Exploring the Impact of the Gamified Metaverse on Knowledge Acquisition and Library Anxiety in Academic Libraries

Pradorn Sureephong, Suepphong Chernbumroong, Supicha Niemsup, Pipitton Homla, Kannikar Intawong, and Kitti Puritat

EDITOR'S NOTE (OCTOBER 21, 2024)

It has been brought to the attention of the ITAL Editorial Board that the works cited in endnote 16 are fake. We have edited endnote 16 to state this. We have verified that the remaining citations correspond to published works. The authors acknowledge the error in their writing and editing processes that left these citations in place.

ABSTRACT

This paper investigates the potential of the Gamified Metaverse as a platform for promoting library services. The study compares the effectiveness of a traditional library program with a Metaverse-based library program in terms of knowledge acquisition and library anxiety. The research also examines students' perceptions of implementing gamification within the context of the Gamified Metaverse platform. A mixed-methods approach was adopted, including pre- and post-test analysis, statistical analysis, and qualitative data collection. The results indicate that both the traditional and Metaverse-based library programs effectively increased the participants' knowledge, with no significant difference between the two approaches. However, the Metaverse-based program was found to be less effective in facilitating interaction with librarians and reducing library anxiety. Additionally, students expressed positive perceptions of implementing gamification in the Gamified Metaverse platform, finding it engaging and motivating. These findings contribute to the understanding of the effect of the Metaverse as a tool for promoting library services and enhancing knowledge acquisition. However, it is not as effective in reducing library anxiety, particularly in terms of interaction with librarians and staff. It should be noted that the platform may have limitations such as high costs and potential side effects of virtual reality, making it more suitable as an additional tool for promoting library services, taking into account its feasibility and potential benefits for specific student populations and larger libraries.

INTRODUCTION

Chiang Mai University, established in 1964, is the first higher education college and the first provincial college located in Thailand, covering a vast area of over 3,500 acres. The university

About the Authors

Pradorn Sureephong (pradorn.s@cmu.ac.th) is Assistant Professor, Chiang Mai University. **Suepphong Chernbumroong** (suepphong.c@cmu.ac.th) is lecturer, Chiang Mai University. **Supicha Niemsup** (supicha_n@cmu.ac.th) is Information Specialist, Chiang Mai University. **Pipitton Homla** (pipitton_h@cmu.ac.th) is PhD Student, Chiang Mai University. **Kannikar Intawong** (kannikar.i@cmu.ac.th) is Assistant Professor, Chiang Mai University. **Kitti Puritat** (corresponding author: kitti.p@cmu.ac.th) is Assistant Professor, Chiang Mai University. © 2024.

encompasses over 39,000 students, with the majority specializing in Humanities and Social Sciences, followed by those in Science and Technology and Health Sciences. Comprising 19 libraries, including academic libraries situated within the Faculty of Humanities, Chiang Mai University caters to diverse academic needs.[1] Libraries have always played a pivotal role in the dissemination of knowledge and information. They serve as storehouses of information and offer a variety of services to their patrons. However, with the advent of the digital age and a significant shift in the way people consume information and interact with the world, libraries have had to adapt to new technologies to keep up with the changing times and find new ways to engage with their patrons in the digital era. Furthermore, it is known that students may feel anxious when visiting libraries due to various reasons, such as fear of getting lost, difficulty in locating resources, and social anxiety. Van Kampen indicated that students might experience anxiety during library visits because of challenges related to fundamental research skills, including inadequate training in conducting effective searches and a tendency to select articles based on accessibility rather than other criteria.[2] In addition, Kuhlthau pointed out that the overwhelming quantity of available information poses a challenge, contributing to information overload and causing hesitation, confusion, and uncertainty in information seeking.[3] Moreover, the hesitancy to ask for assistance from library staff may lead to a sense of being lost in the library, which consequently heightens anxiety.[4] Consequently, this anxiety can significantly impact students' ability to focus, learn, and perform well academically. Therefore, finding effective ways to reduce anxiety in libraries is essential for students' academic success. One emerging technology that has the potential to address anxiety in libraries is the Metaverse. The concept of the Metaverse has been gaining popularity in recent years due to its promise of offering an alternative space where people can explore, learn, and socialize without the physical constraints of the real world, particularly in the realms of gaming and virtual reality. To illustrate this, the Metaverse refers to a digital realm where individuals can engage with one another and the virtual surroundings simultaneously through online connectivity. It is a fully immersive environment that offers endless possibilities for social interaction, gaming, and exploration.

In this research, we develop a Metaverse as a platform for libraries, specifically for university libraries. The research aims to enhance and promote the library's services to its patrons in a gamified manner, as well as to investigate the potential of the Metaverse in reducing students' anxiety towards libraries. The study explores the use of the Metaverse as a tool for providing a virtual library environment that is accessible, user-friendly, and engaging.

LITERATURE REVIEW

Metaverse
As the concept of the Metaverse has gained popularity, many researchers have attempted to define the term and apply it in various ways. The Metaverse was first introduced in 1992 in Neal Stevenson's science fiction novel *Snow Crash*. The Metaverse was portrayed as a virtual world that was distinct from the physical world. To access this virtual world, users were required to use specialized equipment, such as head-mounted VR glasses.[5]

Ondrejka initially defined the Metaverse as an online space that serves as a real-world metaphor for users to socialize, conduct business, and entertain because of the technical limitations of creating a Metaverse at that time. However, with the advancement of technology, the idea of the Metaverse can now be realized using 3D graphics, network connectivity, and increased bandwidth. This has allowed for the collaborative creation of digital content in games like massively multiplayer online role-playing games (MMORPGs), such as *The Sims Online*, *World of Warcraft*,

