Journal of Library and Information Studies 23:1 (June 2025) pp.109-136
https://doi.org/10.6182/jlis.202506_23(1).109

Constructing Substitute Social Interaction Design: A System to Alleviate Social Anxiety Disorder through Library Interactions

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Abstract

As libraries evolve into dynamic social spaces, they present new opportunities for alternative social interactions. This study explores how books can serve as a medium to foster connections, particularly among individuals with social anxiety disorder (SAD). We propose a "library-based social network" built on two key data points: (1) book reviews and (2) records of who has read or intends to read a book. Instead of asking, "Who else likes this book?" we shift the focus to "Who would be delighted to discover this hidden book?"—encouraging social engagement through shared literary experiences.

Individuals with SAD often find traditional social media overwhelming. Inspired by architect Rem Koolhaas's vision of adaptable public spaces, we examine how libraries can function as spaces for bibliotherapy, where reading provides comfort and indirect social connection. Our methodology combines contextual analysis and user interviews to align library interactions with user behaviors and preferences.

Our findings suggest that interactive book-sharing enhances social engagement in three ways: (1) A messaging system that enables written communication, reducing the stress of face-to-face interactions. (2) Encouraging curiosity-driven discovery, easing the fear of direct engagement. (3) Enhancing users' sense of presence through shared book interactions and library-based messaging.

Ultimately, this study demonstrates how innovative library interactions—centered on books as social media—can create supportive environments that help individuals with SAD engage meaningfully with others.

Keywords: Library Space Interaction; Interaction Design; User Experience; Interface Design; Co-existing Space

1. Introduction

1.1 Background: Library after Covid-19, a place for remonstrating people

In today's fast-paced society, people are increasingly isolated, and have difficulties forming deep and meaningful relationships. This isolation is worsened by a decline in trust and growing social distance, leading individuals to interact in "bubbles" where connections are often superficial. Architecture, as a reflection of social trends, influences how people relate to their environments. While technology both aids and hinders social interactions, even sometimes reducing face-to-face contact and contributing to loneliness when emotional and social needs are unmet (McLuhan, 1964), some

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people are actively seeking out new, technology-based social communities. Sociologist William H. Whyte's research (1980) supports this adaptation, highlighting the potential of urban design elements, such as movable urban furniture, to foster better social interactions.

Urban spaces, particularly libraries, are evolving in response to these societal shifts. Primarily as places for books, libraries are being reimagined as "city living rooms" that encourage community interaction. This transformation is exemplified by Rem Koolhaas's design for the Seattle Public Library, which thoughtfully blends reading and social spaces (Lynch, 2015). The concept of idle space, emerging from social and structural changes, plays an important role in this evolution, carrying both historical and cultural significance (Eom et al., 2021; Kim & Han, 2016).

As libraries transform, they increasingly function as social networks, with books serving as connectors between people. This evolution parallels developments in Social Anxiety Disorder (SAD) therapy, where methods like writing or indirect interactions help reduce the pressure of face-to-face communication. Just as exposure therapy gradually helps patients overcome anxiety through low-risk scenarios, libraries provide quiet spaces where individuals can relax and grow at their own pace. Both therapeutic environments and libraries empower people to control their social engagement, reducing pressure while maintaining opportunities for connection.

The power of shared interests, particularly a common love for books, creates natural pathways for individuals with social anxiety to connect. This approach, utilized in both libraries and therapeutic settings, is enhanced by gamified activities that reduce anxiety by focusing on tasks rather than social evaluation. These strategies help ease the stress of social interactions while building meaningful connections through shared experiences.

Within libraries, various tools facilitate social engagement, from book reviews to information about readers' histories. Our study extends this concept by exploring how libraries can foster connections through shared literary experiences, asking the essential question: "Who would be delighted to discover this hidden book?" This approach encourages organic community building within the library setting.

Libraries have historically shaped cultural development through their role in organizing and preserving knowledge. In the current era of information overload, libraries are under pressure to provide efficient access to information, while still maintaining their crucial role in creating "spiritual journeys" that helps users feel connected and secure (Chuang & Hsieh, 2016; Liu & Su, 2022). However, many academic libraries remain resistant to change, often viewing innovation as routine rather than transformative.

The COVID-19 pandemic has introduced new complications to social interactions, amplifying anxiety and reducing opportunities for connection, particularly for individuals with SAD (Morrissette, 2021). While dating apps attempt to bridge this gap, they often struggle to facilitate the transition from digital to in-person interaction, especially for those with social anxiety. These platforms can reduce social interaction to algorithmic matches, contributing to a fragmented sense of connection during the pandemic.

In response, libraries are innovating with new approaches to encourage social interactions, such

as hosting gaming events. These activities serve multiple purposes, enhancing language skills through peer learning while building community (Abd-alrazaq et al., 2022; Haasio & Madge, 2020; Tripodi et al., 2022). As Bates (2001) notes, puzzle games develop logical thinking skills and can help individuals visualize the process of making new friends, indirectly connecting them to new social networks (Chang, 2005).

This study aims to explore how libraries can support individuals with SAD by leveraging books as catalysts for social connection. Through interactive book-sharing systems and activities, we propose that libraries can create environments where alternative social activities become both accessible and meaningful, particularly for those who find traditional social media overwhelming.

1.2 Motivation and approach: Library, a place of social media for book-lovers

This study reimagines libraries as social networks, where books function as a form of social media to connect people. By providing indirect alternatives to traditional social interactions, this approach creates a comfortable and supportive environment, particularly for individuals with SAD, while also encouraging a more effective use of library resources.

Individuals with SAD often benefit from non-threatening, indirect forms of interaction, such as writing, leaving messages, or connecting through shared interests. These methods reduce the pressure of face-to-face interactions and align with therapeutic strategies like exposure therapy, where low-risk situations help individuals gradually confront and manage their anxiety. Similarly, the quiet atmosphere of library offers a space for relaxation and personal growth, allowing individuals to decide when and how to engage with others. By fostering connections through shared literary interests, libraries can serve as natural, low-pressure environments for social engagement—much like therapeutic settings.

Incorporating gamified tasks and interactive activities further reduces anxiety by shifting focus from self-perception to task completion, which is a strategy commonly used in both therapy and library engagement. These indirect, structured interactions help users gradually build social confidence while facilitating meaningful connections.

This research explores innovative social approaches tailored to specific user groups, enhancing interactions between users, books, digital media, and the library environment. The goal is to create a behavior-based interactive ecosystem that optimizes the use of library resources and activates underutilized spaces.

To achieve this, the study proposes a design and validation framework for understanding and evaluating end-user experiences within specific group contexts. A use case is developed for a library system that integrates physical elements—including energy usage, sensors, networks, and user behaviors—within a smart building environment. By leveraging spatial interactions and embedded information, the system provides real-time feedback on library resources while fostering deeper engagement between users and the library space. In this model, books transcend their traditional role as information sources, instead serving as social connectors that bridge the gap between users and create new opportunities for interaction.

