibility and impact of library activities. In Malaysia, the Open Science movement began with the initiation of the Malaysia Open Science Platform (MOSP) pilot initiative on 7 November 2019, involving research academic universities as the pioneers of open science. Academic libraries may assist universities in embracing open science in a significant way. The difficulties confronted by libraries include a lack of resources, a shortage of personnel, and a lack of institutional policies (Malaysia, 2021). Academic librarians are eager to support citizen science but are currently underprepared (Yusof & Amanullah, 2022).

Research Objective

The study's first objective was to determine the level of involvement of Malaysian academic libraries in citizen science projects. It entailed thoroughly

https://doi.org/10.47657/7566

examining the different involvement levels and modes, as well as the implementation of citizen science projects by these libraries. The second objective was to explore the difficulties faced by academic librarians actively participating in citizen science projects. The study hopes to offer insightful information on the practical hurdles and challenges librarians face while encouraging citizen science engagement in academic libraries. Overall, this dual-purpose study aimed to investigate the progress of citizen science within the setting of academic libraries and provide suggestions to improve its integration and efficacy.

Research Question 1 (RQ1): What is the approach taken and the level of participation in citizen science by academic libraries across Malaysia?

Research Question 2 (RQ2): What challenges do academic librarians encounter when actively participating in citizen science projects?

LITERATURE REVIEW

Citizen Science

Citizen science (CS) allows for public involvement at various stages of a research and innovation process. It makes research accessible and pertinent to the interests of individuals and communities (Wehn et al., 2020). The CS movement is working to "leave no one behind" and develop co-creative processes that engage communities in research and learning relevant to their concerns. Thus, CS is fundamental and can significantly help achieve the goals of open science and, consequently, UNESCO's goal to "bring people closer to science"(Wehn et al., 2020). Broadly defined, citizen science is scientific work undertaken by members of the general public, often in collaboration with or under the direction of professional scientists and scientific institutions. Civic participation in research can range from short-term data collection to intensive involvement in the research process, from technical contribution to genuine research and collaboration to co-creation of knowledge. However, there is still a need to define and establish citizen science as a genuine, open research approach (Open Science Policy Platform, 2018).

Citizen science projects can involve a single participant or millions working together toward a common goal. Public participation typically includes data collection, analysis, or reporting (SciStarter, 2020). Four standard features that characterize citizen science practice are (a) inclusivity, (b) standardized protocols for high-quality data, (c) data that contributes to scientific conclusions, and (d) a collaborative community of scientists and volunteers sharing accessible data (Flagg, 2016). Despite these shared aspects, most definitions of citizen science remain somewhat vague and open to interpretation (Haklay et al., 2021). Figure 1, as depicted by Vohland & Göbel (2017), illustrates the core concepts of citizen science and open science.

https://doi.org/10.47657/7566

Figure 1

Citizen Science and Open Science Core Concepts and Areas of Synergy (Vohland & Göbel, 2017)

Libraries and Citizen Science

Numerous policies and practices in the United States of America and Europe are being put into action to involve libraries in citizen science, aiming to transform them into hubs for citizen science as part of the global Open Science initiatives (Cigarini et al., 2021; Ignat et al., 2018, 2019). The LIBER Open Science Roadmap underlines the relevance of citizen research as part of a cultural transformation and generally supports libraries as partners in citizen science (Ayris et al., 2018). There have been initiatives such as "Libraries as Community Hubs for Citizen Science" by Scistarter and Arizona State University, equipping library workers with resources, practical guidance, and kits for citizen science projects. This aligns with public libraries' missions and community organizations to promote access to information, enhance knowledge, encourage lifelong learning, and foster diverse communities.

Citizen science generates data and promotes scientific literacy (SciStarter, 2019). On both local and international levels, research and public libraries in Europe and worldwide should collaborate to build cooperative citizen science services, aiding in developing a toolkit supported by the European Commission. Libraries can be crucial in demonstrating how such cooperation aligns with open science norms (Ignat et al., 2018). Citizen Science seeks to celebrate diversity, exchange resources, and provide legitimacy and confidence in citizen science in Asia. Its mission is to foster connections, build capacity, and engage in meaningful conversations in Asia, ensuring two-way communication between Asia and the global community through the CSGP network. Asia's vast population and environmental challenges make it a crucial player in citizen science (Wong, 2022).

Citizen Science (CS) Approaches

Citizen science is operationally defined as “scientific endeavors wherein individuals who lack professional, scientific training willingly engage in collecting,

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processing, and disseminating data for a scientific project" (Silvertown, 2009).The model created by Bonney et al.(2009a)was the first to categorize various CS project concepts. The classification of this phenomenon consists of three primary approaches: contributory, collaborative, and co-created. Table 1presents CS approaches derived from the various stages of the research process. Several research studies have utilized Bonney's (2009a) typology to systematically manipulate the experimental settings in CS projects in order to examine the impact of different designs (Bruckermann et al., 2022; Greving et al., 2022; Mady et al., 2023). According to Berndt and Nitz, 2023, no significant effects resulted from variations in the CS design. The concept of CS design pertains to the organization and execution of a CS initiative, encompassing elements such as the extent of public involvement, methodologies employed for data gathering, training provisions, and project management (Fraisl et al., 2022; Kirschke et al., 2023). It is important to note that the projects were conducted in collaboration with citizen volunteers outside the traditional school setting.