Final Fantasy XIV, *Guild Wars 2*, *Elder Scrolls Online*, *Star Wars: The Old Republic*, *Black Desert Online*, *EVE Online*, *Runescape*, and *MapleStory*. These MMORPGs showcase the immersive potential of the evolving Metaverse, enabling users to engage in shared virtual spaces and experiences.[6] Dionisio et al. suggest that the term Metaverse originated from the combination of the prefix "meta," representing beyond, and the suffix "verse," representing the universe. Then, they defined the Metaverse as a completely immersive 3D digital environment that extends beyond the physical world and encompasses the entirety of the online space shared across all representation dimensions. As technology advanced, the Metaverse transformed from a collection of separate virtual worlds to a vast network of interconnected virtual spaces. This shift allowed for greater collaboration and interaction between users within the Metaverse.[7] Ball describes the Metaverse as a collection of interconnected 3D virtual environments that are both massive and real-time. Within this network, it enables users to interact with an unlimited number of other users in synchronous and persistent ways. Furthermore, the Metaverse allows for the continuity of data, including user information, privileges, items, messages, and financial transactions, providing a seamless and immersive experience for users.[8] Mystakidis argues that the Metaverse is a digital environment that provides a variety of experiences, including living, working, exploring, conducting business, and engaging in recreational activities. It is a new type of universe that blends physical and digital virtuality into a continuous and persistent multiuser environment, marking the advent of the post-reality universe. The Metaverse is made possible by the merging of technologies, for example, virtual reality (VR) and augmented reality (AR), to allow for interactive experiences with digital objects, virtual worlds, and other individuals. This linked network of social, immersive environments exists on continuous platforms that allow multiple users to interact and share real-time interactions with digital objects and seamless communication between users.[9]

Regarding the types of interaction, it can be categorized into four types, including augmented reality (AR), lifelogging, mirror world, and virtual reality (VR). To illustrate these, the first type is the AR, characterized by the utilization of location-based technologies and networks to create a smart environment. Examples of AR include applications like *Pokemon Go*, digital textbooks, and realistic content. Second, lifelogging refers to technology that enables capturing, storing, and sharing everyday experiences and information about objects and individuals, as exemplified by applications like Facebook, Instagram, Apple Watch, Samsung Health, and Nike Plus. Third, the mirror world is a technology that reflects the real world while integrating and providing additional environmental information, as exemplified by applications like Google Earth, Google Maps, Naver Maps, and Airbnb. Lastly, VR is an immersive environment created through digital data, offering a simulated reality that seeks to immerse the individual in virtual worlds.[10] Notable examples of VR experiences include *Second Life*, *Rec Room*, *Beat Saber*, and *Superhot VR*. Unlike AR, which enhances the real world, VR strives to create an alternative reality, immersing users in a fully simulated environment. The use of proprietary technology, such as VR glasses, headsets, or head-mounted displays (HMDs), contributes to the high level of presence and immersion in VR experiences.[11] The technological capacity of VR blurs the frontier between the real and virtual world, allowing for the rendering of high-quality images and freedom of movement within the virtual environment.[12] In summary, while AR extends or augments reality, VR provides a substitute reality, both playing unique roles in shaping user experiences.[13]

Metaverse and Academic Library
Libraries have explored introducing AR and VR-based programs and services with multiple intended outcomes. Notably, AR is employed for various purposes, including collection

exploration, navigation, exhibits, instructional activities, and orientations. In Taiwan, for instance, public librarians utilized AR to enhance the book search experience, making it more intuitive and empowering users to take a self-directed approach.[14] Moreover, AR technology was employed at Emporia State University to promote events called Banned Books Week and develop assignments that enhance information literacy.[15] Recent literature highlights an increasing focus on exploring the potential applications of the Metaverse for libraries and librarians. For instance, Pu et al. delved into the possibilities of VR technology in enhancing various library programs and services, proposing improvements like virtual reference services, virtual tours of library spaces, and virtual learning environments.[16] While the implementation of the Metaverse in libraries is not widely prevalent, there is evidence indicating that certain libraries worldwide are testing virtual environments as a means to enhance user satisfaction. For example, some libraries have started offering interactive sessions utilizing virtual reality for purposes such as storytelling, exploration, gaming, and skill-building. These innovative VR initiatives aim to not only enhance user satisfaction but also provide a dynamic and engaging approach to learning within library space.[17] Illustrating the diverse applications, Tang designed an orientation activity for first-year college students called *AR Treasure Hunt*, which utilized AR technology. The game's objective was to assist students in navigating the library by guiding them to discover puzzles located within the library building, which helped them solve a digital treasure box. According to Tang, the students who participated in the *AR Treasure Hunt* game gave positive feedback. They found the game informative and creative, and it helped them become more comfortable with library facilities, resources, and specialized librarians in various subject areas. The paper concludes that the game successfully assisted students with wayfinding in the library and familiarized them with library resources.[18] Furthermore, Chen and Tsai discovered that elementary-age students in Taiwan derived equal benefits from both AR and in-person library instruction, especially when the instruction involved practical application and understanding.[19] AR is also being utilized for library orientations, and participants consistently express positive responses regarding their enjoyment of the activity and the usefulness of the orientation experience.[20]

Library Anxiety
Library anxiety is a common phenomenon experienced by individuals when visiting libraries, characterized by feelings of fear, confusion, and stress in the library environment. The idea of library anxiety was first proposed by Constance Mellon in 1986, arguing that a variety of factors contribute to students' fear of the library. These factors include perceiving the library as overwhelmingly large, lacking knowledge about its arrangement, feeling uncertain about how to initiate its use, and being unsure about the necessary procedures to effectively make use of its resources. This sense of fear can hinder students from approaching research assignments in a rational and effective manner, impacting their ability to complete assignments successfully and achieve academic success.[21] Furthermore, it was argued that library anxiety can negatively impact students' academic achievements and overall learning experiences. For example, students may postpone assignments or submit papers of poor quality.[22] In addition, Kuhlthau asserts that intense emotions are a crucial component of the research process, which can span from initial confusion and anxiety to eventual confidence, satisfaction, or disappointment. Failing to address emotional issues, such as unclear thoughts, gaps in understanding, and limited progress during information searches may leave a significant source of library anxiety unresolved.[23]

Gamification in Library Services
In recent years, gamification has become an increasingly popular approach to enhance user engagement and promote behavior change in various domains. In the library field, gamification

has emerged as a promising tool for improving user experience, increasing patronage, and fostering learning outcomes. By integrating game elements such as challenges, rewards, and competition into library services, gamification seeks to create more immersive, interactive, and personalized experiences for library users. This has led to numerous scholars endeavoring to provide a definition of the term and applying it in diverse ways.