1. **Vacant Space Usage**: Libraries are not just places for learning, they also serve as communal spaces that promote emotional and social well-being. The goal is to move beyond the simple act of borrowing books and to foster emotional connections between users and the library's resources. Finding a book becomes a social, human-centered experience. By using tools like book reviews and data on who has read or plans to read a book, libraries create meaningful interactions that connect users indirectly. This approach transforms the library into a place of discovery—both for books and for fellow readers. To support this, libraries can design various functional zones that encourage user engagement, allowing empty spaces to become hubs for interaction and reflection.
2. **User Behavior and Interaction:** The study explores 2 types of user behavior: regular users and those with SAD. A user-centered software application was tested with 14 participants–7 regular users and 7 SAD users–to analyze how different groups interact within the library's dynamic environment. For individuals with SAD, the library offers an alternative social network that is less overwhelming than conventional social media, helping them engage through the shared experience of books. Two treatment approaches for SAD are considered: (1) medication therapy and (2) cognitive-behavioral therapy (CBT). This research explores how indirect social activities, such as hiding and finding books, can enhance social tolerance and gradually adjust negative thought patterns, helping users with SAD adapt to social interactions in a non-threatening manner.
3. **Information Visualization for the System**: The hypothesis posits that users interact with an agent-based system that adapts its effects based on users' actions. In this model, users are seen as having fluid identities, fulfilling multiple roles, which requires dynamic analysis to understand their behavior. Books act as social agents, connecting individuals through shared reading experiences. By analyzing user behaviors and preferences—such as who has read a book or left a review—the system offers personalized feedback, enriching the overall library experience. This approach enables users to gain deeper insights into their reading habits and book preferences, enhancing engagement by making relevant and accessible information readily available.

2. Literature Review

2.1 Innovative spatial configurations in modern libraries: Enhancing flexibility, community engagement, and data for social networks

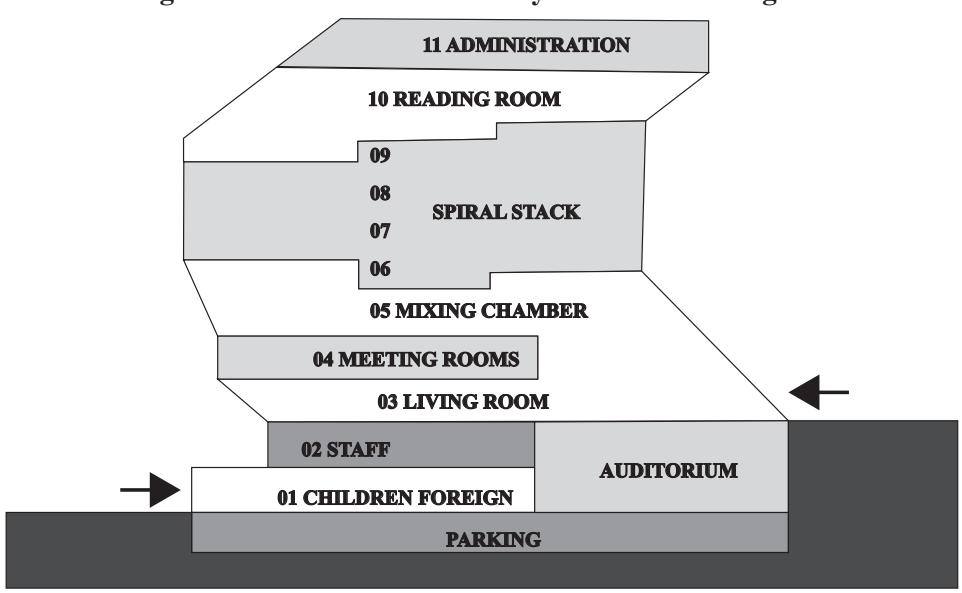
The design of multi-space libraries represents a versatile and innovative approach, focusing on the intentional creation and integration of various functional zones within a single environment. Unlike traditional single-purpose spaces, multi-space design aims to maximize utility and flexibility by accommodating a range of activities in one unified setting (Chang et al., 2023). This concept is commonly applied in architectural and interior design, where spaces are carefully arranged to serve multiple functions seamlessly. By designating areas for work, relaxation, collaboration, and individual focus, multi-space design fosters adaptability and encourages

dynamic interactions. This approach is often seen in modern office layouts, educational institutions and residential spaces, reflecting a contemporary understanding of how environments can meet the evolving needs of individuals and communities.

The essence of a space is closely tied to its content, which captures the public's interest through various sources and symbolic transformations. Human-made environments are significantly influenced by their "openness," defined by the solidity and transparency of boundaries. This openness affects whether a space makes people feel isolated or expansive. A place's attributes are dynamic, evolving with time, seasons, climate, and lighting conditions. For example, libraries are designed to reflect the spirit of the city or campus, offering open, navigable spaces for readers. They combine aesthetic appeal with functionality, ensuring both visual interest and practical utility (Tseng, 2014) .

The public library designed by Rem Koolhaas in Seattle exemplifies this concept with its folded steel structure, creating a mesh-like exterior that reflects the surrounding mountains and rivers. This unique design allows for a column-free, open space with high ceilings, promoting both reading and socializing. The library functions as a public living room integrated into the city center, divided into 5 interconnected areas: office space, paper book area, interactive communication area, commercial area, and park area. This division creates a staggered and organized spatial form (Figure 1). The interior service and office spaces are bright red, reminiscent of human body's interior, contrasting with the open, bright "living room" outside.

Figure 1. Seattle Public Library Architecture Diagram



Note. The diagram is modified and recreated based on Dovey & Permanasari (2010), with additional adjustments to enhance clarity.

Similarly, in Den Helder, Netherlands, School 7 serves as a dynamic community hub, acting as a "living room" for locals to study, and newcomers to learn Dutch. Volunteers organize educational activities, such as programming tiny robots and designing games for children. The library's theater hall also doubles as a wedding venue, demonstrating its adaptability to community needs. Likewise, the Intensity Library in Mandalay, Myanmar, offers a variety of skill-building classes in languages, technology, music, and the arts, playing a significant role in the growth and development of the local community.

2.2 Interactive digital media in library spaces: Enhancing user engagement and social interaction with books as social media

As technology and societal norms evolve, social patterns have shifted from traditional face-to-face interactions to a combination of real and virtual communication modes (Yang, 2003). This change has led to a greater reliance on the internet to form new friendships, making it harder to build personal relationships in real life. Despite these changes, reading remains a consistent and enduring habit, even in the digital age.

In today's rapidly evolving social landscape, SAD has become more prevalent, with many people struggling to seek medical help. Compared to those without the condition, people with SAD often spend more time alone and process their anxieties. Bonsaksen et al. (2023) reveals a correlation between increased social media use and heightened feelings of loneliness, especially among those using social media to maintain relationships. The study also found that the reasons behind social media use can influence the relationship between social media activity and loneliness.

Reading has been shown to alleviate stress and promote well-being. According to research conducted by Lewis (2009) of Mindlab International (as cited in Sutton, 2009), reading can significantly reduce stress levels. Further research indicated that reading not only helps develop empathy but also reduces stress, promotes self-regulation, and boosts overall happiness (Adler, 2021; Harris & White, 2018). Immersing oneself in a captivating story offers a temporary escape from daily pressures, enhancing emotional well-being (Abd-alrazaq et al., 2022; Naina & Pooja, 2023).