Table 1

Three CS approaches- according to Bonney et al. (2009a)

STEP IN THE SCIENTIFIC PROCESS	CONTRIBUTORY	COLLABORATIVE	CO-CREATED
DEFINITION OF THE RESEARCH QUESTION			X
DEVELOPMENT OF HYPOTHESES			X
DEVELOPMENT OF THE STUDY DESIGN		(X)	X
DATA COLLECTION/SAMPLING	X	X	X
ANALYSIS OF SAMPLES		X	X
ANALYSIS OF THE DATA	(X)	X	X
INTERPRETATION, CONCLUSIONS		(X)	X
DISSEMINATION OF CONCLUSIONS	(X)	(X)	X
DISCUSSION AND OUTLOOK			X

X—public included in the step, (X) — public sometimes included in the step

1. Contributory citizen science projects are characterized by the active participation of volunteers who contribute valuable data to scientific research (Stevens et al., 2014). Participants are responsible for collecting and submitting data, which subsequently undergoes analysis and interpretation by scientists. The utilization of this methodology enables the collection of extensive data on a large scale (Nov et al., 2014), as individuals who are not professional scientists can contribute by covering a broader geographical scope and gathering data that

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would otherwise pose challenges for scientific researchers to acquire (Dickinson et al., 2012). Nevertheless, obstacles arise regarding data quality and standardization, given that the precision and dependability of data acquired by individuals lacking scientific expertise may exhibit variability (Burggraaff et al., 2021). Hence, it is imperative to implement meticulous training, establish rigorous protocols, and enforce stringent quality control measures in order to uphold the integrity and reliability of the gathered data (Fisher & Murray, 2021).

2. Collaborative Citizen Science involves collaboration between scientists and the general public at various stages of the research process (Frazer et al., 2023). The project was initially devised by scientists, with subsequent involvement from members of the public in refining, analyzing data, and interpreting results. The methodology mentioned above facilitates the cultivation of a collective sense of ownership and collaborative generation of knowledge (Atias et al., 2023) as participants cultivate a more profound comprehension of scientific procedures and a perception of trust and reciprocal esteem among scientists and the general public is achieved (Frazer et al., 2023). The successful implementation of collaborative citizen science initiatives necessitates the establishment of efficient channels of communication, seamless coordination, and effective collaboration between scientists and participants (Zoellick et al., 2012), which require a significant investment of time and resources (Wilson et al., 2022).
3. Co-created citizen science initiatives are distinguished by citizens' active participation in all phases of the scientific method, from the formulation of research questions to the publication of results (Gunnell et al., 2021). According to Gunnell et al. (2021), these projects involve collaborative efforts between scientists and citizens, where both parties contribute equally regarding decision-making authority and expertise. The co-creation process facilitates incorporating indigenous knowledge, diverse perspectives, and community priorities, leading to research outcomes characterized by enhanced relevance and significance for the local community (Fischer et al., 2021).

Level of Citizen Science (CS) Participation

Haklay (2013) presented a paradigm to evaluate participant involvement and engagement in citizen science activities. This framework prioritizes assessing these levels within the technological, social, and cultural dimensions that define the domain of citizen science. When it comes to citizen research, the interactions are more complicated because many participants respect and value the expertise of the professional scientists overseeing the project and who can explain how a particular piece of work fits within the larger body of scientific knowledge. Simultaneously, volunteers enhance their expertise by actively participating in the project, utilizing web-based resources and project-specific

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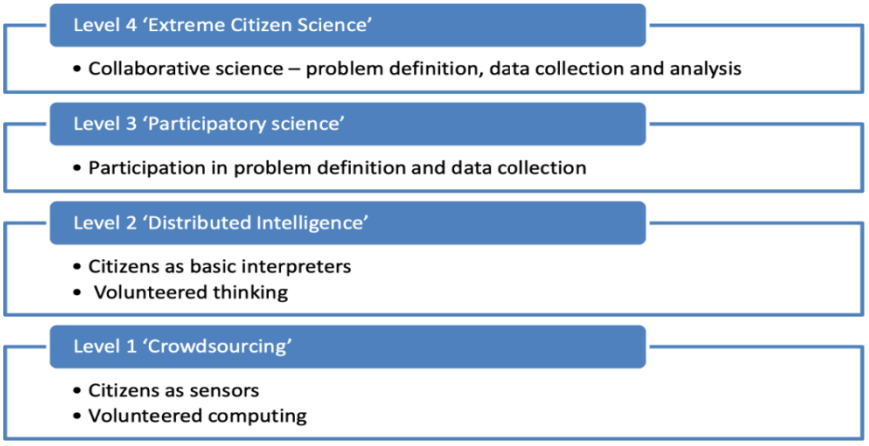
materials to enhance their comprehension. Consequently, they are more inclined to propose inquiries and progress towards higher levels of engagement. In certain instances, individuals may prefer engaging in passive volunteerism, such as volunteer computing, without a comprehensive grasp of the project. This inclination arises from a desire to participate and actively contribute to scientific research. Haklay (2013) delineates four types of engagement observed in citizen science initiatives: crowd sourcing, distributed intelligence, participatory science, and extreme citizen science.

