Empowering Libraries with Conversational AI

A. PROJECT JUSTIFICATION

This project responds to one of the goals of the Laura Bush 21st Century Librarian Program: *Developing faculty leaders by increasing the institutional capacity of graduate programs related to library and information science*, and specifically targets *Objective 2.3*: *Support the research of untenured tenure-track library and information science faculty, furthering the faculty members' long-term research agenda, career trajectory, and professional development*.

In this three-year Early Career Research Development project, I will **explore the potential for library-focused conversational AI (Artificial Intelligence)** to 1) *increase availability of online information and library services, 2) produce novel training solutions that can be used for skill-building and workforce development of library staff, and 3) promote more accessible dialogue with diverse community members.* The proposed research will contribute to both professional knowledge and practice, with immediate and lasting impacts.

The research is driven by the current, broadly significant **challenge** of enabling public library services to cater to diverse needs and dynamic changes in local community populations, which has heightened as a result of the COVID-19 pandemic. Specific communities and groups of people have been disproportionately impacted by the pandemic, which created human, economic, and social crises (UN, 2020). For example, the unemployment rate of the United States jumped in April 2020 to a level not seen since the 1930s (CBPP, 2021); immigrants, lower income Americans, and those with less education were hit hardest by COVID-19 job losses (Kochhar, 2020; Parker, et al. 2020). Locally, the number of immigrants living in Champaign and Urbana County at Illinois increased significantly, making up 12.2% of the total population in 2021 (NAWC, 2021); and their school districts have high percentages of low-income students, ages 3 to 17, e.g. 70% of the students in Urbana and 55 % in Champaign. The fastest-growing regions of origin include non-native English speakers from Central Africa, East and Southern Africa, and Oceania. Libraries, as vibrant community hubs, are well-positioned to help these diverse communities confront these challenges, including the heightened severity of job loss, educational inequality, and mental health issues.

In order to meet the varied and evolving needs of our communities (as stated in IMLS's strategic plan 2018-2022), libraries need **scalable and accessible solutions** to existing problems**.** At present, many public libraries offer chat features for Q/As on their homepage, where patrons can chat with human librarians. Yet, when libraries are short-staffed, *limited availability of Q/As* during off-hours and holidays negatively impacts service quality. In a related challenge, librarians need to collect information on what communities' needs are, why communities have certain needs, and when and how these needs may change, such that they can adapt their resources to provide effective supports. Traditional methods, such as interviews or surveys, have their own strengths and weaknesses (Lazar, Feng & Hochheiser, 2017). For example, running interviews allows for the collection of people's thoughts and helps answer how and why questions, but they take time and manpower, which does not scale to accommodate large populations that may have *diverse language backgrounds* (non-native English speakers) and disabilities (e.g., deaf people).

At the same time, library job positions drastically dropped during COVID-19 while the number of job hunters significantly increased (Ford, 2021). *The pandemic was perceived as a disruptor, not only in the roles libraries play but also in terms of the skills needed by libraries*. Training and re-training librarians is therefore one of the major tasks of libraries (Spacey et al. 2003), as effective knowledge transfer from experienced librarians can enhance library service delivery. But *training librarians (full-/part-time) faces many constraints*, including limited financial support, inadequate staff strength, lack of proper technological infrastructure, lack of interest on the part of the staff, etc; and training is often done through workshops, conference seminars, individual study, classroom /lecture training and coaching (Maiwada & Obaseki, 2018). Therefore, cost efficient solutions of information and communications technology (ICTs) are suggested to support both library functions and librarian training (Luo & Park 2013; Lediga et al. 2018).

In recent years, an increasing number of libraries suggest chatbots enabled by conversational AI to augment their services (Mohammed, 2019; LaBrake, 2019; Sewell, 2019; Nawaz, Gomes & Saldeen, 2020). Conversational agents (CA) are AI-enabled software technologies designed to interact with users using natural language or text in lieu of direct contact with live human agents, and text-based CAs are often referred to as 'chatbots.' While some fear jobs would be replaced by AI

technologies (Phillips, 2017), there has also been serious deliberation within libraries about incorporating CAs (or chatbots) and aligned Human Computer Interaction (HCI) techniques to facilitate dedicated library services, e.g., web site navigations, digital reference interviews and virtual story narrations (Rubin, Chen & Thorimbert, 2020). For example, CAs are conceptualized for developing open-sourced software for libraries, though without user evaluation (Bagchi, 2020), which some academic libraries have used CAs (Bohle, 2018; Kane, 2016). For instance, libraries at the University of California at Irvine (UCI) launched a chatbot called ANTswers (Kane, 2016) and found that students repurposed it for releasing stress during finals (Zalaznick, 2019). However, there is still a lack of systematic research on CAs for libraries.

Unlike academic libraries, public libraries often serve more diverse communities, with a broader range of ages and user-types than typical university libraries. Notably, ten years ago, some practitioners in public libraries saw the potential value of deploying chatbots to promote their reference services. For example, *Emma* was a chatbot released by Mentor Public Library (MPL) in Ohio about ten years ago (McNeal & Newyear 2013). But in these early efforts, librarians had to read and analyze thousands of community questions one-by-one to develop appropriate answers, which impeded efficient and scalable communication *Emma* (Newyear, 2011). Now, recent advancement of NLP and AI technologies enables processing of large numbers of free-formed questions, categorizing them, and examining trends with less effort and high accuracy across *different* languages. Therefore, providing CA-enabled services could **potentially benefit both librarians and their community members immediately by**: 1) providing convenient 24/7 service to community members and address low-level questions when human librarians are not available, 2) releasing librarians from tedious, time-consuming duties and boosting the efficiency of finishing complex tasks, 3) enabling broader accessibility of services to a wide range of age-groups, and in particular, to those who have low literacy and/or accessibility issues (e.g., text-based chatbots for users with hearing loss), and 4) collecting and analyzing community input in different languages to help librarians understand emerging challenges and needs at low cost.