According to Deterding et al., gamification refers to the utilization of game design principles in non-game scenarios, while Zichermann and Cunningham define gamification as the strategy of applying game-thinking and game principles to engage users and find solutions.[24] Gartner, on the other hand, introduced gamification as the application of game elements to promote engagement in non-game business contexts and alter behaviors in a specific audience to attain business outcomes.[25] Bigdeli et al. employed the self-determination theory and flow theory to create games for library websites. The authors emphasized the significance of using methods to generate user interest and engagement and suggested that gamification has great potential to enhance the user experience and make the library more enjoyable for users.[26] Moreover, Hill conducted a study to examine the efficacy of gamification in promoting information literacy among elementary school students in library settings, using *Minecraft* games as a tool. The results indicated that the students exhibited a high level of engagement and participation in the learning process of information literacy elements, and they also showed a strong motivation to learn.[27] Additionally, Nand et al. discovered that children exhibit increased participation while learning with the aid of gamification. Consequently, if gamification is implemented across all library services and programs, it is anticipated that users' engagement with and use of the library will be substantially impacted.[28]

Finally, Jung and Wang conducted a study that examined the effects of gamification on library use intention and participation. The findings revealed that achievement and virality factors influenced the use intention and participation of libraries. Likewise, students in elementary school prefer programs that are targeted and that they have a desire to achieve, as well as information about library programs that they can share with others and use with their peers. Furthermore, to enhance the effects of gamification, it is possible to combine its various elements. Correspondingly, Jung and Wang suggested the integration of elements such as gameplay, communication, rewards or reward points, goals, and leaderboards. This combination of the elements will offer a more enjoyable and engaging experience for users.[29]

Metaverse for Library Anxiety
Studies and research have explored the effects of VR and AR across diverse fields. For example, psychology researchers have examined the impact of AR as a therapeutic approach for diagnosed anxiety disorders, specifically various phobias.[30] While studies suggest that VR can reduce anxiety in various contexts, such as medical procedures,[31] exam preparation,[32] and public speaking,[33] there remains a significant gap in the literature regarding the influence of VR on students' library anxiety. As far as we know, there is no dedicated study on the effect of VR on students' library anxiety, contrasting with the limited research on AR in this context. Notably, only one study has investigated the effect of AR on students' library anxiety. In the study, Kannegiser explores how AR technology can affect students' emotions and confidence levels during library orientations and compares the outcomes between traditional orientations and AR orientations. The study found that both traditional and AR orientations had a positive effect on students' perceptions of the library. Notably, the AR orientation significantly enhanced how students perceived the willingness of librarians to assist them. The findings also suggested that incorporating AR to showcase librarians and staff can effectively reduce students' anxiety toward library personnel.[34]

PURPOSE OF THE STUDY

The purpose of this research is to explore the potential of the Metaverse as a platform for promoting library services in a gamified environment. The study focuses on developing a Metaverse platform for library services that provides patrons with an immersive and engaging environment to access resources. Furthermore, the study incorporates gamification strategies such as quests, challenges, and rewards to promote library services within the Metaverse platform. We propose the following research questions:

RQ1: How does the use of the Metaverse impact students' knowledge acquisition of academic libraries in universities compared to those who do not have Metaverse experience?

RQ2: Does the use of the Metaverse reduce students' anxiety about the library program compared to those without Metaverse experience?

RQ3: What are students' perceptions of the usefulness of the Gamified Metaverse in promoting library services?

And the hypotheses are the following:

H1: The use of the Metaverse will improve students' knowledge of academic libraries in universities compared to those without a Metaverse experience because the Metaverse offers a highly immersive and interactive learning environment that can engage students in a more effective way than traditional methods.

H2: The use of the Metaverse will reduce students' anxiety about their library program compared to those without a Metaverse experience. We believe that the Metaverse can provide a safe and controlled environment where students can practice and gain confidence in their library skills without the pressure of real-world consequences. This could help reduce anxiety and increase students' comfort levels with the library program.

H3: Students will perceive the Gamified Metaverse as a useful platform for promoting library services. We expect that the incorporation of gamification strategies such as quests, challenges, and rewards will enhance students' engagement, motivation, and enjoyment, resulting in positive perceptions of the usefulness of library services offered through the Gamified Metaverse.

METHODOLOGY

To answer the research questions, we adopted an explanatory sequential design, which is a mixed-methods approach.[35] We conducted a randomized controlled trial and randomly assigned students to either a Metaverse-based library program group or a traditional library program group. We chose this design to compare the impact of the Metaverse on students' knowledge acquisition and anxiety levels in comparison to traditional library programs. For quantitative data, we administered a pre- and post-test of library knowledge and library anxiety level to assess students' knowledge acquisition and anxiety levels. The pre- and post-test scores would then be compared between the two groups to evaluate the impact of the Metaverse. We also used statistical analysis to determine the significance of the differences between the two groups. For qualitative data, we used open-ended questions to gather students' perceptions of the usefulness of the Metaverse. We selected this method to gain an in-depth understanding of students' perceptions and experiences with the Metaverse. The open-ended questions allow students to

express their opinions freely and provide detailed information on their experiences with the Metaverse-based library program.

Metaverse Platform

The Metaverse platform is a virtual environment where the library program takes place. For this study, we decided to develop a digital twin[36] of the academic libraries in the Faculty of Humanities at Chiang Mai University within the Metaverse platform, using the Unity game engine. A digital twin is a virtual replica of a physical object or system that can represent the physical space and resources of the library, as well as its users and their activities. To develop a digital twin for an academic library, the first step was to scan and map the physical space of the library using 3D imaging technology, specifically the photogrammetry method.[37] This involved capturing detailed 3D images of the library's interior, including its layout, furniture, and resources. Once the physical space had been captured in 3D, the data was used to create a digital replica of the library using a specialized Meshroom software. Meshroom is a photogrammetry-based 3D modeling tool that can create 3D models from a set of photographs. This digital twin can be viewed and manipulated using virtual reality, allowing users to explore and interact with the library in a virtual environment. The overview of the Metaverse platform is shown in figure 1.