Figure 2

Level of Participation and Engagement in Citizen Science Projects



The most basic form of participation is crowd sourcing (Level 1), whereby participants contribute the processing capacity of their personal computers or the sensors of their cell phones to a research project. However, they do not participate in the investigation's cognitive aspects.In initiatives employing the distributed intelligence level (Level 2), a traditional kind of citizen science, individuals who donate their time gather or analyze data under a predetermined classification system established by expert scientists. This particular form of citizen science is sometimes referred to as contributory citizen science and is widely recognized (Schleicher & Schmidt, 2020). In participatory science (Level 3), citizen scientists have a more significant role in defining the topic and deciding how to collect data. The data is analyzed and interpreted with the aid of scientists. This particular methodology is commonly referred to as collaborative citizen science. In extreme citizen science or co-created citizen science (Level 4), individuals who are not professional scientists actively participate in every phase of the research endeavors, from initial identification of research questions to disseminating findings through publishing.

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Occasionally, such occurrences can transpire even without participation from expert scientists. (Haklay, 2013; Schleicher & Schmidt, 2020; West & Pateman, 2017). Higher involvement rates necessitate more effort and knowledge on the part of the audience (West & Pateman, 2017). In order to ascertain the categorization of a project as citizen science research, as opposed to the mere collection of information by citizens on a particular subject, xxx (2013) proposes that projects should be deemed citizen science if the participants themselves conceptualize the research as citizen science and adhere to established scientific methodologies. Citizen science initiatives are distinguished by their focus on engaging volunteers in collecting or analyzing scientific data. Moreover, the concept of citizen science demonstrates resemblances and, in specific cases, intersects with other research approaches, such as trans disciplinary, depending on the scientific community and the extent of involvement of the citizens (Ferran-Ferrer, 2015; Pettibone et al., 2018; Schleicher & Schmidt, 2020; Wechsler, 2014).

The present study centers on academic libraries in Malaysia that actively participate in citizen science initiatives. The projects will be classified according to Haklay's (2013) framework, which encompasses four levels of participation in citizen science: crowd sourcing, distributed intelligence, participatory science, and extreme citizen science. This will enable us to examine the extent of involvement and responsibilities assumed by libraries and librarians in citizen science endeavors.

METHODOLOGY

Study design and sampling

A cross-sectional survey conducted in Malaysia from February to April 2023 targeted librarians working in 20 public universities. Each university employed around 642 librarians, ranging from entry-level to senior librarian or top management roles. Librarians in these grades were invited via email to participate in a Google Forms survey. The survey aimed to include librarians with experience in CS projects or those interested in participating in a CS project. To boost participation, follow-up invitations were sent twice during the specified period.

The study measured Malaysian librarians' participation in citizen science using the Dimensions of Engagement framework developed by Phillips et al. in 2019. The tool had sections for demographic data and 37 items that represented the five engagement dimensions: behavioral, motivational, affective, social connections, and cognitive. First, the participants were asked whether they had participated in any campus citizen science initiatives. Questions regarding their active involvement were then sent to those who selected YES, while questions regarding their perception of engagement were sent to those who selected NO.

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Informants Criteria

All librarians in the designated grades initially received an email invitation to participate in the survey. The response was strong, with 318 complete responses—representing a wide range of jobs within the university library system. Table 2 lists all participant characteristics, including responsibilities, CS project experience, and demographic data.

Table 2

Participants' characteristics

	Overall (N=318)	Involved in CS Project (n=14)	Not involved in CS project (n=304)
Highest education level			
Undergraduate	130 (40.9%)	4 (28.6%)	126 (41.4%)
Postgraduate	188 (59.1%)	10 (71.4%)	178 (58.6%)
Duration of experience (years)			
Less than 1 year	15 (4.7%)	2 (14.3%)	13 (4.3%)
1 year -5 years	29 (9.1%)	0 (0.0)	29 (9.5%)
6 years -10 years	43 (13.5%)	1 (7.1%)	42 (13.8%)
More than 10 years	231 (72.6%)	11 (78.6%)	220 (72.4%)
Position Grade			
Junior Librarian	80 (25.2%)	3 (21.4%)	77 (25.3%)
Senior Librarian	215 (67.7%)	10 (71.4%)	205 (67.4%)
Top Management	23 (7.2)	1 (7.1)	22 (7.2)

A total of 14 librarians reported their active engagement in citizen science initiatives. In order to identify cases that contained a substantial amount of information for subsequent analysis, the researchers employed a purposive sampling technique, with the criteria of the participant having fulfilled the role of project manager or coordinator for a citizen science initiative. The participant selection criteria for this study included:

- Librarians associated with public university libraries.
- Librarians who have demonstrated a commitment to citizen science activities, from initial awareness to developing and executing initiatives within their libraries.
- Librarians who are occupying roles as project managers or program coordinators within citizen science initiatives.

  Five librarians fit the criteria and were invited as informants to delve into their experiences and viewpoints regarding managing citizen science projects.

Ethical Consideration

This study was approved by the University of Malaya Research Ethics Committee (UM.TNC2/UMREC_2399). Participants were informed that their participation was voluntary.

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They submitted their responses through an email along with a signed consent form. The study's aim was communicated to the participants, and their explicit informed consent was obtained before initiating the interview process. To ensure anonymity, the informants will be denoted as P1- P5, respectively.

Data Collection and Analysis

Data Collection

The study employed in-depth interviews conducted via Zoom Online Meeting, each lasting 40 to 75 minutes and was recorded. These interviews provide valuable insights into participants' experiences, motivations, and challenges in citizen science engagement.