McKenna and Bargh (1999, 2000) explored the differences between virtual and traditional social interactions, identifying key distinctions: (1) the internet provides high levels of protection and anonymity; (2) physical appearance is less significant online; (3) spatial barriers are minimized; and (4) individuals have greater control over the timing and direction of their interactions. Talamo and Ligorio (2001) later suggested that the internet's ability to quickly establish and shape relationships can be advantageous for creating virtual identities. However, misuse of this ability may lead to psychological dependence and avoidance, particularly among individuals with low self-esteem or difficulties in real-life interactions (Armstrong et al., 2000).

Libraries have increasingly integrated games to enhance information literacy and provide interactive alternatives to traditional teaching methods (Battles et al., 2011; Haasio & Madge, 2020). Games can introduce research tools, teach problem-solving skills, and foster collaborative

learning environments. Libraries thus serve as collaborative spaces that build community bonds and support personal development (Battles et al., 2011; Hall et al., 2025). Games in libraries not only provide entertainment but also enrich user experience by offering narratives and educational content (Ko, 2020; Lee et al., 2020). They play a crucial role in promoting critical thinking and problem-solving skills, aligning with curriculum objectives and offering diverse learning opportunities (Palumbo, 2015; Yip et al., 2020).

Given the benefits of reading (Hall et al., 2025; Monroy-Fraustro et al., 2021; Naina & Pooja, 2023), our study focuses on books as the primary medium for interaction. By selecting a library with a wide variety of books, we aim to create a space where like-minded individuals can connect. This tranquil environment offers alternative forms of social interaction that blend virtual and real experiences, potentially enhancing individuals' willingness to engage socially.

2.3 Social Anxiety Disorder: Understanding symptoms and exploring therapeutic approaches in a society where traditional social media and networks present challenges

Social Anxiety Disorder (SAD), also known as social phobia, is a type of anxiety disorder marked by intense discomfort and fear during social interactions. It is commonly categorized into 2 forms: one where individuals experience anxiety in a variety of social settings, and another where symptoms are triggered only in specific situations. Typical symptoms of SAD include nervousness, rapid heart rate, blushing, muscle tremors, and panic attacks. In children, these symptoms may manifest as crying, anger, or tantrums. People with SAD often realize that their anxiety is excessive and irrational, yet they still feel constantly observed by others, fear making mistakes, and experience a sense of inadequacy in social situations. Many of these people can self-assess their condition without the need for professional intervention.

Recent research highlights that individuals with higher levels of social anxiety tend to perceive interpersonal interactions more intensely online (Rauch et al., 2014). The internet offers a platform for these individuals to express themselves freely and avoid the anxiety of face-to-face conversations. Liou (2000) found that internet use can affect daily routines and that people with low self-esteem, who struggle with real-life communication, often feel more accomplished expressing themselves online. The internet's anonymity and ease of communication provide a way for individuals to navigate interpersonal relationships without the conflicts that they may encounter in real life. This has proven to be especially valuable for teenagers and young adults, offering a way to maintain social connections beyond their immediate family (Mantovani, 2001).

Game therapy is an effective form of psychotherapy that uses games as the primary mode of interaction, particularly for children or individuals with language impairments. It aims to address psychosocial challenges, promote personal growth, facilitate social integration, reduce aggression (Wilson & Ray, 2018), regulate emotions (Allen & Barber, 2015), and enhance social skills (Swank et al., 2018). Additionally, game therapy supports sensory-motor development and coping strategies (Cochran & Cochran, 2017; DeGangi et al., 1993). Hsih (2007) found

that games are especially effective in engaging children, easing anxiety, and fostering interest in therapy. A safe and trusting environment is critical for successful game therapy, enabling individuals to express negative emotions in a comfortable setting (Chang & Dai, 2011).

In interactive design, creating a positive user experience requires careful planning and understanding to the target user group. Designers need to explore user needs, concerns, and desires to develop strategies that meet these requirements. This process mirrors the psychological concept of self-awareness, where emotions help protect individuals by minimizing harm. While designers may not fully understand users' preferences better than the users themselves, they can offer insights into potential blind spots. By analyzing user needs, designers can create logical user flows, plan appropriate design frameworks, and develop interfaces that align with user expectations and priorities.

3. Methodology

3.1 Research methodology and scope of user interaction in library settings

Given the complexity of library user behavior, a qualitative research approach was chosen to go beyond simple transaction data and explore the social and psychological aspects of user interactions (Note 1). Through interviews and direct observations, we uncovered hidden behavioral patterns, motivations, and social dynamics that shape library interactions.

Data collection involved semi-structured interviews with library staff who are key observers of user behavior, following a flexible interview guide to capture both general trends and unique insights. Direct observations of library patrons provided further context that reveal behaviors such as users deliberately hiding books in unexpected places. This prompted deeper investigation into the reasons behind such actions and their social implications.

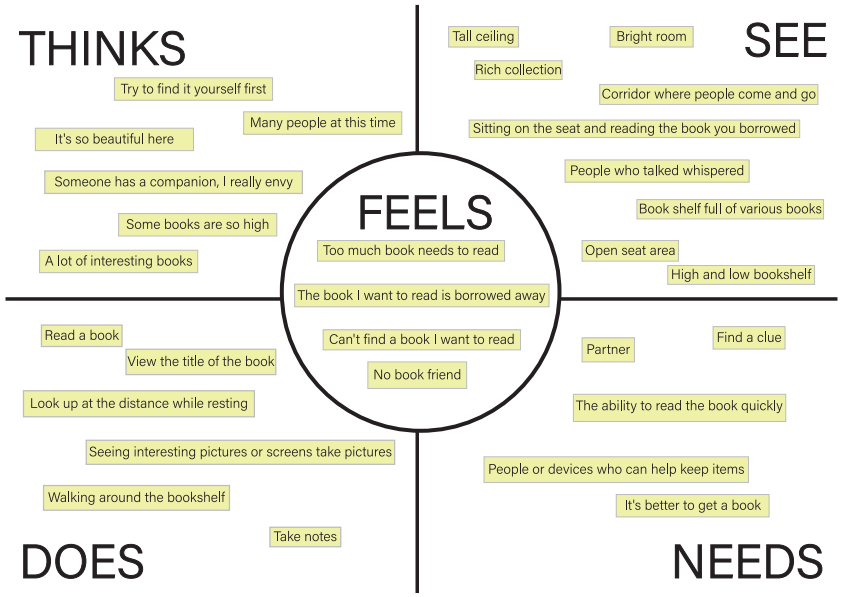
For data analysis, we used thematic analysis to identify recurring patterns and categorized them using the KJ method, refining our understanding of user behavior (see Figure 2). This led to the creation of 3 user personas—book seeker, book hider, and librarian—each representing different interaction modes within the library. These personas provided a structured way to interpret user motivations and engagement strategies.

To ensure reliability and validity, we used triangulation, cross-referencing insights from interviews, observations, and behavioral analysis to enhance accuracy and reduce bias. Ethical considerations were strictly maintained, with confidentiality protocols and anonymization of data to protect participants' privacy (Note 2).

The rigorous methodology ensures that our findings offer reliable and actionable recommendations for improving user engagement and satisfaction within the library. By framing book borrowing, searching, and hiding as key aspects of library interaction, this study highlights their role in shaping user experiences. The insights can inform system designs that accommodate diverse interactions while fostering meaningful social connections. Through careful analysis of the library's book hiding and seeking processes, we developed 3 distinct user personas:

1. Book seeker: A passionate reader who actively searches for hidden books, driven by both literary enthusiasm and a desire for social

Figure 2. KJ Method Used to Brainstorm and Converge on Elements



interaction. This persona finds motivation in the challenge of discovering hidden books and connecting with fellow enthusiasts, often thinking, "I want to find this book. Who loves it enough to hide it?"