Figure 1. The isometric view of the Metaverse Platform of libraries,
first floor (left) and second floor (right).
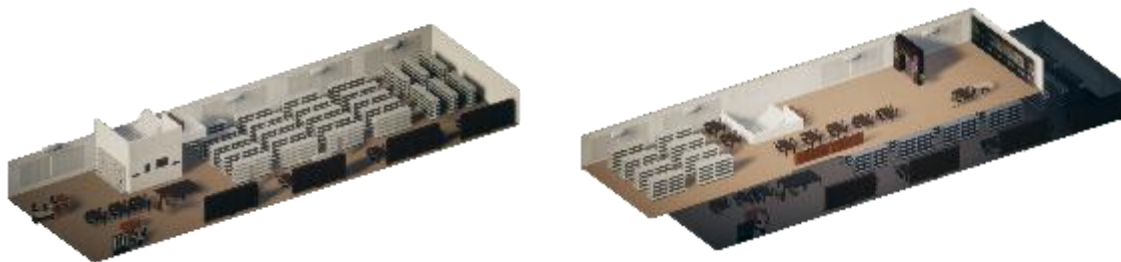
The environment was designed to provide a realistic representation of a physical library while also incorporating features that take advantage of the unique capabilities of the Metaverse, such as the ability to interact with objects as shown in figure 2. We developed a Metaverse for academic libraries by utilizing digital twin technology and 3D imaging to construct a virtual environment within the Unity game engine. This involved designing the layout of the virtual library based on the physical library that was scanned and mapped, and importing 3D models of the library's furniture, resources, and other features, as shown in figure 2. Scripts were created to enable users to interact with various objects in the virtual library, such as picking up and reading books, using computers, or accessing online resources. The user interface (UI) was designed to make it easy for users to navigate the virtual library, with features like the search function that enables users to find specific books or other resources based on keywords.

Figure 2. Interaction with a book (left), virtual environment in the Metaverse (right).
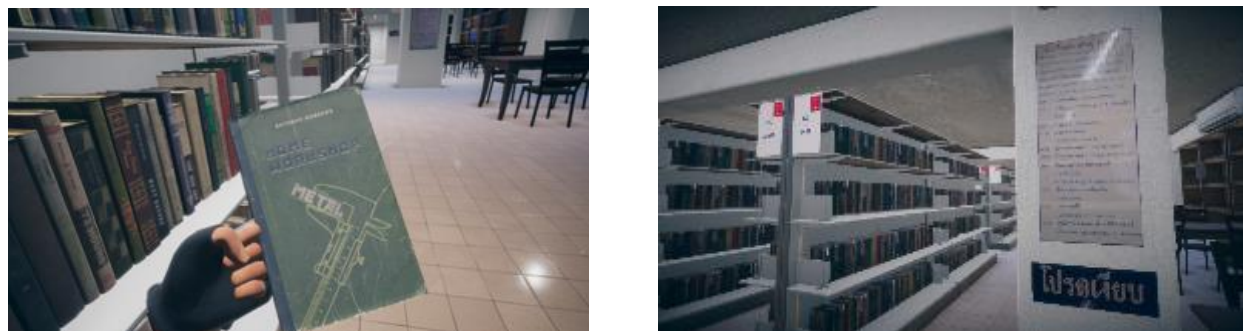
After building the virtual environment of the academic library in the Unity game engine, the next step was to implement the gamification concept to enhance engagement and motivation to participate in our virtual library.[38] We established four gamified services (Library Orientation, Research Support, Book Borrowing, and Technology Services), we included gamification elements such as a leaderboard, points system, level up, and badges in the profile after finishing the tasks, as shown in figure 3. The overview of gamified services is shown in table 1.

Table 1. The Objective, Purpose, and Description of the Metaverse platform

Gamified services	Objective and purpose	Description
Library Orientation	**Objective**: To familiarize users with the layout, services, and resources of the library. **Purpose**: To increase users' confidence and efficiency in using the library.	Users can explore the virtual library in the Metaverse and complete a scavenger hunt to find key library resources and services. The system requires users to follow waypoints and read information. Each completed task earns them points towards leveling up their account.
Research Support	**Objective:** To help users' awareness of the services of libraries to support research skills and find relevant sources for their research literacy by librarians in academics services. **Purpose:** To enhance user success in their academic work.	Users can access a virtual research assistance desk staffed by virtual librarians. They can ask for help with finding sources, developing search strategies, and evaluating sources. The system requires the user to interact with the virtual librarian and answer their questions. Each successful research interaction earns users points towards unlocking badges and leveling up their account.
Book Services	**Objective:** To provide users with information about library rules and regulations, including how to use the library and become a member. **Purpose:** To encourage library usage and promote the library as a learning space.	In the Metaverse, users can access the library's collection of books and resources and learn about library rules and regulations. They can navigate the library's shelves and find books using the Dewey Decimal Classification system. As they find books, they earn points towards unlocking badges and leveling up their account. The system requires users to locate and seek out books based on their classification number

		and understand how books are arranged on the shelves and how to find their location.
Technology Services	**Objective:** To provide users with technology resources support, as well as assistance with software applications and troubleshooting technical issues in academic libraries. **Purpose:** To increase user engagement with technology support students during study in the university.	Users can access the virtual reference desk in the Metaverse, staffed by virtual librarians who can assist with the knowledge of technology resources and services. Users can complete quests provided by the virtual librarians, which require them to interact with various technology resources in the library to earn points towards leveling up their account.

Pre- and Post-Test of Anxiety and Knowledge Questionnaire for Library

We developed a questionnaire consisting of 30 questions adapted from "A Gamified Mobile Application for First-Year Student Orientation to Promote Library Services" to measure the knowledge acquisition gained by using a Metaverse platform designed for academic libraries.[39] To ensure the questionnaire's validity, we asked two librarians from the Faculty of Humanities at the university and a lecturer in Information Sciences to evaluate it. We found high levels of internal consistency with Cronbach coefficients of 0.84, 0.92, and 0.91. The questionnaire is focused on evaluating undergraduate students' understanding and awareness of the services provided by the library, and it is shown in appendix A.

To measure students' library anxiety, we employed Kannegiser's modified version of the questionnaire, based on the original Bostick's five-factor Library Anxiety scale.[40] Kannegiser modified it into four factors, which removed the mechanical barrier-anxiety for working with technology and machine.[41] We also translated the questionnaire into Thai and used a five-point Likert scale ranging from "strongly disagree" to "strongly agree." The questionnaire consists of five questions that assess the level of anxiety regarding Bostick's library anxiety, including:
(1) barriers with library staff—regarding librarians as unfriendly or unhelpful individuals that can cause anxiety; (2) affective barriers—the feeling of helplessness while working in the library; (3) comfort with the library—lack of comfort in the library resulting from the lack of security and sense of belonging, which can cause students to leave the library before finishing their research or refuse to go to the library altogether; and (4) knowledge of the library—unfamiliarity with library and information science skills, the library building, and different resources and facilities provided in the library, which can lead to fear and anxiety. The questionnaire is included in appendix B.