My research focuses on designing interactive technologies for social good, and I have published cutting-edge works on conversational AI (Zheng et al., 2021; Lee et al., 2020a/b; Lee et al., 2021). For example, we analyzed CA works across 50 years of ACM digital library publications and developed a comprehensive framework for evaluating user experience with CAs for mediating human-human interaction (Zheng et al., 2022). Being well versed in existing CA literature and equipped with extensive experience in designing and evaluating CAs, I propose to take a radically different approach to researching the potential for library-focused CAs. More specifically, my work enables **two paradigm shifts**. First, *most existing work focuses on providing answers (predefined by librarians) for community members, without exploring when and how librarians can best use AI technologies for their own growth.* Though there are scholarly works about CAs designed for skill training in other application fields (e.g., Gonda & Chu 2019; Park et al. 2019), to the best of my knowledge, this proposed work will be the first to explore potential CA designs for ***training librarians***. Second, using AI-based technologies seems promising, however, it may be 'mission impossible' for public libraries that are under-staffed and for librarians that do not have the necessary technical background. My research will make unique and novel contributions to ***democratizing CAs for librarians.***

My long-term research agenda focuses on creating a framework for designing and evaluating technologies where humans and AI can best collaborate to provide exceptional public services for community wellbeing. My background and experience grant me **unique strengths** for conducting this *IMLS Early Career Research Development* project. With my computer science background, teaching in the iSchool, and collaborating with colleagues in different disciplines, I have contributed to the research and graduate programs of Library and Information Sciences by conducting highly interdisciplinary work. For instance, I am the lead investigator on two IMLS projects from 2015, in which I worked with five public libraries and three academic libraries (e.g., Dobreski & Huang 2016; Huang et al., 2017). I have extensive experience in designing technologies for public services, publishing in HCI, LIS, eGovernment, and Education venues, as well as releasing and managing production systems for thousands of real users. I have been also working with the Departments of Public Safety at University of Illinois, using a similar approach to design CAs for their incident reporting system and staff training. My earlier work with other public service sectors not only inspired my research for library services, but also brought me confidence in achieving the research goals. To ensure the success of this project, I structured my team with library practitioners, consultants, and advisory board members who share my vision and are keen to contribute their complementary knowledge and expertise. All these efforts have well prepared us for proposed research.

This project will also foster and enrich the dialogue between researchers and practitioners, breaking down the solos of AI research in Library and HCI fields. The research outcomes will contribute to both professional knowledge and practices:

developing a library workforce in the era of AI, strengthening engagement between libraries and diverse audiences, and building a theoretical framework delivering public service.

B. PROJECT WORK PLAN

This project will provide libraries with actionable information in using AI-based technologies effectively for community engagement and librarian training. Given that prior research has proven CAs to be more effective than surveys (Kim, Lee, & Gweon, 2019) and interviews (DeVault, et al., 2014; Lucas, et al., 2017) in collecting people's feedback and in eliciting users' opinions and thoughts (Lee & Choi, 2017; Lee et al., 2020a; Lee et al., 2020b), in this project, we will start with three driving research questions (RQs):

RQ1: *Under what situations would a CA be perceived as (not) valuable by librarians and community members?*
RQ2: *What are effective CA designs for serving the pressing needs of libraries*?
RQ3: *How can we democratize CAs for libraries to improve their community engagement?*

I will work with several public libraries' directors (See Letters of Support) to recruit participants to participate in an iterative design process of CAs. Research partners will include library directors, librarians (e.g., outreach managers, program managers, etc.), part-time employees, library volunteers, and other community service providers (such as New Welcome American Center) who work with libraries on delivering community services together. The initial findings of the project will be used to develop a design and evaluation framework of CAs contextualized by diverse library features, e.g., size, community diversity, technical support, etc. Towards the end of the project, we disseminate research findings to public librarians, releasing research products as open-sourced software on Github. My research team will also create software demo videos for release on YouTube. Since the project initiates a new direction in designing AI-based solutions for libraries, we believe this creates untapped opportunities for many broad and deep future works. Thus, we envision continuing research with IMLS and other funding agencies.

The remainder of this narrative provides details of the research methods, including: the data collection activities for iterative design of CAs, tool design, development and user experience (UX) evaluation, the theoretical grounding of the proposed idea, and performance measurements for project evaluation.

Methods

Considering the aforementioned challenges that seek scalable and accessible solutions, we plan to address the proposed three RQs in the following **three** scenarios:

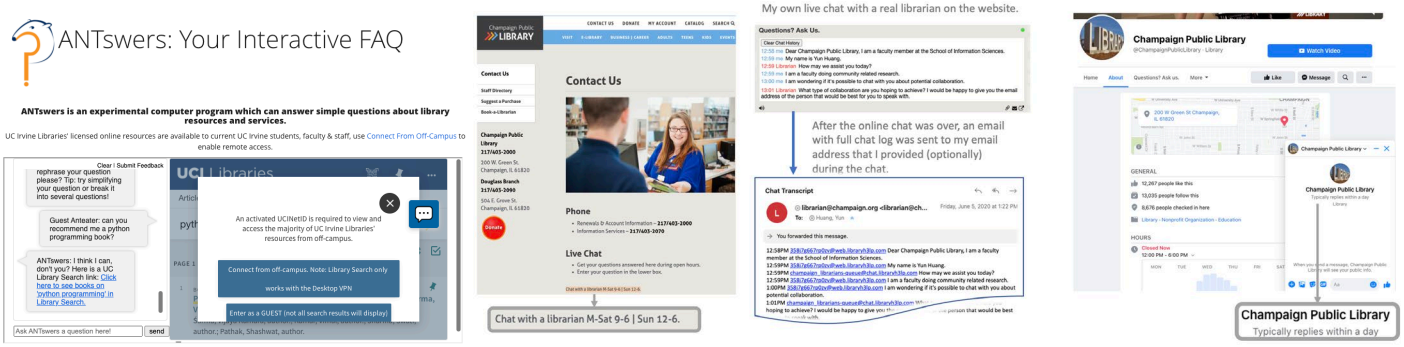
- Year 1 (***Q/A***): CAs provide answers to community members' questions when librarians are not available (e.g., during off working hours or vacation),
- Year 2 (***Training***): CAs give questions and collect answers for training full-time or part-time librarians,
- Year 3 (***Feedback***): CAs collect feedback from non-native English speakers (e.g., French, Spanish, and Chinese are major languages of immigrants in Champaign County) to improve library programs.