Interview Guide

A guide was developed to maintain consistency in the interview topics. This guide covered aspects such as the nature of citizen science projects, librarians' roles, challenges faced, and perceived benefits. The literature research, study objectives, and preliminary survey results were considered when creating the interview guide. The questions ranged from open-ended to more focused queries, allowing for exploratory and targeted talks.

Data Analysis

The research design involved using the ATLAS.ti software to conduct thematic analysis. This approach enabled the systematic identification, analysis, and organization of emergent themes and patterns within the qualitative data. The utilization of ATLAS.ti facilitates a methodical examination of the data, allowing for the identification and analysis of significant discoveries related to levels of involvement and associated difficulties. Data validation was conducted via member checking. To enhance the credibility of the findings, preliminary results were shared with participants for their input and validation.

There were multiple steps in this process:

1. First coding: Finding initial themes and patterns in the information.
2. Code refinement: To ensure the codes appropriately reflect the interview information, examine and improve them iteratively.
3. Theme development: Combining related codes to create more comprehensive themes that summarise the main conclusions of the research.
4. Validation: Ensuring the validity of the results by member checking, in which some participants were given access to preliminary results in exchange for their comment and validation.

FINDINGS

Several significant conclusions emerged from the informants with extensive experience in their respective professions, specifically about the launch of citizen science programs at their universities. The citizen science initiatives generally

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revolved around domains such as biodiversity, environmental sciences, astronomy, and water quality assessment. The participants played significant roles in these projects, showing a solid dedication to initiating and planning for maintaining citizen scientific efforts.

The extent and degree of involvement in citizen science by university libraries in Malaysia

In-depth interviews with project managers and coordinators responsible for managing citizen science (CS) programs revealed a consistent trend: all the CS projects implemented by university libraries used contributory approaches. In order to exemplify this discovery, a participant concisely encapsulated the fundamental nature of these contributing endeavors, expressing that:

"Our citizen science initiatives primarily engage library patrons in collecting and observing data (P1)."

"Participants primarily gather data using platforms like iNaturalist, limiting their involvement to data collection and interpretation using the provided apps" (P1)

"The public's involvement does not extend to detailed data handling; instead, it primarily falls to the responsibility of the library and researchers to manage. (P1, P2)"

In Malaysia, university libraries have undertaken citizen science projects that rigorously conform to the contributory approach. This approach is generally designed by scientists and for which public members primarily contribute data.

"We have completed the awareness stage and eagerly anticipate the hands-on phase with iNaturalist. Our journey begins with harnessing the capacity within our campus, where we will actively engage with the platform and its capabilities to further our citizen science efforts."(P3)

"Our focus now shifts to the practical phase as we dive into iNaturalist. Our journey commences within the confines of our campus, where we are excited to explore the tangible, hands-on aspects of this citizen science endeavor."(P5)

The contributory strategy represents a systematic foundation for libraries as they embark on their foray into citizen science. Library of P3 has commenced its program by forging collaborations with faculty members and opting for iNaturalist as the most appropriate platform. Presently, the primary focus lies in augmenting public consciousness and acquainting individuals with the program, guaranteeing a methodical and deliberate implementation process. Implementing this gradual method not only facilitates the library in enhancing its capabilities but also provides the chance to collect significant input from participants, enabling iterative enhancements.

"Our institution is in the first phases of developing a program with our academic staff centered around iNaturalist. Our main emphasis is enhancing awareness through an introduction program…we have initiated conversations with

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the faculty. Within this joint endeavor, the participants' primary responsibility is to collect data and engage in data interpretation utilizing the available applications. The allocation of program management duties is a collaborative endeavor undertaken by both the library and the faculty". (P3)

"Initially, our citizen science projects concentrated on robotics, agriculture, climate change, including food technology. However, we are shifting our focus towards biodiversity and water quality monitoring; with over 20 researchers involved, the participants will collect the data. It will be managed primarily by our team, with limited data management responsibilities placed on the participants for now."(P4)

"Our approach to citizen science is firmly rooted in fostering an inclusive and evolving engagement model… we aim to lay a strong foundation for the library's foray into citizen science. This phase not only allows us to nurture awareness and community participation but also empowers us to fine-tune our program in alignment with the public's needs and preferences. As our journey unfolds, we envision transitioning towards more participatory data analysis experiences, enabling the public to actively explore and interact with the wealth of scientific data, thereby enriching their learning and involvement in the scientific process."(P5)

Although the participant's present responsibility mainly revolved around data collecting, it is evident that the library has future intentions to augment public involvement with the data by leveraging the integrated tools offered by iNaturalist. This is consistent with the overarching pattern observed in online citizen science platforms, which prioritize active engagement of participants with project data rather than solely focusing on data contribution (Bruckermann et al., 2022). As the program progresses, it is foreseeable that the library will strive to develop additional interactive and participatory data analysis experiences for the public, fostering enhanced engagement and facilitating more profound learning. The strategy highlights academic libraries' flexibility and forward-thinking nature in promoting citizen scientific involvement within their populations (Rammutloa, 2023). Using Haklay's typology(Benyei et al., 2021; Haklay, 2013; M.Haklay et al., 2018), the majority of citizen science initiatives carried out by academic libraries in Malaysia involved participants at Level 1 and Level 2 [see Figure 2].

"As I am involved with citizen science projects, the participants identify the data through the apps, but it is not more than that. The details about the research are between the library and researchers."(P1)

"It is remarkable to see that the start of our citizen science projects tended to encourage our participants to collect the data through iNaturalist, and if they are willing to analyze it with us later, it will be great.