Open-ended Questionnaire

To explore students' perceptions of the usefulness of the Metaverse as a platform for promoting library services, we administered an open-ended questionnaire to a sample of students who had varying levels of experience with the platform. The questionnaire included open-ended questions that allowed students to freely express their opinions and provide detailed information on their experiences with the Metaverse-based library program. The questionnaire is included in appendix C.

Participants

Eighty first-year university students were recruited for the study because they are less likely to have had prior experience with academic libraries. Participants who had never used the university library were randomly assigned to either a Metaverse-based library program group or a traditional library program group, including 31 male (38.75%) and 49 female (61.25%)

participants. Please note that participants received financial compensation of one hundred baht (approximately 3 USD) for their participation in the study.

Procedures and Experimental Design
The study involved four distinct steps, with the second stage differing between the two groups. All participants completed the necessary questionnaires online, with only the Metaverse-based library program group doing open-ended questionnaires afterward. A flowchart of the procedure is presented in figure 4. Here we provide a detailed description of each of the four steps.

Step 1: Consent Form, Pre-test of Anxiety and Knowledge Questionnaire
Both groups completed a pre-test to assess their baseline knowledge of academic libraries and anxiety levels related to library programs. We administered both pre-tests using a Google Form survey that students accessed on their personal mobile devices. Participants in both groups also signed a consent form. This step aimed to evaluate the participants' understanding of library usage and anxiety levels. We estimated that this step would take around 30 minutes.

Step 2: Brief Description and Prepared Devices for Participants
In the second step, the Metaverse-based library program group used a 6DOF virtual reality device of Meta Quest 2, which accessed our Metaverse. We provided a brief description of how to use the device and made sure that there were no issues for the participants and gave the login details to the Metaverse system to each participant. Participants from both groups are shown in figure 3. Meanwhile, the research team also gave a brief description to the traditional library program group and separated them into small groups led by the library staff. Students then followed the activities assigned by the librarian by walking throughout the building, asking questions, reading signs, and working together. We estimated that this step would take approximately 30 minutes.

Figure 3. Traditional library program group (left) and
Metaverse-based library program group (right).

Step 3: Experiment
When the two groups confirmed the four task activities for the Metaverse platform and physical academic libraries in the university, the Metaverse-based library program group participated in an immersive library program within the Metaverse platform, as shown in figure 3, while the traditional library program group took a tour with a librarian in the academic library and were given tasks to do, mimicking traditional library experiences. Please note that even though both groups did the same activities, the Metaverse-based library program group had a gamification concept that involved incorporating game-like features such as level up, points, and leaderboards that were different from the traditional library program group. The content and activities of both groups are shown in table 2. We estimated that this step would take approximately two hours.

Figure 4. The virtual librarian in the Metaverse (left),
leaderboard implemented in the Metaverse (right).


Table 2. The content and tasks of both groups

Number	Metaverse-based library program group	Traditional library program group
Task 1: Library Orientation	Participants explore the virtual library in the Metaverse, follow the waypoints, and read signs and information.	Researchers assign participants to tour the library, follow the checkpoints, and read signs and information explained by librarians.
Task 2: Research Support	Participants interact with the assistance desk staffed by virtual librarians to explain the research supported by the library. The system requires participants to interact with the virtual librarian and answer their questions.	Librarians explain the services for research support in the academic library and then ask participants questions to check understanding.
Task 3: Book Services	In the Metaverse, the system asks participants to navigate the library's shelves and find books using the Dewey Decimal Classification system.	Librarians explain the Dewey Decimal Classification system and how to arrange the books on the shelves. After that, librarians will ask participants to find a specific book.
Task 4: Technology Services	Users can access the virtual reference desk in the Metaverse, staffed by virtual librarians who can assist with Technology Services support and answer their questions.	Researchers assign participants to checkpoints, and at each checkpoint, a librarian explains and asks questions regarding the Technology Services support provided by the library.

Step 4: Post-test of Library Anxiety, Knowledge Questionnaire and Open-ended Questionnaire
After completing the library programs, both groups completed a post-test to assess their knowledge acquisition and anxiety levels related to the library programs. Moreover, we administered an open-ended questionnaire to a sample of 40 participants from the Metaverse-based library program group only to gather their perceptions of the usefulness of the Metaverse platform. We estimated that this step would take approximately 30 minutes. After that we compared the pre-test and post-test scores to evaluate the impact of the Metaverse on first-year students' knowledge acquisition and anxiety levels related to library programs. We analyzed the

data collected from the questionnaires and pre/post-tests using both qualitative and quantitative methods.

Figure 5. Overview of the research methodology.
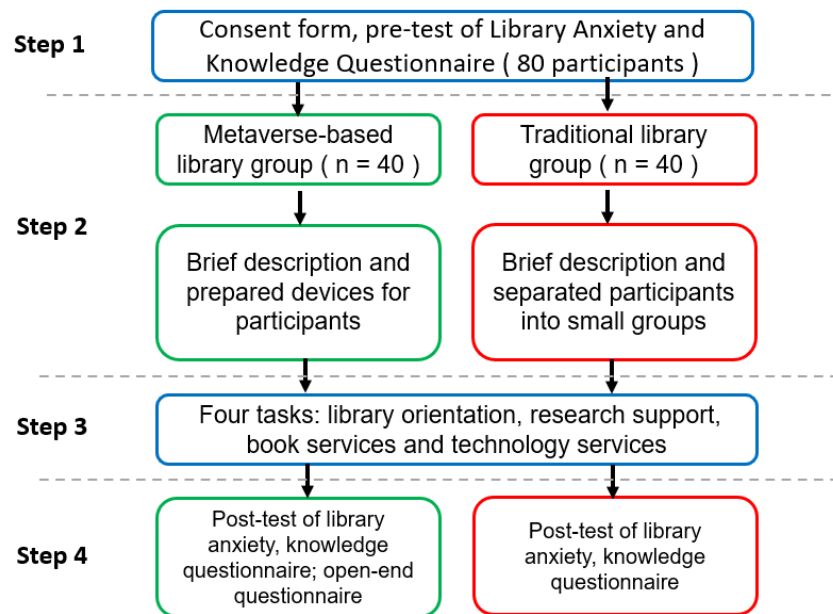
DATA ANALYSIS AND RESULTS

Results and Data Analysis of the Pre- and Post-Tests of Knowledge Acquisition
We analyzed the results of the pre- and post-tests designed to measure knowledge acquisition in academic libraries, comparing a control group (traditional library program) to an experimental group (Metaverse-based library program). Descriptive statistics were used to identify data trends in both groups. To determine the significance of specific knowledge acquisition, we conducted a paired sample t-test on the different scores between the pre- and post-tests for both groups. For questions that showed a significant impact, we calculated the effect size using Cohen's d test. A small Cohen's d value, around 0.2, suggests that the difference may not be very meaningful in the real world, while a large value, typically 0.8 or higher, indicates a practical and significant difference between the two groups. The results of the pre- and post-tests are shown in table 3 and the data analysis of the t-test is shown in table 4.