For each scenario, I will supervise my Graduate Research Assistants to conduct the following major research activities. We will collect and examine existing materials generated by the three scenarios to identify patterns in social interactions. For example, for the *Q/A* scenario, we will collect public FAQs of community libraries from their websites and chat logs of human librarians from our partnering libraries; for the *Training* scenario, we will collect training materials developed by experienced librarians; and for the *Feedback* scenario, we will gather survey forms from outreach managers or program managers of partnering libraries. The types of documents and data sources may be supplemented with social media data, news, public reports, and scholarly papers. Along with data collection and analysis, we will also conduct and analyze 50 semi-structured interviews with data generators (e.g., librarians, program managers, new employees, and community members). The final number of interviewees may be adjusted given the findings. The RAs will code interview transcripts to identify design opportunities, needs, and (potential) issues before/after the use of CAs. We will identify situations where different types of CAs may or may not support librarians' work. Once design implications are made, we will prioritize design tasks and propose dialogue designs given the librarians' and members' feedback. Conversational activity UX patterns (e.g., Moore & Arar, 2019) may be applied to process unexpected questions, e.g., by first providing either simple, naturalistic answers, or requests to rephrase the question. After prototyping a CA for the scenario, we will then design and run field trial studies to evaluate user experience (UX). For example, if we want to compare the effects of

two CA designs, we will randomly assign the participants into two groups, with each using one CA design, like how we did in our previous projects (Lee et al., 2020a/b; Lee et al., 2021). We then collect user logs and perceived UX measurements to compare which design leads to optimal results, e.g., better perceived engagement with the CA in dialogue. Research findings will be presented at conferences, and both software and training materials will be released for a broader audience.

Data Collection Activities for Iterative Design of CAs

Data collection activities to address the proposed three RQs will be similar for each scenario. Below we first detail the *Q/A* scenario as an example, and then briefly discuss the expected differences with the other two scenarios (*Training* and *Feedback*).



(a) UC Irvine's chatbot (b) Champaign Public Library's chat window (available between *M-Sat 9-6 and Sun 12-6*) (c) Facebook messaging (*typically replies within a day)*

Figure 1. Sample screenshot of UCI library's chatbot (a), and one library partner's current chat interfaces that are supported by library staff on library website (b) and Facebook(c).

To address **RQ1** about users' *perceived* applicability and value of CAs, we plan to start by examining existing chat logs created by human librarians and an academic library's chatbot. Currently, many libraries provide information about their programs, resources, and services through two interfaces: a library homepage and a Facebook page, as shown in Figure 1.

AI is meant to augment library services rather than replace human librarians, thus Q/As in chatbot conversations will not be fully supported by automated algorithms (Allison, 2012). There is extensive foundational literature on virtual reference service (Radford, Costello & Montague, 2021; Radford, et al., 2017), also called digital reference service (DRS). They are offered by libraries in two types (Ramos & Abrigo, 2012): asynchronous (where librarians respond to patron users' emails or questions sent through web forms at a later time) and synchronous (where librarians use short messaging system, instant messaging, voice-over-IP, and video conferencing to interact with patron users). Researchers advocate library chatbots for its unique opportunity to enhance (virtual and physical) reference and instruction services (of community and academic libraries) (Kane, 2016; McNeal & Newyear 2013), e.g., it was found that CA conversations could appeal to patrons who suffered from library anxiety or lack of library knowledge because of the anonymity chatbots provide (Christensen, 2007). If questions are not addressed by the chatbots, they would be sent to human librarians (Vincze, 2017). To explore effective design for when human librarians are not available, we will also continue with an ongoing collaboration with Danielle Kane, who created the UC Irvine Libraries' chatbot (Kane, 2016). My research team will analyze chat logs provided by Danielle and work with her to identify communication patterns in the library chatbot. Our initial results (from data collected by 2021) showed that people asked the library chatbot about library hours, available tools, parking, policies, room reservation, interlibrary loan, book recommendations, and accessibility to databases, etc. The log showed that most of the common questions were handled by the chatbot, and expectedly, there were breakdowns in the conversation (e.g., when the chatbot was asked about learning a particular subject that was not recognized). We then plan to present representative sample dialogue from the chats to participants (both librarian and community members) and seek their perceptions and invite them to codesign better dialogue, e.g., by applying exceptions-handling strategies developed by prior works (Ashktorab et al., 2019).

Regarding **RQ2**, my research team has extensive experience in developing chatbots and has published work in top HCI venues (e.g., Lee et al., 2020a/b, Lee et al., 2021). The proposed software will leverage the team's existing programming frameworks, which can generate chat content, track whether the various users have completed conversations with the chatbot, and, where necessary, issue reminders. The chat content will include predefined questions and responses that are bootstrapped by chat logs and input from participating librarians. The initial questions may be categorized as directional, equipment, ready reference and research (Kane, 2016). We also expect new categories of questions from analyzing publicly released FAQ banks. We will also explore chitchat features to increase the naturalness of user-chatbot interactions and to handle users' exceptional questions and requests, which may improve users' sense of intimacy and promote the sharing of their thoughts (e.g., Park & Lee 2020).

Once we evaluate the proposed CA for online Q&As with one partnering libraries, we will create live demos and examine to what extent their successes and lessons learned may be applicable to other libraries, which leads towards **RQ3** about democratizing CAs. We plan to conduct participatory design activities to elicit input from librarians in other communities to identify impacting factors (e.g., library size, community type, staff skills, etc) on their adoption. We will propose system and interaction designs that can lower the barriers of deploying and managing a CA for libraries with resource constraints (people/skill/computing). For example, when a library is short of technological support, the CA could be enabled on the library website by adding a snippet of code with all the computations taken care of by cloud services. If librarians do not have relevant technological background, setting up Q/As without coding could be an option.