2. Book hider: An avid reader who uses book hiding as a means of engaging with other literature lovers. This persona creates intrigue through strategic book placement and anticipate the joy of others when discovering them, while wondering: "I will hide this book. Who will be the one that loves it enough to search for it?"
3. Librarian: A resource manager who utilizes user preference data to curate activities and enhance the library environment, creating diverse experiences that enrich the overall library ecosystem.

In addition to these primary personas, other readers represent external factors influencing the interaction process. They contribute to the dynamic nature of library and may affect the experiences of book seekers and hiders. By analyzing these personas and their interactions, we aim to design a system that enhances emotional interactions through social substitutes, ultimately improving user engagement and satisfaction in the library setting.

3.2 From staff insights to reader journeys: Designing user-centered interactions in libraries

To explore the potential of libraries as supportive environments for social interaction, particularly for individuals with SAD, this study utilized a mixed-method approach. The methodology incorporated interviews, ethnographic observation, and scenario simulations to develop user personas and inform system design.

Semi-structured interviews were conducted with library staff to gain firsthand insights into user interactions with resources, equipment, and

borrowing processes. These interviews helped identify patterns in user behavior and highlighted challenges faced by different user groups, especially those experiencing social anxiety. Staff observations also provided a foundation for understanding the library's role in facilitating indirect social engagement.

3.2.1 Qualitative interviews

Another semi-structured interviews were conducted with library staff to gather in-depth insights into the daily interactions and challenges faced by users. Staff were selected based on their direct engagement with users, including the lending process, technology support, and event coordination. The interviews covered topics such as: (1) Common user behaviors when borrowing or returning books; (2) Observations of users' interactions with library spaces and equipment; (3) Anecdotal accounts of how users, especially those with SAD, engage with library resources and social opportunities within the library. Interview transcripts were coded and analyzed to identify recurring themes, such as the barriers users face and the potential for books to act as intermediaries in social connections.

3.2.2 Ethnographic observation and persona development

Researchers conducted unobtrusive observations of library users in various contexts, such as browsing shelves, using reading areas, and interacting with self-checkout kiosks. Particular attention was paid to users' body language, movement patterns, and engagement levels. These observations informed the creation of user personas, which represented archetypes of different library users, including those with SAD. Personas included key attributes such as: (1) goals and motivations (e.g., seeking solitude, exploring new genres), (2) pain points (e.g., discomfort with public interactions, challenges in navigating the library), and (3) interaction preferences (e.g., self-service technologies vs. staff assistance). By observing users in their natural interactions within the library environment, the study mapped specific tasks and identified behaviors associated with using library resources. Observations informed the development of 3 representative user personas that reflect diverse preferences, challenges, and motivations, as shown in Table 1.

3.2.3 Scenario simulations and user journey mapping

Using the Activities, Environments, Interactions, Objects, and Users (AEIOU) framework, the study designed and executed scenario simulations to model user interactions. Scenarios included tasks such as: (1) Borrowing or returning books; (2) Discovering and sharing book reviews through digital or physical means; (3) Participating in indirect social activities like book hiding or discovery. The AEIOU framework provided a granular understanding of user behaviors and their interaction dynamics. Key findings included (see Table 2):

1. Activities: Users navigated bookshelves, organized misplaced items, and utilized technology to enhance their library experience.
2. Environments: Physical spaces like the reading room and digital systems played complementary roles in supporting user preferences.
3. Interactions: From asking staff for directions to using self-service kiosks, interactions varied across user personas, highlighting different comfort levels with social engagement.

Table 1. User Personas Developed

	User A: The Introverted enthusiast	User B: The adventurous seeker	User C: The tactile purist
Profile	A 25-year-old avid reader who enjoys a wide range of literature. She is socially anxious and avoids crowded spaces but finds solace in libraries.	A young, optimistic individual eager to explore new genres. Financial constraints drive his preference for borrowing books.	A university student with a disciplined routine and a love for physical books, who is environmentally conscious and prefers second-hand books.
Behaviors	Uses library systems to locate books but occasionally seeks staff help when overwhelmed. Shares reflections online but struggles to find in-person discussion opportunities.	Actively browses random shelves and explores new areas in the library. Engages in online forums to discuss books but yearns for deeper connections with local readers.	Enjoys the tactile experience of flipping through pages and spends time in library seating areas. Uses library systems confidently to locate books.
Pain Points	Limited avenues for meaningful engagement with other readers due to anxiety.	Lack of opportunities for spontaneous in-person book discussions.	Challenges in connect with others who share her preference for physical books over digital alternatives.
Feature	Anonymous book-sharing or note-leaving functionality allows users to connect through shared literary interests without direct interaction.	A "book hide-and-seek" game where users leave books in curated or random locations for others to find.	A visual interface that highlights the journey of a physical book—who has read it, their reviews, and where it has been found or shared.
Impact	Encourages introverted users to feel part of a community while respecting their boundaries.	Creates a sense of excitement and engagement, allowing users to interact with others indirectly while exploring new genres.	Reinforces the unique emotional connection to physical books, building a community around shared touchpoint.

4. Objects: Digital tools (computers, mobile phones) and physical books were central to user experiences, acting as mediators of interaction.
5. Users: The personas revealed distinct motivations, including a preference for indirect connections facilitated by books and library spaces.

Table 2. AEIOU for the User Behaviors

Activity	Environment	Interaction	Object	User
Finding book	Library Floor 5	Used computer to find direction Through the local guideline to find the book Asked the manager how to get the book	Computer Mobile phone Book	An introverted 25-year-old girl who enjoys reading
Place books randomly Collection of books	Library Floor 7 Library Floor 5 Reading Room	Through the local guideline to find what he interests floor Randomly put comic book	Mobile phone Book	A youth who likes to try new things
Library seating area Finding book Organize books	Library lobby Library Office	Confirm book location Through the system to check the real situation In the seating area reading books	Computer Book Library system	A passionate university student who enjoys the tactile sensation of physical books

3.3 Social activities for individuals with SAD: User requirements and interaction design for an inclusive library system

The system was designed with a dual focus: Enhancing the experiences of regular library users while also addressing the unique needs of individuals with SAD. Insights gained from user observations and persona development played a crucial role in shaping the system, ensuring its features align with the identified needs and preferences of users.