Nevertheless, it is more important to collect the species through the apps first. These individuals are not only eager to participate, but they also represent a community of enthusiastic, yet not necessarily specialized, contributors." (P5)

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"When we are doing this CS project about water saving, we are starting with awareness and then proceeding to the community, including a student from school, and the data coming from them, analyzing it will be another task to train."(P4)

In Level 1, often known as "crowdsourcing," individuals primarily contribute resources such as processing power or gathering sensor data, exhibiting minimum cognitive involvement. Numerous libraries employed crowdsourcing methodologies, whereby individuals contributed data via platforms like iNaturalist without active involvement in comprehensive data analysis. At Level 2, also called "distributed intelligence," users assume interpretive responsibilities that extend beyond mere data collection but with a relatively passive level of engagement. Specific libraries facilitated the involvement of individuals in rudimentary data processing and interpretation by utilizing the resources offered by citizen science platforms. Nevertheless, the libraries and scholars undertook deeper data management tasks. In general, the participation models utilized in this study were primarily focused on beginning crowdsourcing and dispersed intelligence strategies. However, these models did not fully encompass the more advanced levels of involvement that enable citizens to actively assist in problem formulation, analysis, and knowledge production. The results mentioned above highlight the significance of university libraries in facilitating citizen science programs that foster engagement and diversity. In order to progress, it is crucial to sustain the development of a participatory culture. This entails acknowledging the considerable capabilities of individuals at Level 1 and Level 2 participation and delving deeper into the various possibilities that contributory approaches present for engaging libraries and communities in scientific research and conservation endeavors.

The findings indicated that academic libraries in Malaysia have solely implemented participatory citizen science methods up to this point. This is consistent with worldwide patterns that indicate the prevalence of collaborative initiatives that involve members of the public primarily in gathering data via designated platforms. Nevertheless, previous studies also emphasize the unexplored capacity of online citizen science platforms to foster more inclusive and engaging experiences, empowering individuals to investigate and analyze project data actively (Bruckermann et al., 2022). Libraries can use existing tools to boost their capacity and adopt dispersed intelligence initiatives, promoting increased engagement through fundamental data analysis. This evolution reflects the demands within the library and information science field to redefine libraries as more than meresources of information but also as hubs for dynamic knowledge generation in collaboration with various communities (Cox & Pinfield, 2019; Lynch et al., 2021).

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The difficulties faced by academic librarians when engaging in citizen science projects.

Multiple problems and barriers encountered during active engagement in citizen scientific programs were revealed. Table 3 presents a comprehensive overview of the emerging topics about the difficulties encountered by academic librarians before, during and after engaging in citizen science initiatives.

Table 3

Challenges faced by librarians

Timeframe	Challenges
Before	Lack of awareness and understanding of citizen science
	Building Trust and Credibility
During	Skills Gap
After	Sustaining engagement and participation from the public
	Managing and curating large volumes of crowdsourced data

Before Lack of Awareness and Understanding of Citizen Science

A primary challenge academic librarian's encounter before implementing citizen science projects is the limited awareness and comprehension of this concept among the general public and library staff. This lack of awareness poses a significant obstacle, hindering individuals' successful engagement and participation in citizen science initiatives. The findings from the interviews indicated that academic librarians in Malaysia encountered a weighty first obstacle in the form of poor knowledge and lack of experience with citizen science when attempting to execute citizen science projects:

"The main challenge we faced was being newcomers to this. We had no local references since no libraries in Malaysia were doing this. We got some initial ideas from sharing sessions or talks conducted. We found the concept too advanced when we explored foreign websites. We wondered how to start, like someone sharing their first experience or a to-do list for a citizen science project. So, we needed to ask for advice. We did not have prior experience. I listened to an online webinar and did some online research. I also read articles about how libraries abroad evolved in this field. Even though it felt challenging and somewhat out of reach, this was our initial hurdle." (P1)

Another librarian expressed the necessity of providing comprehensive explanations of citizen science to fellow professionals, acknowledging that there exists a segment of individuals who lack awareness of this field and may experience confusion when confronted with the terminology and descriptions employed:

"The term 'citizen science' itself is not clear. Some consider it obligatory, while others see it as an added element. Even within our librarian community, it is a challenge. It has not become a core responsibility yet. It is currently tied to research, but the starting point and approach are unclear."(P3)

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"At first, the librarians did not want to be involved because they did not know about citizen science. Most of us, librarians, were already involved with citizen science activities, but we might have different terms for it."(P4)

"In my case, when we plan to initiate CS awareness programs, I am fully aware that some people do not know about CS and may be confused by our terms and descriptions. At times, even the committee members do not know about CS. I need to explain to them so they fully understand what CS is about. The knowledge they acquired will help to run the program better." (P5)

The excerpt indicates that many librarians lacked prior experience with citizen science and found the concepts abstract and unfamiliar. As one librarian said, "We had no local references since there were not any libraries in Malaysia doing this."(P1)

This shows that citizen science was an entirely new approach for Malaysian academic libraries, with no local precedents or examples to follow. With minimal local expertise, librarians had to rely on global resources to grasp citizen science principles. Starting with an unfamiliar concept required librarians to build knowledge from non-local sources proactively. As a librarian explained:

"I listened to an online webinar and did some online research. I also read articles about how libraries abroad evolved in this field."(P1, P2)

"CS is a new subject of interest to us. So, we need to look through the resources we acquire to ensure that it is in line with our awareness program and make it warier for others to understand." (P5)