The above presents an overview of the activities in the first scenario (*Q/A*). Similar processes will done for the other two scenarios; however, differences to consider include: the data source for drawing potential design implications, the participants who conduct the dialogue design, and the evaluation platform, etc. Specifically, for the *Training* scenario, experienced librarians who serve as trainers and new librarians who are trainees will participate in the design and evaluation activities, and the CAs do not need to be deployed through Facebook. For the *Feedback* scenario, participants should include under-served community members, e.g., non-English speaking immigrants (See Gloria Yen's letter).

Tool Design, Development & User Experience (UX) *Evaluation of the Proposed CAs*

The above data collection activities are proposed to identify feasible designs for library-focused CAs in the three scenarios. We will keep ethical concerns in mind throughout all research activities. Below, we discuss potential ethical concerns, software platforms, and user experience (UX) evaluation that are consistently applied to all three scenarios.

- Ethical Concerns

Whenever working with AI-based technologies, privacy and other ethical issues should be carefully considered. Kretzschmar et al. outlined minimum ethical standards for using CAs, including privacy and transparency, efficacy, and safety (Kretzschmar et al., 2019). First, regarding privacy and transparency, user information should be kept confidential and de-identified. Users should have the option of anonymizing their content. During research, we should always clearly state that participants' conversation data would only be analyzed by the researchers for research purposes and would not be shared with others without their permission. When human librarians are not available to chat, users' contact information must not be saved without their permission. When releasing the CAs for real use, many chatbots are deployed on existing messenger platforms (e.g., Skype and Telegram), in which case third parties' privacy policies should address how to prevent users' data from being collected by third parties without permission. Second, regarding efficacy, when users expect professional feedback from the CA, they may assume the chatbot has more intelligence than it actually does. CA design should not mislead users to skip professionals for proper help. Hence, when deploying a CA system, users should be informed and reminded what effects/risks to expect from the CA. Regarding safety, users should be provided with emergency contact information so that they can ask for help in case of an emergency. It is also worth noting that CAs may pose specific risks for children who may use them without supervision (Radford, 2020). Our research will design chatbots for adult use and carefully address concerns about child access.

In addition to the above concerns, we should always be mindful of potential biases (Schlesinger et al., 2018; Feine et al. 2019) as a result of the sample size and background, as well as the contexts in which the study is conducted and the scenarios that the CAs are designed for. By no means, can this 3-year project provide solutions to mitigate the various biases involved in the Human-AI collaboration. However, we will keep a close account of the research

environments, carefully acknowledge the limitations of our methods, and contextualize the findings. The project will therefore pave the way for future research with more complexities and at a larger scale.

- Software Platforms

We plan to build the CA prototype using Manychat, Dialogflow, and MongoDB. Manychat can generate chat content and track whether individual users have completed conversations with the CA. Dialogflow is used to increase the naturalness of user-chatbot interactions and to handle users' exceptional questions. Since most libraries have their own websites and Facebook pages, the CAs can be deployed through their websites and Facebook messenger. We have already identified a technologically feasible and sound solution that allows the plugin of our chatbot features on any library's homepage by adding only a few lines of code, which keeps the maintenance of the chatbot program on websites to a minimum. Additionally, Facebook Analytics is a powerful tool for optimizing the chats and the app can be used on both smart phones and web browsers with relatively low software development cost.

- UX Data Collection and Analysis

This research requires an Institutional Review Board application. We already received approval for designing chatbots to improve social interaction in a general context. With IRB approval, the partnering libraries' collaboration, and users' informed consent, we will be able to log participants' chats and perception input to conduct both qualitative and quantitative analysis. Users' chats from chatbots will be logged for the purpose of analyzing use of the CAs. Using Likert-scale questions, we will collect self-reported measurements from CA users to triangulate their chat logs for UX research. Our recent work proposed a comprehensive list of metrics for evaluating CAs in terms of its communication quality, sociability, task-related competence, emotional intelligence, etc. (Zheng et al., 2022). Depending on the scenarios and research goals, appropriate measurements will be selected to collect participants' input. For example, participants will be asked to self-report their level of *Engagement* with the chatbot, as such engagement could influence their perceived interactions with the chatbots. To evaluate this facet, we will take 12 measurement items adapted from prior literature (O'Brien et al., 2018). Because *trust* is crucial for individuals to make decisions about whether or not to engage with the library CA, regardless of whether their interlocutors are humans or machines, we will evaluate people's perceived trust in computer agents by collecting nine measurement items adapted from prior literature (Lee et al., 2017).

Before any analysis, user identifiable information (e.g., Facebook users' account information) will be translated to pseudo IDs to protect users' privacy. Below, we present several data analysis methods that can help address the RQs. For example, we will conduct content analysis and statistical analyses of the conversation data. We will first utilize LIWC2015 (Tausczik et al, 2010) to calculate the word length of users' chats. For the *Q/A* scenario, we will collect the list of frequently asked questions over time and apply natural language processing techniques (NLP) to classify similar topics across the two platforms (Facebook and the Website) to train the CAs. We will consult with librarian participants to clarify users' needs and interview them about their user experience. For the *Training* scenario, we will collect people's perceived usefulness after user participants have used the CAs for training. For the *Feedback* scenario, prior research has shown that higher word count is positively corelated with self-disclosure (Kreiner et al., 2019). To further investigate how different dialogue designs affect user interactions, two GAs will code the data using three levels of self-disclosure (e.g., feelings, thoughts, and information) proposed by (Barak & Gluck-Ofri, 2007). We will then compare these measurements between different chatbot dialogue designs. Our research findings will help librarians learn new AI knowledge and skills.

Theoretical Framework

The proposed research not only builds on existing theories and frameworks, but also has the potential to enrich and expand them.