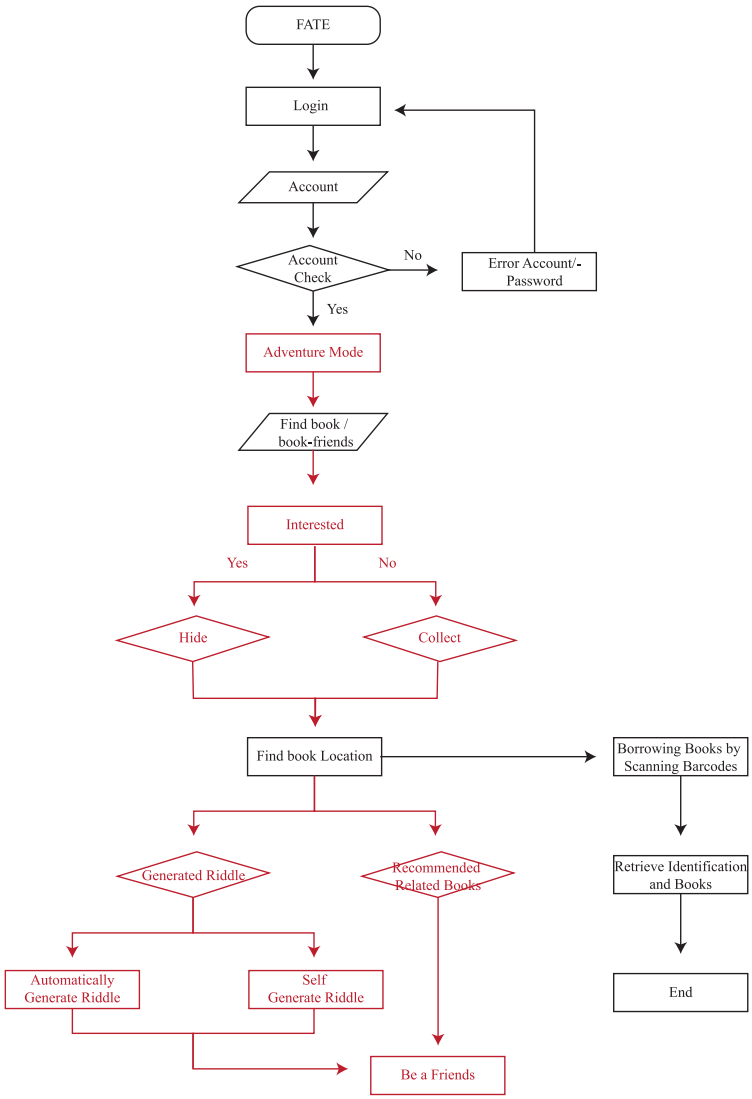
By leveraging user personas and scenario simulations, we gained valuable perspectives on user experiences, which were instrumental in designing and refining the system. Reimagining the library as a social network, these findings shaped the conceptual framework of the system—positioning books as a form of social media to foster indirect connections between users. By integrating social elements into the library experience, the system transforms the library into an inclusive space where individuals with SAD can engage meaningfully through shared literary experiences. Key features include:

1. Shared experiences: Allowing users to leave notes or reviews, creating a sense of community around shared literary interests.
2. Interactive activities: Encouraging playful engagement through “hide-and-seek” book placement, fostering non-verbal connections among users.
3. Visualizing connections: Offering interfaces to show who has read or plans to read a book, helping users feel part of a broader reading community.

For users with SAD, the system acknowledges the challenges they face in traditional social

settings, where direct interaction can be overwhelming. Instead, the system leverages books as the central medium of connection, offering a comfortable, non-intrusive platform that encourages engagement while respecting personal boundaries. By fostering indirect social connections through shared literary experiences, the system transforms libraries into inclusive spaces that cater to a wide range of user preferences and social needs. The interaction process is detailed in the system flowchart (Figure 3), which outlines 2 primary workflows. Traditional library processes are depicted in black, including standard borrowing and

Figure 3. Functional Flow Chart



returning procedures. Enhanced system features are highlighted in red, introducing gamified and exploratory elements designed to promote indirect social interactions.

After logging into the system and verifying their account, users can choose to enter "Adventure Mode," a highly engaging feature that transforms the traditional library experience into an interactive and gamified activity. Through this mode, reading is no longer just about acquiring knowledge—it becomes an adventurous journey filled with challenges and exploration.

However, "Adventure Mode" is not available for all books; it is limited to specific categories, such as novels, popular science books, or those suitable for gamification. Professional books, for instance, are not supported by this mode, as their primary purpose is to provide academic and specialized knowledge, ensuring the integrity and professionalism of these resources.

In an existing library system, a simple marker can be used to indicate whether a book contains a riddle. This ensures that as long as the book remains in the library, the system's records are not affected. In our system, however, if a book has been checked out, the riddle mechanism will not be triggered in order to prevent unnecessary interruptions to the borrower. Additionally, our system will comprehensively record all riddle-related information, including the solver, the creator of the riddle, and the solving process, making user interactions more complete and more personalized.

This design not only minimizes changes to the existing library system but also significantly enhances user interaction with the library. With "Adventure Mode," users can enjoy additional fun and challenges while reading, further stimulating their motivation for exploration and learning, ultimately making the library a more engaging space for knowledge discovery.

4. User Experience Involved in User Interface

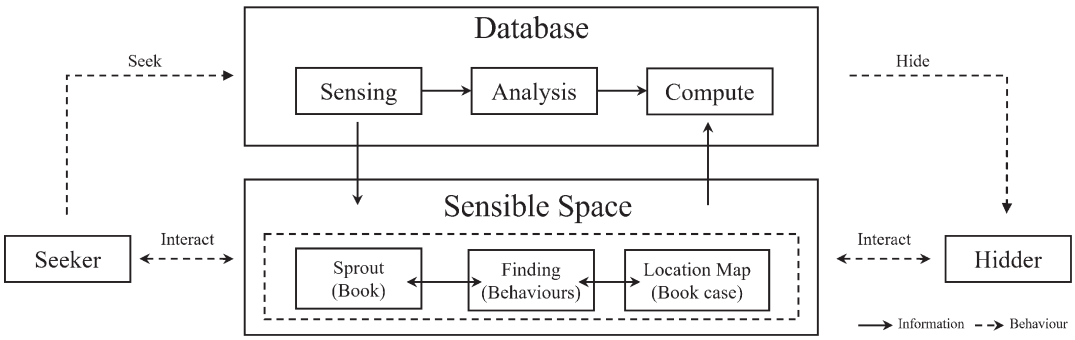
4.1 Enhancing emotional interaction design with social substitutes system

Based on insights from our interviews, we identified that users initially engage with the library through unilateral searches for book information. To address this, our system aims to enhance the library experience by visualizing library data, user reading habits, and behaviors, demonstrating that library offers more than just books for reading or borrowing—it also hosts a range of new events and activities. Consequently, our research system is designed with both physical and virtual components to create an integrated user experience.

Figure 4 illustrates the sensible space component, which incorporates the SENS+ framework for library design as proposed by Chang et al. (2023). In the physical environment, user interactions with smart sensors trigger real-time data collection, which is then sent to a central server. The virtual environment translates these physical interactions and locations into numerical and computational data, facilitating service and interaction management. This dual approach ensures that physical data recorded by sensors can influence the virtual environment and vice versa, creating a cohesive system that bridges the physical and digital realms.

Each library user is assigned a unique IP address, and every book is equipped with RFID/

Figure 4. System Structure



NFC technology. Additionally, beacon devices are installed on each floor to prompt and alert users. The system focuses on the core activities of "seekers" and "hiders," offering the following basic functions including searching for books, reserving books, finding book friends, guiding book locations, providing reader comments, suggesting books, and offering library information.

