Empirical Study on Factors Influencing Users' Intention to Use Public Library Makerspaces (Postprint)

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Date: 2023-08-26T00:00:00+00:00

Abstract

[Purpose/Significance] This study constructs a model of influencing factors on users' willingness to use public library makerspaces and provides suggestions for improving their operation. [Method/Process] Based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and integrating characteristics of public library makerspaces and users, a model was constructed. A questionnaire was designed and administered to public library makerspace users through online and offline channels to collect data, which was analyzed using Structural Equation Modeling (SEM). [Results/Conclusion] Performance expectancy, perceived enjoyment, perceived service quality, and individual innovativeness significantly and positively influence users' willingness to use public library makerspaces. Recommendations for operating public library makerspaces are proposed from four perspectives: meeting users' performance expectancy, enhancing perceived enjoyment, improving service quality, and promoting innovativeness.

Full Text

Preamble

ChinaXiv Cooperative Journal, Vol. 62, No. 9, May 2018
An Empirical Study on the Influencing Factors of User Willingness to Use Public Library Makerspaces
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Abstract

[**Purpose/Significance**] This study constructs a model of the factors influencing user willingness to use public library makerspaces to provide recommenda-

tions for improving the operation of such spaces. [**Method/Process**] Based on the Unified Theory of Acceptance and Use of Technology (UTAUT) and considering the characteristics of public library makerspaces and their users, we developed a model of the factors influencing user willingness to use public library makerspaces. We designed a questionnaire and collected data from public library makerspace users through both online and offline channels, analyzing the data using structural equation modeling. [**Result/Conclusion**] Performance expectancy, perceived enjoyment, perceived service quality, and personal innovativeness have significant positive effects on user willingness to use public library makerspaces. We propose recommendations for improving public library makerspace operations from four perspectives: meeting user performance expectations, enhancing user enjoyment perception, improving service quality, and fostering innovativeness.

Keywords: public library makerspace; UTAUT model; use intention
Classification Number: G252
DOI: 10.13266/j.issn.0252-3116.2018.09.011

Since 2006, the number of global makerspaces has grown nearly 14-fold, with approximately 1,400 makerspaces built or planned [1]. A makerspace is a physical venue that integrates functions such as laboratories, workshops, and machining rooms for knowledge sharing, aiming to enhance users' literacy in design, science, technology, engineering, arts, and mathematics through a series of innovative activities [2]. The essence of makerspaces—knowledge learning, sharing, and creation—aligns with the core functions of libraries, providing new opportunities for library service upgrades. Establishing makerspaces in libraries has become a prominent trend in recent years [3]. Library makerspaces can enhance users' enthusiasm for learning new knowledge and skills, improve their comprehensive literacy, and promote knowledge sharing and innovation through the makerspace environment, activities, tools, equipment, and professional services [4]. Currently, library makerspaces take various forms, such as study rooms, seminar rooms, workshops, studios, and processing labs. Some library makerspaces provide diverse tools and equipment including processing materials, electronic building blocks, rainbow cube kits, electronic sewing machines, 3D printers, CNC engraving machines, laser cutters, laser drilling machines, laser welding machines, and multimedia devices. They regularly organize various activities such as handicraft making, industrial design, robot programming, 成果展览, maker competitions, maker salons, and project seminars [5-6].

The use of library makerspaces has attracted scholarly attention. Zhang et al. validated the decisive role of perceived ease of use and perceived usefulness in users' willingness to use university library "digital media production" makerspaces based on the Technology Acceptance Model and Innovation Diffusion Theory [7]. Ming et al. verified the influencing factors of university students' participation in library makerspaces based on grounded theory, finding that participation attitude, participation norms, and perceived behavioral control were the main factors affecting willingness [8]. However, existing research has

primarily focused on university library makerspaces, lacking in-depth analysis of user willingness factors in public library makerspaces. University library makerspaces serve faculty and students whose primary purposes are academic learning and research. In contrast, public library makerspace users are highly diverse in age, education level, occupation, income, experience, interests, and needs, leading to different expectations regarding makerspace functions and values, and consequently different influencing factors compared to university library makerspaces. This study constructs a model of the factors influencing user willingness to use public library makerspaces and conducts a questionnaire survey to explore these factors, aiming to provide references for improving the operational effectiveness and user experience of public library makerspaces.