First, the Computers Are Social Actors (CASA) paradigm, derived from the media equation theory (Nass, Steuer & Tauber, 1994), explains that when humans interact with computer agents, they unconsciously apply the same social heuristics as they would when they interact with humans. This sets up a foundation for scholars to understand why CAs can be applied in many fields, e.g., automating customer service (Casillo, et al., 2020), healthcare (Zhang, et al., 2020) and education (Winkler et al., 2020). For example, research has shown that CAs can assist users in soliciting social support (Lukoff, et al., 2018; Fitzpatrick, Darcy, & Vierhile, 2017) and guide people to conduct self-reflections on their daily activities (Park, et al., 2019, Kocielnik, et al., 2018). Social presence theory suggests that greater immediacy of online communication can improve social presence (Gunawardena, 1995). Thus, even if the other party in the conversation is an AI agent, users' perceived quality of service will be higher than receiving no responses.

In the *Q/A* and *Feedback* scenarios, building on these theories, we will explore how the use of CAs may impact the relationship between community members and librarians. For example, online disinhibition effect (Hollenbaugh & Everett 2013) says online users engaged in more self-disclosure under the condition of discursive anonymity (a message cannot be linked to a specific source or person). Therefore, providing an anonymous and private communication channel between the chatbot and community members will have the potential to improve people's engagement with library services and relationships with librarians. Additionally, in the *Feedback* scenario, the proposed CAs will be designed to encourage people to share their perceived quality of the libraries' offered programs. Prior work shows that people are more willing to disclose to CAs than to humans because they feel the AI-based agents are not judgmental (Croes & Antheunis, 2020). CAs are further shown to provide support for facilitating interactive conversations by: eliciting people's deeply-held attitudes toward self-disclosure; enabling transformative reflection; supporting storytelling; and building intimacy between the chatbot and the users (Kim, Lee & Gweon 2019; Lee, et al, 2020ab). After collecting input from our librarian participants, we may design the CAs with two forms of listening (active and verbal) and evaluate which one fits the current practices of collecting community feedback (Santos, Ong, & Resurreccion, 2020).

Besides the widely adopted theories about human-AI interaction and the widely perceived phenomena with respect to people's self-disclosure to AI agents, recent years, more works are trying to build theoretical frameworks for using conversational AI for supporting human-human communication (Zheng et al. 2022). For example, a chatbot-mediated public service framework is proposed for promoting services at three levels (Makasi et al, 2020). The first level is *information provisioning,* which involves responding to a users' general service query, without the need for the users to authenticate themselves. Our *Q/A* scenario largely belongs to this level of service. The second level is *targeted audience*, which offers CA-mediated service, e.g., the CA can use the users' personal information to customize a response. Our *Training* scenario may fit in this category, since when training librarians, the learning materials or objective may be adapted based on the trainees' backgrounds and roles. The third level is *service negotiation*, which aims to provide different options and negotiate the best option to address users' needs. Our *Feedback* scenario can be designed towards this level, namely, when collecting community members' feedback about the programs they have attended at the library, new program ideas can be provided to elicit community members' input. This dialogue can help community members to co-design new programs with librarians more effectively.

The new framework (Makasi et al, 2020) also provides a suite of public service value. For example, for the *information provisioning* level of service, it suggests that adaptability, user orientation, professionalism, effectiveness, efficiency, fairness, acceptability, openness, accountability, and social license are the important value dimensions to address. For the *targeted audience* level of service, privacy and trust in the service provider may need the most attention. For the *service negotiation* level of service, collaborative intelligence raises the highest level of importance. However, the framework is proposed by reviewing existing literature on varied public service domains, e.g., transportation, department of human services without evaluation. Extensive research is needed to empirically validate this framework. Our proposed research will contribute empirical findings to examine this framework.

We plan to evaluate the three levels of CA-based services proposed by (Makasi et al, 2020) by applying our own UX evaluation measurements (Zheng et al., 2022). Therefore, our work has the potential of expanding the framework by associating different UX evaluation metrics with the top service value. Specifically, in our UX evaluation framework, we identified two types of human-CA interactions: *dyadic* when the interaction happens between one human user and one CA in a conversation, and *polyadic* when CAs are designed to mediate human-human interactions (Zheng et al., 2022). The first *Q/A* scenario mainly addresses a *dyadic* interaction, and the other two (*Training* and *Feedback*) could be designed for either *dyadic* or *polyadic* interaction. *Polyadic* CAs can support human-human communication, engagement, connection, and relationship maintenance, but also require careful designs to set up boundaries between different users for privacy and disclosure concerns, e.g., how to design and evaluate the CAs to facilitate the dialogue and negotiation in the *Feedback* needs to be unpacked through the research tasks. This 3-year project will contribute theorical implications for future works that can systematically evaluate and expand the theoretical framework, which is aligned with my long-term research goal.

Evaluation and Assessment Plan

Our work will create open-sourced tools for community members and librarians to use and will generate training materials for librarians to gain AI knowledge. A tentative plan is proposed in the *Schedule of Completion* document. The proposed timeline is based on my research team's prior experience with CA research, where several longitudinal studies in which

participants used our CAs for several months (e.g., Lee et al., 2020a; Lee et al. 2020b). *The success of the proposed work can be evaluated from multiple perspectives across* four categories as initial measurements. Please find the Performance Measurement Plan in the attachment for details.

- *Effectiveness* will be evaluated by data being successfully collected, by the novelty of the research findings, and by the release of publicly available CA designs.
- *Efficiency* of the budget and staffing will be reviewed quarterly by the PI (me) and our departmental grant support staff.
- *Quality* will be assessed by looking at the project's output, including software release, publications at top venues, and materials created for diverse beneficiaries.
- *Timeliness* will be ensured by conducting meetings weekly with the GAs, bi-weekly or monthly with the consultants, and quarterly with the advisory board members.

C. DIVERSITY PLAN

This project addresses diversity from several perspectives: 1) the team and advisory board, who contribute complementary expertise and practices; 2) a diverse audience as beneficiaries, varied by accessibility challenges, language competence, socio-economic status, age, etc; and 3) reliance on multiple communities for teaching and research, e.g., conducting the interdisciplinary research in LIS and HCI.