Forty participants were assigned to each of the two groups, control and experimental, with each group having a similar gender distribution. The mean pre-test scores were comparable between the two groups (control: M = 2.37, SD = 1.77; experimental: M = 2.45, SD = 1.79), indicating that the groups were equivalent at the beginning of the study. After completing the library programs, both groups showed significant improvement in knowledge acquisition, as indicated by their respective post-test scores (control: M = 17.50, SD = 4.87; experimental: M = 18.10, SD = 5.15). However, the t-test conducted to compare the pre–post differences between the two groups was not significant (p = .677), suggesting that the difference in the effectiveness between the two library programs was not statistically significant. Cohen's d effect size for the difference between the two groups was small (d = .244), indicating that the difference between the two groups was not practically significant.

Table 3. Results of the pre- and post-tests of knowledge acquisition of academic libraries.

Group	N	Pre-test (SD)	Post-test (SD)	Pre–post difference (SD)
Control (Traditional)	40 (15 male / 25 female)	2.37 (1.77)	17.50 (4.87)	15.12 (5.09)
Experiment (Metaverse)	40 (16 male / 24 female)	2.45 (1.79)	18.10 (5.15)	15.65 (5.71)

Table 4. Results of the t-test of the pre-post test difference and Cohen's d

	Mean	Std. deviation	Std. error mean	Sig. (2-tailed)	Cohen's d
Pre–Post	0.520	7.922	1.252	.677	.244

Results and Data Analysis of the Pre- and Post-Tests on Students' Library Anxiety

The results of the pre- and post-tests for the traditional library program and the Metaverse-based library program groups were analyzed to determine the impact on students' library anxiety levels. Paired t-tests were conducted on the different scores of the pre- and post-tests for both groups, and Cohen's d test was used to measure the size of the impact. In the traditional library program group, table 5 shows that the paired t-tests resulted in significant improvements in students' library anxiety levels in four out of five survey questions. Specifically, there was a significant decrease in anxiety related to asking librarians for help ($p = 0.012$), feeling overwhelmed in libraries ($p = 0.009$), feeling comfortable in libraries ($p = 0.061$), and utilizing library services and resources ($p < 0.001$). However, there was no significant difference in anxiety levels related to the availability of librarians to provide research and technology support ($p = 0.575$).

On the other hand, in the Metaverse-based library program group, table 6 shows significant improvements in anxiety levels related to feeling overwhelmed in libraries ($p = 0.025$) and utilizing library services and resources ($p < 0.001$). However, there was no significant difference in anxiety levels related to asking librarians for help ($p = 0.323$), feeling comfortable in libraries ($p = 0.512$), and the availability of librarians to provide research and technology support ($p = 0.390$). Furthermore, Cohen's d showed that there was a large impact on the question "I know how to utilize the services and resources offered by academic libraries" for both groups. However, it is important to note that while the Metaverse-based library program may be effective in reducing anxiety related to specific aspects of library use, it may not be as effective as the traditional library program in addressing overall library anxiety levels.

Table 5. Results of the traditional library program group regarding the paired t-tests with the addition of Cohen's d

	Pre-test (SD)	Post-test (SD)	Mean difference	Std. dev.	Std. error mean	Sig. (2-tailed)	Cohen's d
I am comfortable asking a librarian for help.	3.425 (0.50)	3.725 (0.59)	-0.300	0.723	0.114	.012	-.415
Libraries are welcoming places.	2.85 (0.76)	3.325 (1.07)	-0.475	1.339	0.211	.031	-.355
Libraries overwhelm me, so I feel frozen and don't even know where to begin.	2.85 (0.73)	3.35 (0.97)	-0.500	1.154	0.182	.009	-.433
The librarian is available to provide help in Research Support and Technology Services.	2.3 (1.11)	2.425 (1.05)	-0.125	1.399	0.221	.575	-.089
I know how to utilize the services and resources offered by academic libraries.	2.4 (0.98)	3.8 (0.85)	-1.400	1.428	0.225	<.001	-.980

Table 6. Results of Metaverse-based library program with paired t-tests
with the addition of Cohen's d

	Pre-test (SD)	Post-test (SD)	Mean difference	Std. dev.	Std. error mean	Sig. (2-tailed)	Cohen's d
I am comfortable asking a librarian for help.	3.275 (0.59)	3.35 (0.57)	-0.075	0.474	0.075	.323	-.158
Libraries are welcoming places.	2.725 (0.81)	2.825 (0.71)	-0.100	0.955	0.151	.512	-.105
Libraries overwhelm me, so I feel frozen and don't even know where to begin.	3.075 (0.69)	3.425 (0.59)	-0.350	0.948	0.150	.025	-.369
The librarian is available to provide help in Research Support and Technology Services.	2.225 (0.99)	2.425 (1.19)	-0.200	1.453	0.229	.390	-.138
I know how to utilize the services and resources offered by academic libraries.	2.325 (1.09)	3.675 (0.76)	-1.350	1.291	0.204	<.001	-1.045

Results of the Open-ended Survey Questionnaire
The survey questionnaire, conducted via Google Form with 28 participants, provided valuable insights into the users' perceptions of the Metaverse-based library program as a tool for promoting library services. Overall, the participants had a positive impression of the platform and found it to be a useful tool for accessing and utilizing library resources.