In "Adventure Mode," users can act as hider or seeker. This mode facilitates social connection by allowing users to interact with shared resources in a non-intrusive, imaginative manner. Hiders can either create their own riddles or use AI-generated suggestions to craft clues about hidden books. This role encourages creativity and allows users to engage deeply with library resources. By hiding books and crafting riddles, hiders connect with future finders through shared literary puzzles. On the contrary, seekers search for hidden books using the riddles provided. Upon locating a book, seeker can either write commendations or generate new riddles, continuing the interactive cycle and building what we term "book friendships." Throughout the usage, the user's role remains consistent, but a new phase begins upon successfully locating a book. At this point, users can choose to either continue as a "seeker" or switch to being a "hider." If a user opts to become a hider, they are prompted to create a new riddle or select from suggested riddles, initiating a fresh challenge within the library.

Recognizing the unique challenges faced by users with SAD, the system incorporates features that ensure engagement is safe, enjoyable, and non-demanding, aiming to reimagine libraries as dynamic and inclusive social spaces. These innovative elements include:

1. Alternative social interaction: By framing books as the medium of connection, users can form bonds indirectly, avoiding the discomfort of face-to-face or traditional social media interactions.
2. Inclusive design: Gamified elements like "Adventure Mode" provide low-pressure opportunities for exploration and connection, allowing users to engage at their own pace.
3. Empathetic interfaces: Features such as anonymous book-sharing, note-leaving, and review-contributing create an environment where users feel being part of a community without compromising their comfort.
4. Fostering creativity: Allowing users to hide and seek books through riddles, we can connect them in an indirect but meaningful way.

5. Building community: Features like shared reviews, commendations, and interaction histories create a sense of belonging and encourage ongoing engagement.
6. Supporting diverse needs: By catering to both regular library users and individuals with SAD, the system bridges social barriers, ensuring the library remains a welcoming and engaging environment for all.
7. Books as social agents: Through these features, the system transforms books into active social agents, fostering connections not just between individuals and the library but among users themselves. Activities like crafting riddles, leaving notes, and exploring hidden books create a network of shared literary experiences, enabling users to connect through their mutual love of reading.

This approach redefines the library as more than a place for borrowing books—it becomes a platform for safe, meaningful interactions. For those with SAD, this reimagined environment offers a much-needed alternative to traditional social spaces, turning the library into an inclusive, supportive, and vibrant community hub. This interaction encourages users to form connections as "book friends" and engage in the library's social dynamics. Conversely, if a book is inadequately hidden, the system provides relevant book suggestions to maintain user engagement. Both seekers and hiders follow the same initial process of locating a book but encounter a branching point after their successful discovery. Users can enhance their experience by adding new levels to the game based on their preferences, embarking on a new journey each time they interact with the system.

4.2 Enhancing user interaction through puzzle-based book discovery

The system integrates puzzle-solving and puzzle-making processes to enhance the discovery and interaction with books, fostering a more engaging and socially supportive library experience. The underlying concept draws from the idea of visualizing the process of making friends through indirect interactions (Chang, 2005). By transforming conventional library queries into puzzles, the system creates a platform for indirect social connections—Especially beneficial for people with SAD, who may find traditional social interactions overwhelming.

The puzzles embedded in the system are designed to facilitate exploration and discovery, turning routine library processes into engaging activities. These puzzles are not traditional in the sense of riddles but are instead interactive challenges that invite users to engage with the library's resources and the wider user community (Table 3).

Transforming conventional queries into puzzles plays a key role in fostering social interaction, particularly for individuals with SAD. Traditional methods of socializing, like direct conversation or participation in group activities, can be daunting for individuals with anxiety. By providing an engaging, indirect way of connecting through books, the system makes social interaction more accessible and less stressful in 3 ways:

1. Indirect interaction: Puzzles like the "Find the Hidden Book" or "Who Would Be Interested?" allow users to connect based on shared interests without requiring direct social engagement. For users with SAD, this indirect interaction reduces the anxiety typically associated with socializing.

Table 3. Examples of Puzzles

	Structure	Design	Impact
1. Find the Hidden Book Challenges	Users are prompted with a riddle or clue that leads them to a hidden book within the library. For example, a clue might be: *"The book you seek rests between the pages of adventure, on a shelf that's always busy but never crowded."*	These puzzles are designed to be solvable through hints provided in the system or clues generated by other users, making the experience collaborative.	Users must interact with the library's physical and digital spaces, subtly guiding them through social spaces without direct communication. For individuals with SAD, this indirect approach offers a non-threatening way to engage with others while pursuing a personal goal.
2. Who Would Be Interested?	A transformation of the question "Who else likes this book?" into a puzzle prompt: *"If I were to hide this book, who would be interested in finding it?"*	This puzzle invites users to think about others' interests and preferences, prompting them to reflect on who they might want to interact with, without having to directly identify or meet them. It becomes a way to connect over shared literary interests.	By participating in these puzzles, users are encouraged to consider the potential for social connection, yet they are not required to engage in face-to-face interactions. This fosters connections in a way that feels safer and more manageable for individuals with SAD.
3. Book Recommendation Riddles	Users are asked to write riddles or clues that recommend a book to others based on themes, genres, or personal experiences. For example, *"For those who love stories of resilience, seek the book that changed the lives of those who persevered."*	The system allows users to share personalized book recommendations through puzzle-like clues, fostering an environment of social interaction where books are the common threads.	These riddles not only challenge users' creativity but also provide a low-barrier opportunity for interaction. Users may discover new books based on the clues, leading to indirect conversations and fostering a sense of connection through shared interests in literature.
4. Book Journey Puzzles	This type of puzzle involves following a "journey" through the library. Users might need to find a specific book, then locate another related to it, perhaps through author recommendations or thematic connections.	Each book in the journey acts as a puzzle piece that leads to the next, and users can leave notes or riddles about their experiences with the books along the way.	This journey of discovery turns the process of finding books into a collaborative social game. For individuals with SAD, it allows them to indirectly engage with others through shared literary explorations, without the pressure of direct conversation or face-to-face interaction.

2. Sense of community: By completing puzzles and leaving clues for others, users contribute to a collective experience that enhances the sense of belonging. These interactions feel more personal and less formal, which can be comforting for individuals who find traditional social settings intimidating.
3. Low-pressure engagement: The gamified nature of the puzzles encourages users to engage with the system at their own pace. Unlike traditional social activities, there is no immediate need for verbal communication or emotional investment. Instead, users can take their time, feel a sense of accomplishment, and gradually develop connections through shared book experiences.

Finally, in the user experience flow and prototype development, once the puzzles are defined, the next step is to integrate them into the system prototype. The initial design includes defining function keys and page layouts, followed by the configuration of the user interface (UI). The wireframe is tested to ensure smooth interaction flows (Figure 5), ensuring that users can easily access and engage with the puzzles. Visual elements are incorporated into the interface to create an intuitive and enjoyable experience.

The sequence of user interaction scenarios for using the system is as follows (Figure 6):

1. Discovering Books
   a. Book evaluation: After reading a book they enjoyed, users log into the system to see who else is interested in the book and view their evaluations.
2. Exploring Book Information
   a. Review access: Users can read reviews and responses from others. They then select "Guide to find this book," which presents two modes, game and normal.
   b. Game mode: Provides a riddle to locate the book.
   c. Normal mode: Offers straightforward guidance without riddles.
3. Solving Puzzles
   a. Riddle activation: Upon approaching the book's location, users will encounter a few "?" riddles on the screen.
   b. Book location: Users solve these riddles and use environmental clues to find the book.