Team and Advisory Board

The team is well-qualified and fully prepared for the proposed activities. With years of experience engaging multiple stakeholders in public service projects, their interdisciplinary dialogue across different fields and practices will be highly valuable. Drawing on my experience in working with public and academic libraries in prior IMLS projects, I intentionally constructed a team with varied views and expertise. Our advisory board members and consultants therefore include both practitioners and domain experts from Library Science, including five library directors with extensive and diverse experience in providing services, and leading industrial organizations in AI research.

We will recruit diverse participants from a collection of libraries and their close collaborators, including the Champaign Public Library, Cortland Free Library, Parkland College Learning Commons (previously Parkland Community College Library), Urbana Free Library, and New American Welcome Center, to conduct the proposed research. Please find *support letters*, and related *resumes*, from associated ***Directors*** (in the attachments of this proposal submission) including: Morgann Quilty, Donna Pittman, Celeste Choate, Jen Graney, and Gloria Yen (NAWC). The partnering libraries serve communities with a wide spectrum of socio-economical statuses. They all are very excited by the vision of this IMLS project and keen to contribute their expertise to the success of this research.

The project will be conducted in my research lab (https://salt.ischool.illinois.edu/). Insights and feedback can be acquired from both lab members and affiliated faculty members (who are also prominent researchers) regarding a variety of topics, e.g., privacy, data security, and information policy, etc. For example, Professor Yang Wang, iSchool faculty who conducts and publishes extensively on inclusive privacy for marginalized users, is available to share his expertise for this research. My team is highly interdisciplinary with students from the iSchool, the Informatics program, and the department of Computer Science. Two doctoral students will be sponsored by this research and one of them comes from an underrepresented group. I have already graduated two doctoral students: Yi-Chieh Lee will join the School of Computing at Yale-NUS as an Assistant Professor, and Chi-Hsien Yen is working full-time at Meta (new name for Facebook) Inc. I believe this project will give the students solid training for their future careers.

Our advisory board members not only include the ***Directors*** from participating libraries (see **their letters and resumes**), but also have Professor Lisa Janicke Hinchliffe and Dr. Michelle Zhou (please find **their letters and resumes** in the attachments). Professor Hinchliffe is a board member of ORCID and the Society for Scholarly Publishing. She has consulted, presented, and published widely on privacy and library services. She will contribute her research expertise in information literacy, library assessment, evaluation, and library quality. Dr. Michelle Zhou, the founder and CEO of Juji Inc. (a leading AI-based chatbot company) has led many innovations that are featured by ACM and NY Times, etc. Their

guidance and feedback to our project will help the team better understand how size, community population, type of library, etc. can impact the design and adoption of the CAs.

Beneficiaries

This research aims to promote inclusive engagement that benefits diverse communities and members. Participating libraries will be drawn from local and remote libraries that differ in size, type of communities served, staff skills, IT support, etc. Champaign and Urbana public libraries serve a high concentration of immigrants who are non-native English speakers (e.g., French, Spanish, and Chinese are major languages of immigrants in Champaign). (Please see letters from Celeste Choate and Donna Pittman.) Since chats in multiple languages facilitate non-native speakers, and text-based chatbots enable accessibility for users with hearing loss, the research will recruit subjects with accessibility challenges to broaden the impacts of the research. The PI, meanwhile, has experience conducting accessibility research (e.g., her DHHS project and recent NSF project with Gallaudet University on improving online learning for deaf students and another NSF project on AI ethics for young adults and children).

Teaching and Research

As the project director, I will lead the research and serve as a bridge to connect different experts, as well as ``translate the languages" to promote dialogue. First, I teach both masters and undergraduate students' courses in the iSchool, where LIS students learn about my research methods and applied research, and I will integrate this research into course lectures and coursework. For example, in the class projects, students will be encouraged to reach out to both local and remote libraries to identify service areas that may potentially benefit from using conversational AI technologies. Students will learn classic research method and program proof-of-concept prototypes. This will help train LIS students to apply research thinking and better prepared for their future career.

Deploying research products to solve real world problems is my passion. I received funding support from both government agencies, e.g., IMLS, NSF and NIDILRR, and industry companies, e.g., Google and IBM research as a solo PI. My research yielded several production systems and open software, including: a crowdsourced public transit information system called Tiramisu (Huang et al. 2015; Tiramisu 2011; Tomasic et al. 2014; Zimmerman et al. 2011), and a location-based system with participatory sensing (Huang, et al., 2019). Findings of this project will also be shared with industries, practitioners and scholars, thus the dissemination of this research will reach across multiple sectors.

D. PROJECT RESULTS

The project aims to 1) yield empirical understandings of the factors that may impact the adoption and effective design of CAs for community engagement and library workforce development, including potential benefits and potential pitfalls of applying conversational AI solutions in public libraries; **2) explore effective designs** of CAs for to support library missions in different settings; and **3) democratize conversational AI** to provide improved services to library communities with individuals of diverse backgrounds and **produce first-hand materials** that can be used for skill training and innovating library services.

Sustainability

We will provide comprehensive documentation to support the continued development of chatbots as an open-sourced project on GIT hub (https://github.com/). Depending on each library's preference, we may either release their corresponding CA source code, such that more libraries can directly use the software, or we will release the design framework of the chatbots for scholars or practitioners to reproduce the services and develop new chatbot-enabled practices. The budget proposed for *computing services* is estimated for the purpose of conducting the research with heavy testing and running user studies within the 3-year project timeline (See the *Budget Justification*). Once the project is over, libraries may choose different setups to keep their CAs working, and the selection of the setup is based on their resources, e.g., available library staff, computing, and IT technicians. They can choose to maintain the level of the computing and storage service by paying the same rate or can choose to switch to free versions of the same services for handling a certain number of requests. For example, a free version of Dialogflow may handle 180 new requests per minute, and the remaining *Q/A* services can be delegated to human librarians.