Building Trust and Credibility

Academic librarians had early challenges in obtaining buy-in and establishing confidence while attempting to undertake citizen science projects. According to a librarian's explanation, a significant aspect of the process entails obtaining support, especially from upper-level management:

"In our efforts to secure funding, a substantial component involves gaining buy-in, particularly from top management. This project faced multiple delays due to challenges in convincing top management to approve it. However, with perseverance, we eventually moved the project from planning to implementation, which played a crucial role in rebuilding trust and credibility."(P2)

The acquisition of consent and financing necessitated persistent efforts to persuade organizational leaders of the significance of citizen science. Another librarian highlighted the necessity of leveraging the citizen science movement and persuading well-informed persons who may lack familiarity with the subject:

"For a project in the planning phase, we are tapping into the citizen science movement. Convincing knowledgeable individuals is also challenging, but they have embraced the concept. Their director spoke with them, and they see the value in it.

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They agreed that all future project data could be housed in the library. While they have embraced the idea, we still have details. We have got a long journey ahead."(P3) Within the library profession, librarians were required to showcase their skills and establish trust within their teams in order to make meaningful contributions:

"The challenge is to gain the trust of stakeholders like researchers and other potential partners. We need to earn their confidence that we, as librarians, are capable of handling these citizen science projects". (P4)

"One of our hurdles was convincing our team, researchers, and potential partners that librarians can effectively contribute to citizen science projects. Since citizen science is a relatively new movement here, we needed to provide detailed explanations and make a concerted effort to establish credibility within our team and the broader community. It took time, but eventually, we could demonstrate our value in this domain."(P5)

Given the novelty of citizen science in libraries in Malaysia, librarians were required to furnish comprehensive arguments in order to establish credibility. The results suggest that librarians encountered challenges in dispelling the notion that citizen science fell outside the purview of conventional library responsibilities. The early lack of credibility presented obstacles, but they were overcome by consistently communicating the advantages and creating confidence in the library's ability to make a meaningful impact.

During Skills Gap

The interviewees clarified that taking on citizen science projects requires academic librarians to gain expertise in new fields outside their specialization areas. According to a librarian's statement, their experience extends beyond the field of librarianship:

"We are not limited to expertise in librarianship alone. We become librarians who are versatile and multi-talented. You can say that if a researcher needs consultation on biodiversity, you are knowledgeable. If they need help with something else, you are equipped to assist. It is akin to being a subject expert and incredibly beneficial."(P1)

Although the ability to transfer knowledge skills is valuable, investing time in developing a comprehensive understanding of the specific topic and its underlying concepts is crucial. Another librarian concurred that gaining a profound comprehension of the novel subject matter inside this project would provide considerable advantages:

"I firmly believe that a deeper understanding of the new subject within this project would be highly beneficial. I have conducted my research, but it takes time to become a true expert in this field."(P5)

The results suggest that librarians engaged in citizen science did not possess inherent subject expertise and instead needed to acquire new skills through research

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and self-directed learning. The interviews revealed that other obstacles to successful implementation are the lack of topic expertise and community engagement, which indicate significant skill gaps. Multiple librarians have acknowledged the necessity of acquiring extensive expertise in the particular scientific disciplines relevant to their citizen science initiatives. One librarian elucidated this point by stating,

"One of our hurdles was convincing our team, researchers, and potential partners that librarians can effectively contribute to citizen science projects. Since citizen science is a relatively new movement, we needed to provide detailed explanations and concerted efforts to establish credibility within our team and the broader community. It took time, but eventually, we could demonstrate our value in this domain."(P5)

Although the abilities required for librarianship could be applied to other fields, developing a deep understanding of scientific subjects was crucial, albeit a time-intensive process. When considering the involvement aspect, librarians emphasized the difficulties associated with strategically promoting projects and cultivating collaboration between researchers and the general public. As expressed by a participant:

"One thing we need to understand is how we engage the community, what people refer to as evoking, that is the challenge, connecting the community with researchers, whether it is researchers or faculties, whatever it may be. We need to inform them of our role. However, let us not just leave our researchers, as most people provide contact numbers, and that is it. We can do more, we can say, 'If you need help in education, technology transfer, and more, we can facilitate that.' So, it is all about advocacy."(P4)

The task at hand involves establishing a connection between the community and researchers. Another participant worried about the library's legitimacy and ability to make meaningful contributions. This highlights the need for ongoing communication to demonstrate the library's worth:

"Ongoing research is a constant. To progress, we need skillful, strategic collaboration within and outside the university. This enhances our library's exclusive status, particularly in academic settings. By strengthening research elements in library activities, we are poised to become a hub for citizen science, skillfully connecting researchers with the community and potentially industry."(P3)

The results suggest that while implementing their citizen science initiatives, the librarians faced challenges such as a lack of proficiency in understanding the scientific principles that drive these projects and difficulties in successfully utilizing their talents in outreach, advocacy, and relationship-building to encourage involvement. Focused up skilling and capacity building are needed in these domains.

After Managing and Curating Large Volumes of Crowdsourced Data

The findings from the interviews indicated that academic librarians had notable difficulties in managing the substantial volumes of data produced by citizen science initiatives.