Learning and Knowledge Acquisition
The results of the qualitative survey questionnaire regarding learning and knowledge acquisition indicated that most of the participants provided positive feedback, stating that the Metaverse-based library program was an interesting, effective, and engaging way to promote learning and knowledge acquisition of library services in academic libraries. We extracted the positive feedback from all 34 comments, which noted that the platform was "interesting," "great," and "a good platform for learning." Some valuable feedback also stated that the platform was a unique and immersive experience that increased the users' interest in library resources. For example, one participant noted that "The platform is an innovative approach to learn about library resources. It was fascinating to explore the virtual library and discover new resources that I was not aware of before." The program was also found to be useful for learning the rules of book services and technology services provided by the library, as expressed by one participant: "I learned how to

find books from the shelf and how to use software services that I never knew about before. It was very useful for students at the university."

However, some participants highlighted concerns about the cost and accessibility of the program due to its requirement for virtual reality equipment. As one participant noted, "The platform requires expensive virtual reality equipment, which may limit its accessibility to some users." Furthermore, some participants reported experiencing symptoms such as nausea, dizziness, and loss of balance during the program, indicating potential health risks associated with the use of virtual reality.

Reducing Students' Anxiety towards the Library
According to the questionnaire on reducing students' anxiety, the Metaverse-based library program may have had limited impact on reducing anxiety related to the lack of familiarity with the library staff. However, the platform helped participants overcome anxiety related to the physical space of the library and not knowing how to use it. Most comments stated that the program "helped a lot to understand the library," "was great for reducing library anxiety," and "was a good platform for reducing library anxiety." One useful comment stated that "the program helped me understand how the library works and where to find resources without feeling lost or overwhelmed." The platform also helped participants feel more comfortable with library resources and reduced their anxiety about using them. Another participant commented that "The platform, using virtual reality equipment, was interactive and fun to use, which made it easier for me to remember where things were in the library."

However, some participants still reported that they feel that the platform could not reduce library anxiety in terms of lack of familiarity with the library staff. One participant noted that "I think that the platform cannot reduce the barriers with staff due to the virtual librarian, who is just an NPC (non-player character) that cannot communicate with the user." Some participants felt that the virtual librarian in the metaverse lacked the personal touch and empathy that they experienced when interacting with a real librarian. As one participant put it, "I feel that the virtual librarian felt robotic and unapproachable." Others noted that the virtual librarian was not able to answer their questions adequately or provide the same level of support and guidance that a real librarian could. To clarify, the "virtual librarian" in our Metaverse is an NPC, designed with predefined responses and interactions, in contrast to a human-controlled avatar. This design choice may have led to perceptions of reduced personalized engagement and empathy compared to interactions with actual library staff.

Perceptions of the Usefulness of the Gamified Metaverse in Promoting Library Services
The majority of the comments indicated that students had a positive perception of the usefulness of the Gamified Metaverse as a platform for promoting library services. They found the platform to be engaging, interactive, and enjoyable, which heightened their interest in accessing library resources. Apart from comments like "Good," "Fun," and "Great idea to implement game elements," one student specifically mentioned that "I feel that the Gamified Metaverse made it more enjoyable and engaging compared to the Metaverse without game elements." The students also appreciated the unique experience of competing with other users through game elements such as the leaderboard, quests, points, and leveling. Another student expressed that "I feel engaged and motivated to earn more points than other users when I see the leaderboard in the Gamified Metaverse," while another stated that "I believe that the Gamified Metaverse appears more interesting than the Metaverse without gamification. It feels like there's more than just a virtual environment without any interaction with other users or the surroundings."

DISCUSSION AND FINDINGS

Knowledge Acquisition of Academic Libraries (RQ1)
We compared the effectiveness of a traditional library program with a Metaverse-based library program in terms of knowledge acquisition. The results of the pre- and post-test analyses revealed interesting findings as shown in table 4. Both the control and experimental groups demonstrated significant improvement in knowledge acquisition based on their respective post-test scores. This indicates that both library programs were effective in increasing participants' knowledge. These findings suggest that engaging students in library programs, whether traditional or Metaverse-based, can lead to improved knowledge outcomes.

However, when comparing the effectiveness of the two library programs, the results of the t-test did not show a significant difference in pre–post differences between the control and experimental groups. This suggests that there was no statistically significant variation in knowledge acquisition between the two programs. In other words, the Metaverse-based library program did not demonstrate a significant advantage over the traditional program in terms of knowledge acquisition. The qualitative data also support this, as one comment mentioned: "The platform is an innovative approach to learning about library resources. It was fascinating to explore the virtual library and discover new resources that I was not aware of before."

To the best of our knowledge, there are no existing studies specifically exploring the use of the Metaverse for promoting libraries. However, our findings align with previous research that utilized augmented reality to enhance learning and the use of academic libraries, as well as virtual reality technology to improve the learning experience of using library services.[42]

Impact on Library Anxiety (RQ2)
In the traditional library program group, significant improvements were observed in students' anxiety levels for four out of the five survey questions, specifically, anxiety related to asking librarians for help, feeling overwhelmed in libraries, feeling comfortable in libraries, and utilizing library services and resources significantly decreased. In contrast, the Metaverse-based library program group demonstrated significant improvements in anxiety levels specifically related to feeling overwhelmed in libraries and utilizing library services and resources. This suggests that the immersive and interactive elements of the Metaverse-based program played a role in reducing anxiety in these areas. However, no significant difference was found in anxiety levels related to asking librarians for help, feeling comfortable in libraries, and the availability of librarians to provide research and technology support. These findings indicate that the Metaverse-based program may be less effective than the traditional program in addressing certain aspects of librarian participation.

Interestingly, the qualitative data from our study revealed that the Metaverse platform was not effective in reducing library anxiety compared to traditional programs. Participants expressed that the virtual librarian, being just an NPC (non-player character), was unable to effectively reduce barriers with the library staff. One participant mentioned that "I think that the platform cannot reduce the barriers with staff due to the virtual librarian, who is just an NPC that cannot communicate with the user." This lack of real interaction with librarians may have limited the program's ability to alleviate anxiety in certain areas. Our findings do not align with previous research that utilized augmented reality to reduce students' anxiety toward the library and specifically targeted non-traditional and international students.[43] Our findings suggest that the Metaverse is not effective for reducing library anxiety compared to other technologies such as augmented reality, which allow users to interact with real librarians.

Perceptions of Implementing Gamification (RQ3)
The qualitative data from our study shed light on the perceptions of students regarding the usefulness of implementing gamification in promoting library services within the context of the Gamified Metaverse platform. Overall, most comments indicated a positive perception of the platform's usefulness in enhancing library services. The students also appreciated the unique experience of competing with other users through game elements such as the leaderboard, quests, points, and leveling. They reported that they felt engaged and motivated to earn more points than other users when they saw the leaderboard in the Gamified Metaverse. This competitive aspect enhanced their experience and encouraged them to interact more actively with the platform.