Communications Plan

We plan to share our experiences with LIS and STEM communities. Besides the plan to promote our research in *Multiple Communities for Teaching and Research*, we will create a project page within the current SALT lab website to host the final research findings and training materials for public use. Our findings will also be submitted to conferences such as ALISE and ASIS&T, as well as top HCI venues (CSCW and CHI), where we believe this interdisciplinary research will draw significant attention from scholars in different domains. I will work with the public libraries to make works to Public Library Association or the American Library Association. I am an affiliate faculty with Illinois' Informatics program, which supports multi-disciplinary research (52 different majors) across campus. We can hold speaking events at different departments and centers to promote the dissemination of the research. We will also disseminate information about the project through the iSchool's rich network of library science students, alumni, and affiliated libraries.

Risks

The COVID-19 pandemic has impacted many scholars' productivity, especially for those requiring physical presence at labs. Fortunately, all our proposed work can be conducted remotely. For example, surveys, interviews, and user studies with the CAs can be executed online or via video conferencing. Releasing software updates can be also completed online. Ideally, visiting the libraries in person will provide us with more rich input about the services that our technologies will be supporting. Meanwhile, as a *contingency plan*, we can always meet our collaborators and conduct all the studies online if travel constraints are in place.

When conducting the research, several aspects need to be planned to reduce the risks that may negatively impact the research. Research on human and AI interaction always involves many ethical concerns, as discussed in the *Tool Design* section. Besides IRB approval, the team will ensure proper handling of user data. Please find the supplement document for details. Additionally, the specific practices of each scenario may be affected by the partnering libraries at the time when we conduct our research in the 3-year period. Having significant experiences in conducting research with multi-stakeholders, we have developed agile practices that can ensure the deliverable of the research, e.g., expanding interview or survey protocols to cover newly emerged themes.

Broad Impacts

This project will explore AI-driven solutions to promote public access to information and library services and effectiveness and efficiency of library workforce training. CAs offer the ability to provide immediate, 24/7 access at low cost (e.g., human effort), as well as an efficient analysis of community needs. *In addition to these benefits, CA-based solutions can improve **accessibility** at an unprecedented level*: translating texts to multiple languages further makes library services accessible to community members who are non-English speakers, and text-based communication provides people with hearing loss an efficient channel to conduct Q/As; converting texts to audios (or voice-based conversational agents) can better support blind users or other potentially sight-limited groups, like seniors. Even though this 3-year project will not cover all the above populations, the current project will establish a strong foundation for longer-term, future projects that address different variations of CAs to target specific population groups.

In the era of industry 4.0, conversational AI is projected to reduce global business costs by $1.3 trillion, as they are able to reduce response time, deal with 80% of routine questions, and facilitate conversations (Reddy, 2019; Casillo, et al., 2020). They are gaining traction across a wide variety of fields quickly (e.g., ecommerce, education, and IT support) and urge human adaptation (Casillo, et al., 2020). This *early career research development* project aims to create new knowledge of the factors that may impact the adoption and effective use of library-focused CAs, novel CA design for promoting library engagement with underrepresented community populations, and enhanced AI-focused digital literacy amongst new and established librarians.

Empowering Libraries with Conversational AI

Yun Huang

University of Illinois at Urbana-Champaign

ACTIVITIES	Y1 (*Q/A*)				Y2 (*TRAINING*)				Y3 (*FEEDBACK*)			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
MANAGEMENT & PREP												
Meeting with partners and advisory board members												
IRB approval and potential updates												
Literature review & details of the study design												
RQ1: SCENARIO 1-3												
Participant recruitments and interview												
Data collection and analysis to develop design insights												
Prioritize the goals in each scenario and propose CA interaction design												
RQ2: SCENARIO 1-3												
Developing and testing the proposed CAs												
Running field trials with participants and conducting UX evaluation												
Collecting user chat logs and feedback, analyzing UX results, and identifying the effective design												
RQ3: SCENARIO 1-3												
Creating demos for collecting more input from diverse libraries and for public use												
Writing papers, giving conference presentations, releasing code on github												
Incorporating research into teaching/mentoring												

Note:

This is a tentative schedule. It is possible for some tasks to take longer or shorter time to be finished.

Testing of the software will be conducted along with the software development.

Empowering Libraries with Conversational AI

Digital Product Plan

Type.

The research project will produce conversational-based software applications and research data. For example, the applications can be a chatbot that has pre-defined Q/A dialogue designs and repositories of questions and answers.
Research data will include stored chat logs between community members and librarians, existing training materials, current forms of library program managers for collecting community feedback, interview transcripts, audio recordings, and survey feedback, etc.

Interview results can be both recorded in audios or noted in text.
System prototype design will be in figures.
Data sets resulted from the software will be in CSV file format.
Reports and papers about the project are generated in Word, Latex and pdf format.

Availability

The software program will be open access for research purpose under the Creative Commons agreement. Data Management Plan specifies that depending on the sensitivity of the research data, different access and sharing policies are provided. For example, the human subject data will be only accessible by the research team during the project period.

The project website and application servers will be hosted by the School of Information Sciences at University of Illinois at Urbana-Champaign. Depending on the final decision choices, user content may be also stored on the partner libraries' web servers.

Access

The university owns the copyright for the source code of the application.
The source code will be open access for research purpose by following the Creative Commons agreement.
The source code will reside on a web server for free download.

Sustainability

Quality of interaction design will be controlled by walk through processes, where the researchers and designers will walk through the paper prototype of system design with different use case scenarios.
All content produced in this project will be documented with descriptive names, version numbers and dates. Assessment data and analysis derivatives will be stored in a password protected server and accessible only by the PIs and IRB approved researchers.

They are stored in scripts, txt, CSV, image, audio or video formats. The iSchool ITS conducts regular backup for the entire server. All data is stored on disk, all disks are backed up nightly.

We will provide comprehensive documentation to support the continued development of chatbots as an open-sourced project on GIT hub (https://github.com/). Depending on each library's preference, we may either release their corresponding CA source code, such that more libraries can directly use the software,

or we will release the design framework of the chatbots for scholars or practitioners to reproduce the services and develop new chatbot-enabled practices. The budget proposed for computing services is estimated for the purpose of conducting the research with heavy testing and running user studies within the 3-year project timeline (See the Budget Justification).