Figure 5. User Testing Task for Searching and Finding the Book

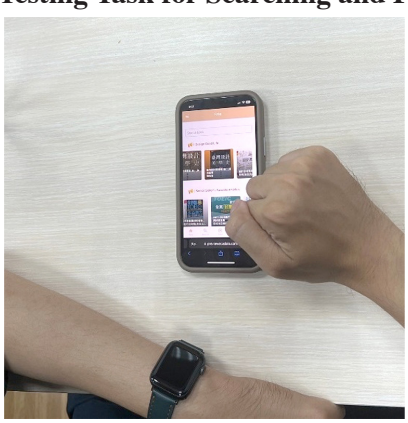
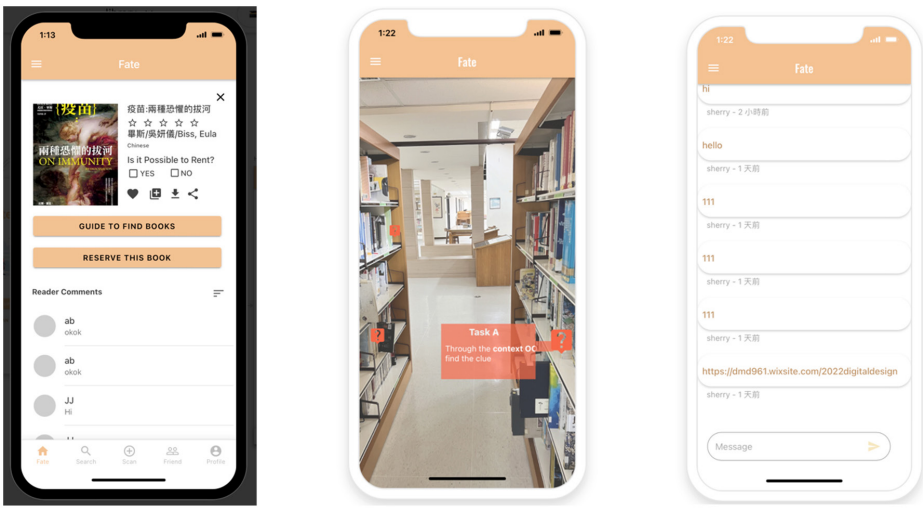


Figure 6. User Interface Logs and Pop-Up Riddles



Note. Left: guide to find this book. Middle: riddles will pop up on the screen. Right: add new riddle.

4. Post-Finding Options
   a. View "Recommended Book List": See people who read the same book have explored what other books.
   b. Add a riddle: Creating an "Automatically generated riddle" or a "Customized riddle."
   c. View "List of Riddles": Access a list of users who have previously created riddles.
5. Social Features
   a. Find book friends: Users can connect with other book enthusiasts and leave messages.
   b. Camera integration: Users can scan with their camera to view book reviews directly.
6. Alternative Discovery
   a. Recommended books: If users are unsure about a book, they can explore a recommended book list related to their discussion topics through friend-making and chat pages.

4.3 Interactive system testing and outcomes in social anxiety assessment

Our study aimed to provide an accurate depiction of individuals' experiences with social anxiety by assessing their responses through interviews and psychological evaluations. Participants were categorized based on their social anxiety status, with explicit and implicit social anxiety groups identified through medical records and scale assessments. The former provided insight into physical and mental health visits, while the later helped detect implicit social anxiety.

The study involved 14 participants aged 21–40, divided into 2 groups: those with social anxiety and those without. The social anxiety group had an average score of 30.85 with a standard deviation of 4.14, whereas the non-social anxiety group had an average score of 21.42 with a standard deviation of 1.51 (see Table 4).

Table 4. Test Scores of the Control and Experimental Group of the Social Anxiety User

Anxiety	Number	Average	Standard deviation	Average number	Gender
Yes	7	30.8571	4.14039	1.56492	3 Male & 4 Female
No	7	21.4286	1.51186	.57143	4 Male & 3 Female

These results demonstrate a significant difference in social anxiety scores between the two groups, confirming that individuals with social anxiety exhibited higher scores compared to those without. This finding underscores the effectiveness of our assessment methods and enhances our understanding of social anxiety within the study population.

In the Levene test (see Table 5) used to compare variances between the 2 sample groups, the *F*-test yielded a *p*-value of 0.189, which is greater than the 0.05 threshold. This indicates that the variances between the 2 groups are not significantly different, supporting the assumption of equal variances. In the subsequent *t*-test for equal means, the t-statistic was 5.659, and the two-tailed significance *p*-value was 0.00, which is less than 0.05. This result leads us to reject the null hypothesis and accept the alternative hypothesis, indicating a significant difference in usage patterns between the 2 groups.

Our testing focused on evaluating the interactive system's smoothness and intuitiveness by recording and analyzing user interactions. This included assessing whether the interface and instructions matched users' reading styles and preferences. Using context and user journey maps, we extracted valuable insights into page sequencing and function button design based on user experiences.

The interface was subjected to experimental testing to gather feedback, which was then categorized and used to identify issues such as the unintuitive up-and-down motion of the turntable, small numbers and buttons, the potential need for arrows, and insufficient text descriptions. Integrated feedback resulted in design modifications to enhance the system's interface. Each feedback point was carefully addressed, leading to adjustments aimed at achieving a more intuitive and user-friendly operational experience.

5. Discussion and Conclusion

5.1 Discussion

User feedback was systematically analyzed and categorized into key themes to refine the system's design and functionality. The primary areas of improvement included ease of navigation, social interaction features, transparency of book availability, personalization through AI integration, and private communication spaces.

First, participants noted that the original navigation system was unintuitive, particularly the return key which caused confusion and hindered user flow. This issue was addressed by simplifying the navigation structure, making it easier for users—especially those with SAD—to interact with the system without experiencing cognitive overload or frustration.

Table 5. Test Scores of the Control and Experimental Group of Independent Sample *t*-test

	Levene test with equal number of variations		Average Equal *t*-test	
	F-test	Significant	*t*	Average difference
Assume that the number of variations is equal	1.937	.189	5.659	9.42857
Not assume that the number of variations is equal			5.659	9.42857

Second, users expressed a strong preference for controlled and private communication channels. A private messaging feature was integrated into the system, enabling users to interact in a more personalized and safe manner without the pressure of public conversations. This enhancement directly addressed the needs of individuals with SAD, who often find direct social interactions stressful.

Additionally, the study found that transparency in book availability played a crucial role in reducing anxiety. Users wanted clear, real-time information on whether a book was currently borrowed or available. As a result, a book availability indicator and an interactive activity feed were added, allowing users to track book status and interactions without uncertainty. For users with SAD, these features provided structure and predictability, helping to mitigate anxiety related to social or environmental unpredictability.

The integration of personalization features further improved user engagement. AI-driven book recommendations and a chatbot were introduced based on participant feedback, ensuring that users received tailored content aligned with their interests. This feature was particularly beneficial for individuals with SAD, as it allowed them to interact with the system in a way that felt personally relevant and under their control.