Our findings on qualitative data align with previous research that utilized the concept of gamification in the Metaverse to enhance the learning experience.[44] However, it is important to note that these studies collected only qualitative data, which may not be strong enough to draw definitive conclusions about the effectiveness of gamification in the Metaverse.

Summary of Findings
Based on the study's results and the researchers' perspectives, the following findings can be summarized regarding the Gamified Metaverse platform:

- The Metaverse can enhance knowledge acquisition in academic libraries, although it did not demonstrate a significant advantage over traditional methods.
- The Metaverse was less effective in reducing library anxiety compared to traditional methods due to the lack of real interaction with librarians.
- Implementing game elements such as leaderboards, quests, and points can enhance student engagement and motivation in the Metaverse.
- However, developing the Metaverse requires expertise and significant resources, which may not be feasible for small libraries.
- The platform may have limitations such as the cost and potential side effects of virtual reality, making it more suitable as an alternative tool for specific student populations or those with accessibility needs.

CONCLUSION

The aim of this research was to study the effect of using the Gamified Metaverse platform to promote library services to university students. The study included 80 participants divided into a Metaverse-based library program group and a traditional library program group to assess and compare the effectiveness of the Metaverse. Our study addressed three research questions related to knowledge acquisition, library anxiety, and the perception of implementing gamification within the context of a Metaverse-based library program. In terms of knowledge acquisition, both the traditional library program and the Metaverse-based program effectively increased the participants' knowledge, with no significant difference between the two approaches. These findings suggest that both methods can lead to improved knowledge outcomes. Concerning library anxiety, the traditional program demonstrated significant improvements in various aspects, while the Metaverse-based program specifically reduced anxiety related to feeling overwhelmed and utilizing library services. However, it was less effective in addressing anxiety related to asking librarians for help and feeling comfortable in libraries. The qualitative data suggested that the absence of real interaction with librarians in the Metaverse may have limited its ability to alleviate anxiety in certain areas. Lastly, the perceptions of implementing gamification elements revealed

positive student responses to the Gamified Metaverse platform, as they appreciated the competitive elements and found them engaging and motivating.

FUTURE RESEARCH AND LIMITATIONS

Based on our findings, several potential areas for future research and limitations can be identified. First, it is important to consider the limitations of this study. The generalizability of the findings may be limited to the specific context of university students. Furthermore, this study did not comprehensively explore participants' previous experiences with virtual reality technology, which might have influenced their reactions and the symptoms reported. Understanding this aspect would provide a more nuanced insight into how familiarity with VR technology could influence user experience, particularly regarding anxiety and the physical symptoms associated with VR engagement. To enhance the validity and applicability of the results, future research should aim to replicate the study with diverse populations, thereby assessing the generalizability across different demographics. Second, conducting long-term studies would provide valuable insights into the sustained impact of the Gamified Metaverse platform. By examining knowledge retention, continued reduction in library anxiety, and prolonged engagement with library services over an extended period, researchers can better understand the long-term effects and benefits of using the platform. Lastly, exploring the potential integration of AI-powered chatbots or virtual assistants to enhance librarian-student interaction is an interesting avenue for future research. By incorporating virtual entities and utilizing artificial intelligence technology, researchers can explore how these elements can facilitate more realistic and engaging interactions between librarians and students within the Metaverse environment.

APPENDIX A: PRE-TEST / POST-TEST OF KNOWLEDGE ACQUISITION

1.	How are books arranged in the Dewey Decimal System?
2.	Who is automatically considered a library member without registration?
3.	What is the maximum number of books an undergraduate student can borrow?
4.	What are the channels for returning borrowed items after the library is closed?
5.	How many times can a student renew a borrowed book if they haven't finished reading it?
6.	On which channels can students renew their borrowed items by themselves?
7.	Under what circumstances can students not renew borrowed items from the library?
8.	What is the fine for failing to return a book on time?
9.	Can reference books be borrowed from the library?
10.	How are French books classified in the Dewey Decimal Classification?
11.	What type of books does the letter "N" refer to in the Dewey Decimal System?
12.	Please arrange the following call numbers in the correct shelf order: 734.8, 267.9, and 599.1.
13.	In which section would you find a book about the prime minister of Thailand?
14.	What channels can students use to keep track of new books in the library?
15.	What does ISBN stand for?
16.	What citation style is typically used for writing papers in engineering?
17.	When is Question Point available for online chat with a librarian?
18.	What is the name of the plagiarism checking service in the library?
19.	What services are available for disabled individuals who cannot physically reach the library?
20.	What does the acronym OPAC stand for?
21.	How can students use the plagiarism checking service in the library?
22.	What is the purpose of the library's interlibrary loan service?
23.	How can students access the library's online databases from off-university?
24.	What is the purpose of the library's document delivery service?
25.	How can students access the library's electronic reserves?
26.	What is the difference between UNIVERISTY e-Theses and UNIVERSITY e-Research?
27.	How can students request a book or article that is not available in the library's collection?
28.	What is the Journal of Open Access?
29.	What are the services offered by Open eBooks?

APPENDIX B: LIBRARY ORIENTATION: STUDENT POST-ORIENTATION QUESTIONNAIRE

On a scale of 1 to 5, please rate how much you agree or disagree with the following statements.

	1 Strongly Disagree	2	3	4	5 Strongly Agree
I am uncomfortable asking a librarian for help.	○	○	○	○	○
Libraries are welcoming places.	○	○	○	○	○
Libraries overwhelm me, so I feel frozen and don't even know where to begin.	○	○	○	○	○
The librarian is available to provide help in Research Support and Technology Services.	○	○	○	○	○
I know how to utilize the services and resources offered by academic libraries.	○	○	○	○	○

APPENDIX C: OPEN-ENDED QUESTIONS FOR STUDENTS

1.	How do you think the platform can support the learning and knowledge acquisition compared to the use of traditional library services?
2.	How do you think the platform can reduce students' anxiety towards the library compared to the traditional methods?
3.	What is your experience with the Gamified Metaverse platform for promoting library services? Do you think the game elements such as quests, challenges, and rewards impact your engagement?

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