Once the project is over, libraries may choose different setups to keep their CAs working, and the selection of the setup is based on their resources, e.g., available library staff, computing, and IT technicians. They can choose to maintain the level of the computing and storage service by paying the same rate or can choose to switch to free versions of the same services for handling a certain number of requests. For example, a free version of Dialogflow may handle 180 new requests per minute, and the remaining Q/A services can be delegated to human librarians

Data Management Plan

Types of Data

The main data generated in the project will include various datasets generated via the interviews, surveys, and experiments as explained in the project description.

Types of Software

The project will produce library-focused conversational agents (CAs). The software will be providing the following functions

- Year 1 (***Q/A***): CAs provide answers to community members' questions when librarians are not available (e.g., during off working hours or vacation),
- Year 2 (***Training***): CAs give questions and collect answers for training full-time or part-time librarians,
- Year 3 (***Feedback***): CAs collect feedback from non-native English speakers (e.g., French, Spanish, and Chinese are major languages of immigrants in Champaign County) to improve library programs.

Data and Metadata Format

We will collect and examine existing materials from partnering libraries and consultants to identify communication patterns in the above three scenarios. Specially, for the *Q/A* scenario, we will collect public FAQs of community libraries from their websites and chat logs of human librarians from our partnering libraries; for the *Training* scenario, we will collect training materials developed by experienced librarians; and for the *Feedback* scenario, we will gather survey forms from outreach managers or program managers of partnering libraries. The types of documents and data sources may be supplemented with social media data, news, public reports, and scholarly papers. The data contains when a user sends a question to the librarians and specific questions that are asked, as well as the answers sent by the human librarians or the CA agent.

Along with data collection and analysis, we will also conduct and analyze 40 semi-structured interviews with data generators (e.g., librarians, program managers, new employees, and community members).

After the GAs code interview transcripts to identify design opportunities, needs, and (potential) issues before/after the use of CAs, design implications are made. User perception data (likert scales) are collected for running user evaluation.

Sensitive Information

Whenever working with AI-based technologies, privacy and other ethical issues should be carefully considered. Personal indentifiable information (PII) should be kept confidential and de-identified. Users should have the option of anonymizing their content. During research, we should always clearly state that participants' conversation data would only be analyzed by the researchers for research purposes and would not be shared with others without their permission. When human librarians are not available to chat, users' contact information must not be saved without their permission. When releasing the CAs for real use, many chatbots are deployed on existing messenger platforms (e.g., Skype and Telegram), in

which case third parties' privacy policies should address how to prevent users' data from being collected by third parties without permission.

The proposed tool will not collect trade secrets or proprietary information.

By default, the data collected from participants will be stored in an encrypted form in databases (e.g., MongoDB). Documentation of the schema of the collected data will be available in as PDF.

Policies for Access and Sharing

With the participants informed and consent, all data will be held confidential during the research, and all participants will be assigned a pseudo-random ID for their data. A code linking them to the data will be stored in a secured cabinet at University of Illinois at Urbana-Champaign.

During the course of the project, the data will be shared only with named investigators according to IRB policies. By default, the data is handled only at a secured server, which can be accessed only with encrypted connections (such as https and ssh). Local copies can be checked out on a case-by-case basis, and investigators will be required to delete the local copy as soon as required analyses or computations have been completed. All data including participants' contacts will be collected with explicit permission from the participants.

Policies and Provisions for Reuse and Redistribution

Work products (e.g. presentation materials, technical reports) will be made publicly available and searchable through the project website. The data will be gradually made available for the research community and public in anonymous format. The datasets will not include any personally identifying information. The code for linking the data to participants, and consent forms will be destroyed after the required project retention period.

Plans for Archiving and Preservation of Access

Our data will be backed up daily on separate servers at UIUC. We will also archive and store data off-site, quarterly, in an encrypted format. All research work products will also be archived, preserving access, according to standard UIUC practices and policies.

After the completion of the award-funded project, the expectation is that these data will be of general interest to the research community. We will make them available on the project website.

Software Sharing Plan

In general, we advocate the use of open-sourced software as an effective method of dissemination of our system to the research community. However, in some cases, retaining the intellectual property rights of all or part of the software and commercializing the results is a more effective method to have a broader impact on society. Depending on the results of the research, either path may be chosen.

Data Management Plan Review

We plan to review the data management plan quarterly when meeting with the advisory board members. The project director will review the status of the data collection, access, sharing, and archiving with the GAs to ensure the plan is executed as documented.

Organizational Profile
University of Illinois at Urbana-Champaign and the School of Information Sciences

Since its founding in 1867, the **University of Illinois at Urbana-Champaign (Illinois)** has earned a reputation as a world-class leader in research, teaching, and public engagement. With a wealth of resources and highly ranked departments, Illinois long has been recognized for accomplishments in research and graduate education, and is among the top five universities in number of earned doctorates awarded annually in the United States.

PD Huang's home institutional unit, the **School of Information Sciences (iSchool)**, is a world leader in information science education, research, and practice, and consistently ranks as one of the best in the field. Much of this strength lies in the interdisciplinary expertise of the core faculty, who engage in work across more than forty broad-reaching research areas, including: community informatics; data curation; design & evaluation of information systems and services; digital libraries; information literacy, practices, & behaviors; information retrieval; libraries & librarianship; social and information networks; youth services, and others.

This interdisciplinary foundation, in turn, attracts a talented, diverse cohort of students at both graduate and doctoral levels. The iSchool currently offers 6 distinct degree programs, including the oldest LIS doctoral program in the country and 3 advanced certificate and licensure programs, all supported by an award-winning online education program. The iSchool is currently home to more than 870 graduate and doctoral students, and its population will only grow as it has initiated a new undergraduate degree program in Fall 2020.

As part of its engagement, the iSchool's researchers collaborate on interdisciplinary projects with scholars across our campus, including the University Library, and our local community, including local public and school libraries, as well as institutions across the country and around the world. Local collaboration allows the iSchool to serve the Champaign-Urbana community and surrounding areas beyond the university itself. This service area includes the combined population of Champaign-Urbana, plus nearby small towns, and rural communities, (total population: approx. 230,000).