One of the most significant findings from the study was the need for a private dialogue space where users could interact in a non-judgmental environment. Many participants with SAD reported feeling more comfortable engaging in social exchanges when they had a designated, pressure-free space for communication. In response, a feature named “Book Buddy” was developed, enabling users to form connections through books without the expectation of direct social interaction. This feature reinforced the system’s goal of providing emotional comfort while fostering indirect yet meaningful relationships.

The implementation of these refinements resulted in 3 key outcomes:

1. Reduced anxiety

   Participants reported feeling more at ease using the system after improvements were made to navigation, transparency, and privacy settings. The ability to engage with books as social tools—rather than through direct, high-pressure interactions—helped reduce stress and increase willingness to participate in social exchanges.

2. Enhanced engagement
   The addition of AI recommendations and interactive features such as the activity feed increased user engagement by making the system more dynamic and personalized. Users felt more inclined to explore books and interact within the system, fostering a sense of connection and belonging.
3. Strengthened social bonds through books
   The study confirmed that books serve not only as sources of knowledge but also as social mediators. By refining the system's design based on user behavior, the study demonstrated how books could be leveraged to build social connections in a way that feels safe and manageable for individuals with SAD.

Overall, these findings highlight how an interactive library-based system can transform book-seeking behaviors into meaningful social experiences, making library a space for both knowledge acquisition and indirect social engagement. The results support the notion that designing systems around emotional interaction and social substitutes can create inclusive environments for individuals who struggle with traditional social dynamics.

5.2 Conclusion

The study examined the behaviors and emotional needs of individuals with SAD and explored how an interactive library-based design—termed the Emotional Interaction Design with Social Substitutes System—could alleviate social fears by using books as a medium for indirect social connection. The findings revealed that traditional social interactions often feel overwhelming for individuals with SAD, whereas books offer a unique combination of emotional safety and curiosity, making them an effective tool for facilitating non-intrusive social engagement.

Through participant feedback and system usage analysis, the study identified that making information transparent and visualized significantly reduced anxiety during face-to-face interactions. However, books, as both physical objects and imaginative tools, introduced an element of uncertainty. This paradox between security and curiosity enabled books to function as social agents, allowing users to engage with shared literary interests while maintaining a comfortable level of interaction. The system's core design principles were validated by user responses, which indicated that books could serve as emotional and social bridges, reducing anxiety and fostering alternative pathways for social connection.

The research into emotional interaction design for SAD has led to the creation of a system that integrates IoT technology with library book-searching behaviors, transforming library experience into a treasure map-like journey. This innovative approach, grounded in the user experience process and contextual analysis from user interviews, reimagines traditional library interactions. While users typically engaged with library systems in a unilateral manner, simply searching for books and information without social interaction, this new system embeds social elements into the book-searching process, creating a more inclusive and engaging environment that addresses the unique needs of those with SAD.

The primary goal of this interaction design is to facilitate social engagement for individuals with SAD, who often struggle with a paradoxical desire: while they wish to connect with others,

they fear social situations due to the risk of making mistakes or the pressure of direct interaction. By leveraging books as a social medium, the system enables users to engage in indirect social activities, offering a safer path to building social confidence.

User feedback has revealed several design features that particularly benefit users with SAD. The broadcast messaging system allows users to communicate through written messages, reducing the anxiety typically associated with real-time, face-to-face interactions. The book medium naturally induces curiosity, serving as a gateway to interaction while lowering the stress of social engagements. Additionally, the system allows users to view library scenes and leave messages, providing a sense of presence and community without requiring direct social interaction. The book search functionality enables users to search by title, make reservations, and follow a treasure map-like path to their location, transforming routine book-finding into a playful and rewarding activity. Furthermore, improved directory categorization and virtual tours help users efficiently navigate the library space, making the process more interactive and socially engaging.

During user testing, several design features demonstrate particular effectiveness. The broadcast messaging functionality successfully alleviates the anxiety of direct communication by enabling asynchronous social interaction, where users can engage in dialogue without the pressure of immediate response. The system's use of books as social agents encourages curiosity-driven interactions while mitigating the stress of face-to-face communication. Moreover, the ability to view library scenes and leave messages fosters a subtle but significant sense of presence and participation within the library's community, while integrated book-searching tools ensure the system remains intuitive and enhances the overall user experience.

Through this study, we have demonstrated how thoughtful library interaction design can help individuals with SAD engage in social interaction in a comfortable and manageable way. The system's design not only offers new perspectives on addressing SAD but also provides valuable insights into the broader realm of library system design and social interaction research. By reimagining books as social media, this system has the potential to transform libraries into alternative social spaces where users can form connections and communities through shared literary experiences, while free from the pressures of traditional social media or direct social networks.

This study presents a novel approach to fostering social interaction for individuals with social anxiety, opening new avenues for research and practice in both emotional interaction design and library systems. The findings suggest that by carefully considering the needs of users with SAD, we can create more inclusive and engaging library environments that serve both educational and social purposes.

Notes

Note 1 It is considered while quantitative methods could provide numerical insights, they would miss the nuanced ways users engage with resources, other patrons, and staff.

Note 2 As this study is part of a subproject under the National Cheng Kung University Governance Framework for Human Research Ethics (Case No. 110-281), strict

adherence to ethical guidelines is ensured. Informed consent was obtained from all participants, with clear explanations of their rights and the study's purpose to ensure voluntary participation.

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(Received: 2024/10/3; Accepted: 2025/3/12)

圖書資訊學刊　第23卷第1期　（2025.6）　頁109-136
https://doi.org/10.6182/jlis.202506_23(1).109

建構替代性社交互動設計：一個透過圖書館互動緩解社交焦慮症的系統

Constructing Substitute Social Interaction Design: A System to Alleviate Social Anxiety Disorder through Library Interactions

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摘　要

本研究探討圖書館作為動態社交空間的潛力，特別針對患有社交焦慮症（social anxiety disorder, SAD）者，提出以書籍為媒介的社交網絡。透過書評與閱讀紀錄建立連結，轉變焦點為「誰會因這本書而感到驚喜？」，藉由分享文學經驗促進間接社交互動。受到建築師雷姆・庫哈斯關於公共空間適應性的啟發，研究強調圖書館可作為書目療法場域，提供舒適與低壓力的交流方式。透過背景分析與使用者訪談，研究設計三項互動策略：支援書面訊息溝通、促進好奇心導向的探索，以及透過書籍互動提升存在感。結果顯示，創新的圖書館互動機制有助於建立支持性社群環境，協助SAD患者進行有意義的社會連結。

關鍵字：圖書館空間互動、互動設計、使用者體驗、介面設計、共存空間

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註：本中文摘要由作者提供。

以APA格式引用本文：Chang, T.-W., Huang, H.-Y., Chien, H.-T., & Tsai, S.-T. (2025). Constructing substitute social interaction design: A system to alleviate social anxiety disorder through library interactions. *Journal of Library and Information Studies*, 23(1), 109-136. https://doi.org/10.6182/jlis.202506_23(1).109

以Chicago格式引用本文：Chang, Teng-Wen, Hsin-Yi Huang, Hsiang-Ting Chien, and Shih-Ting Tsai. “Constructing Substitute Social Interaction Design: A System to Alleviate Social Anxiety Disorder through Library Interactions.” *Journal of Library and Information Studies* 23, no. 1 (2025): 109-136. https://doi.org/10.6182/jlis.202506_23(1).109.