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According to a librarian's explanation, a significant challenge that they encountered was the administration and organization of the substantial quantities of data produced by the collective group:

"One of the primary obstacles we face pertains to managing and curating the considerable volumes of data generated from the crowd. Efficient processes are required to effectively sort, verify, and arrange information in order to enhance its value for study and analysis." (P3)

Managing the quality, relevance, and organization of the numerous observations, measurements, and other data provided by several contributors posed a significant challenge. In order to effectively validate, organize, and augment the value of the information obtained through crowdsourcing, it was imperative to establish resilient systems and processes:

"Managing and curating large volumes of crowdsourced data can be daunting. Ensuring data quality and relevance with so many contributors becomes a constant challenge. It requires robust systems and careful organization." (P5)

The magnitude of the data necessitated the allocation of specialized resources for data administration, an aspect that librarians had not anticipated. The results indicate that using crowdsourcing for data gathering yielded many advantages. However, effectively handling the large volume of data obtained from numerous decentralized sources in a structured manner was an unexpected obstacle, necessitating the development of novel workflows and infrastructure.

Sustaining Engagement and Participation from the Public

The interviewees revealed that sustaining community involvement and enthusiasm for citizen scientific activities was challenging. According to a librarian's statement, their primary concern involved guaranteeing the perpetuation of the subsequent undertaking, specifically in terms of how to maintain it, rather than relying solely on isolated operations:

"The challenge lies in ensuring the continuity of the next project. I need to figure out how to relate it to something else, essentially, how to sustain it. We do not want to do something and then leave it there. So, what you achieve should be used for the next project, and you should think about things like that."(P1)

Some scholars highlighted the significance of attaining enduring effects by maintaining continuous involvement that aligns with objectives such as sustainability and community welfare (P2, P4). However, maintaining a continual interest from the public necessitated the utilization of creativity and novel concepts (P4):

"In terms of alignment between this project and us, it is in the data collection and information gathering. That is what I see. Furthermore, we can raise awareness, especially in terms of sustainability. This project also contributes to the UN's Sustainable Development Goals regarding sustainability.

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The importance of sustaining this citizen science project cannot be overstated, as it ensures our continued progress in achieving these goals and promoting a lasting impact on our community and environment."(P2)

"Keeping the community engaged and enthusiastic about our citizen science initiatives is tough. We need to continuously find ways to inspire their involvement and ensure they remain committed to the cause. This means constantly developing fresh ideas and activities that maintain their interest."(P4)

Additionally, librarians had to effectively manage their workload and obligations while simultaneously focusing on these endeavors:

"There needs to be continuous brainstorming about the program, and we need a working team. Our problem here is that we have our normal day-to-day job, but at the same time, we need to consistently continue with this CS program so that the community and researchers can better understand CS." (P5)

The results suggest that although it was possible to raise initial awareness, there was a continuous implementation issue in maintaining participant motivation by effectively communicating the value and impact of their efforts over time. This highlights the necessity of implementing community-building initiatives, establishing effective communication channels that facilitate dialogue in both directions and adopting participatory co-design methods to cultivate long-term stakeholder support. In order to implement citizen science, libraries and librarians must acquire new skills such as public involvement, data literacy, and competence in areas beyond the library's usual scope (Ignat et al., 2019; Rammutloa, 2023). This professional development program enables librarians to enhance their ability to assist in developing research methodologies and offers the opportunity to showcase their importance in facilitating open and participatory science.

DISCUSSION

The findings provide insight into the complex correlation between the extent of engagement in citizen science initiatives and the difficulties academic librarians face in Malaysia. The prevailing approach employed by academic libraries has been that of participatory citizen science, wherein public members predominantly participate in data collection using platforms such as iNaturalist. Most projects are classified as having Level 1 or Level 2 participation, which suggests a limited level of public engagement in the more intricate parts of data management and analysis, as suggested by Haklay (2019). The connection observed between the approach employed and the level of engagement is not incidental but rather arises from the difficulties encountered by academic librarians within this environment. The main hurdle has been the limited awareness and comprehension of citizen science among the librarian community and the public. The lack of consciousness in this context hinders greater involvement and increased levels of participation, as it impedes the progress of more intricate citizen scientific initiatives.

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Establishing one's authority in this particular arena can be pretty challenging, further contributing to the prevalence of Level 1 or 2 participation. The presence of skills gaps among librarians significantly influences the extent of their involvement. It is possible that a significant number of librarians lack the requisite scientific knowledge and skills to support citizen science initiatives effectively or actively and include the public in data processing and interpretation. The issue of data quality is an additional challenge within the realm of citizen science. There is skepticism among specific individuals regarding the capacity of individuals who lack scientific expertise to gather coherent and significant data (Weir et al., 2019). In order to effectively participate in citizen science initiatives, libraries should prioritize addressing these concerns by implementing robust data-collection processes and offering comprehensive training and support to citizen scientists. This approach is crucial to uphold the integrity and dependability of the collected data (Hansen et al., 2021; Weir et al., 2019). Otherwise, their capacity to develop and guide participatory activities at an advanced level is constrained. Many librarians are not trained in citizen science methods or have not worked with them before, which makes it difficult for them to offer sound advice and assistance (Cigarini et al., 2021; Lukyanenko et al., 2016; Rammutloa, 2023). Providing extensive training opportunities for librarians is paramount to enhancing their capacity. Librarians may lack the necessary scientific knowledge and abilities to adequately support citizen science initiatives spanning various disciplines, and partnerships with subject experts can help fill knowledge gaps (Hansen, 2021; Rammutloa, 2023). Concern exists aboutdata quality assurance in citizen science, necessitating expertise in domains such as data management, analysis, and visualization (Cigarini & Bonhoure, 2022; Lukyanenko et al., 2016). Libraries possess the capacity to contribute their specialized knowledge in the curation, preservation, and facilitation of access to research data.

On the other hand, the prevalence of Level 1 or 2 engagement intensifies the difficulties librarians encounter. Librarians might struggle to promote citizen science as a multidimensional endeavor due to restricted public engagement in advanced data management and analysis (Rammutloa, 2023). The absence of deeper interaction might inhibit the development of essential skills and knowledge among librarians and the public, producing a cycle that maintains the status quo of largely contributed citizen science programs with limited public participation. In essence, the degree of engagement in citizen science initiatives within academic libraries in Malaysia is inherently intertwined with the obstacles encountered by librarians. The prevalence of participatory citizen science corresponds to the gaps in awareness, credibility, and abilities perpetuating these issues. In order to break this recurring pattern and foster more profound involvement in citizen science, librarians and their institutions must confront these obstacles and actively advocate for a shift towards increased levels of engagement.

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This approach would effectively enhance the capacity of citizen science initiatives within academic library Environments (Cigarini & Bonhoure, 2022). In response to these challenges, academic libraries must actively build capacity. This might encompass professional development initiatives targeting citizen science approaches and data management (Shwe, 2020). Enhancing the librarians' scientific knowledge and technical expertise would empower them to lead extensive citizen science programs and involve the public in advanced parts of these endeavors (Rammutloa, 2023). Additionally, university libraries should contemplate establishing partnerships with research departments and external specialists. (CEPAL, 2023). These collaborations could offer librarians the essential assistance and resources to improve their citizen science initiatives. By implementing this approach, libraries could expand the range of their citizen science efforts, progressing from simple data gathering to more advanced levels of public involvement and data analysis (Shwe, 2020).

Moreover, it is essential to increase public knowledge and understanding regarding the importance and possibilities of citizen science. Libraries might have a crucial impact on this matter by arranging workshops, lectures, and awareness campaigns. Disseminating knowledge to the general population regarding the importance of their involvement in scientific research might promote a more profound comprehension and active participation in citizen science initiatives (Barros et al., 2023).

LIMITATIONS

This study's primary focus was public university libraries in Malaysia, which restricts its wider application and might impact how well our findings could be applied to other geographic areas or library types. Furthermore, the study's conclusions are based on a narrow subset of individuals, primarily librarians participating in citizen science. This small sample size might not adequately represent the range of experiences and opinions throughout the larger community of librarians in various academic settings.

CONCLUSION

In summary, this research offers significant contributions to understanding the ever-evolving domain of citizen science pertaining to academic libraries in Malaysia. The results suggest that university libraries have mostly adopted a participatory citizen science approach, wherein the general public primarily engages in data collection activities using user-friendly platforms such as iNaturalist. This technique exemplifies a purposeful and methodical strategy to bring citizen science to the community and lay a strong groundwork for deeper involvement in subsequent endeavors.

An essential focus of this study has been the difficulties faced by academic librarians. The challenges encompass a spectrum of issues, including limited awareness and comprehension of citizen science and the imperative for librarians to establish their credibility in scientific realms and bridge the gap in knowledge

https://doi.org/10.47657/7566

between their professional expertise and the particular scientific disciplines pertinent to citizen science initiatives. The issues have been further exacerbated by skills gaps in science and community involvement and the complexities of managing and curating substantial crowdsourced data. To address these issues, suggestions have been put forth to improve librarians' training, optimize data management, and implement community-based techniques to overcome these impediments effectively.

In conclusion, this research study contributes significantly to the academic community by offering a helpful resource for university libraries aiming to establish and enhance citizen science activities. Academic libraries have the potential to strengthen their position as intermediaries between the scientific community and the public by actively confronting obstacles, promoting public involvement, and cultivating a more profound comprehension of this more significant domain.

By engaging in these endeavors, libraries have the potential to make significant contributions towards the overarching goals of open and community-driven science, thereby enhancing their influence on society, research, and education. In light of the dynamic nature of citizen science, academic libraries in Malaysia and other regions must maintain flexibility and ingenuity in their strategies. This research emphasizes the present situation and offers a strategic plan for academic libraries to effectively address the difficulties, capitalize on opportunities, and establish a significant influence in citizen science. Researchers have discovered that academic librarians are receptive to supporting citizen science despite a lack of knowledge, dedicated staff, and other obstacles. Studies recommend training, collaboration with other campus departments, and the formation of specialized support teams.

Future research might examine the emergence of specialized citizen science support positions in specific academic libraries. It could disclose effective models, necessary skills, obstacles encountered, and lessons learned that could serve as a guide for other institutions. Moreover, to support citizen science, analyze collaborations between academic libraries and campus entities such as research offices, technology transfer, and community engagement. This could reveal partnership best practices for the future. Furthermore, future studies must undertake a comparison analysis by examining studies conducted in other geographical places. Implementing such a strategy would address the constraints of the current study's range and yield a more sophisticated comprehension of citizen science's impact on academic libraries worldwide. Exploring the progression of specialized citizen science positions and analyzing effective collaborations between libraries and other campus organizations might yield valuable insights. These studies are crucial for advancing the role of libraries in citizen research, providing a worldwide outlook, and pinpointing the most effective methods for promoting collaboration and assistance in this rapidly growing sector.

https://doi.org/10.47657/7566

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