1. Introduction to the Unified Theory of Acceptance and Use of Technology

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a theoretical framework for studying user acceptance of information technology, proposed by V. Venkatesh et al. based on integrating elements from the Theory of Reasoned Action, Technology Acceptance Model, Motivational Model, Theory of Planned Behavior, Combined TAM-TPB, Model of PC Utilization, Innovation Diffusion Theory, and Social Cognitive Theory [9]. The model primarily explains how performance expectancy, effort expectancy, social influence, and facilitating conditions positively determine technology use intention. The UTAUT model has been widely applied as a theoretical foundation for technology acceptance research in studies on user willingness to adopt mobile libraries and electronic library technology services [10-11].

Since library makerspaces provide new technology services, the UTAUT model can be used to study the factors influencing user willingness to use public library makerspaces. In the model shown in Figure 1 [Figure 1: see original paper], performance expectancy refers to the degree to which users believe that using public library makerspaces will help them achieve their goals. It can be measured through three variables: perceived usefulness (PE1), comparative advantage (PE2), and outcome expectations (PE3) [9]. Perceived usefulness refers to the belief that using public library makerspaces is beneficial for improving users' work, study, or life. Comparative advantage indicates that using public library makerspaces enables users to perform better. Outcome expectations refer to users' estimates that using public library makerspaces will yield good results [12-14]. Research has validated that performance expectancy in the UTAUT model positively influences user willingness [11], leading to our first hypothesis: Performance expectancy has a positive effect on user willingness to use public library makerspaces (H1).

Effort expectancy refers to users' expectations regarding the amount of effort required to use public library makerspaces, which can be examined through three measurement variables: perceived ease of use (EE1), complexity (EE2), and ease of use (EE3) [9]. Perceived ease of use means users believe that learning to use

the tools, equipment, and materials in public library makerspaces is simple. Complexity refers to the time-consuming nature of using library makerspaces. Ease of use indicates that the tools, equipment, and materials in public library makerspaces are simple to use [12-13, 15]. Research has validated that effort expectancy in the UTAUT model positively influences user willingness [11], leading to our second hypothesis: Effort expectancy has a positive effect on user willingness to use public library makerspaces (H2).

Social influence refers to the impact on users from how important people in their social circles perceive public library makerspaces, which can be examined through three measurement variables: subjective norm (SI1), social factors (SI2), and image (SI3) [9]. Subjective norm means that most people important to the user recommend using public library makerspaces. Social factors refer to important people in the user's life using public library makerspaces. Image means that users believe using library makerspaces will enhance their status within their social group [13, 15-16]. Research has validated that social influence in the UTAUT model positively affects user willingness [11], leading to our third hypothesis: Social influence has a positive effect on user willingness to use public library makerspaces (H3).

Perceived enjoyment refers to the pleasure and happiness users feel when using public library makerspaces [17]. It can be examined through three measurement variables: the makerspace itself being interesting (PEN1), enjoyable communication with makerspace staff (PEN2), and the enjoyable process of using the makerspace (PEN3). The makerspace itself being interesting means the space is full of fun. Enjoyable communication with staff means interactions with makerspace personnel are pleasant and relaxing. The enjoyable process means using the makerspace is a pleasant and relaxing experience. Existing research has shown that perceived enjoyment positively influences use intention. For example, F.D. Davis et al. verified that perceived enjoyment positively influences the intention to use computers for work [17], and Bai Bo validated the positive effect of perceived enjoyment on university library WeChat user acceptance [18], leading to our fourth hypothesis: Perceived enjoyment has a positive effect on user willingness to use public library makerspaces (H4).

Perceived service quality refers to users' perceptions and cognitions of public library makerspace service quality, which is associated with service tangibility, reliability, responsiveness, security, and empathy [19]. It can be examined through four measurement variables: service variety (PSQ1), service timing (PSQ2), service notification (PSQ3), and service-content fit (PSQ4). Service variety means the makerspace offers a rich variety of services. Service timing means services are scheduled at convenient times for users. Service notification means the makerspace can promptly inform users about service matters. Service-content fit means makerspace services are tailored to user needs. Existing research has shown that perceived service quality positively influences use intention. For example, W.T. Wong et al. validated the positive effect of e-learning system service quality on user willingness based on the UTAUT model

[20], and N. Nisha et al. verified that mobile healthcare service quality positively influences mobile health adoption intention [21], leading to our fifth hypothesis: Perceived service quality has a positive effect on user willingness to use public library makerspaces (H5).

Personal innovativeness refers to users' characteristics of liking to try new technology services, which can be examined through three measurement variables: enjoying experiencing new technology (PI1), being willing to learn about new technology (PI2), and being willing to try new technology first (PI3) [22-23]. Existing research has shown that personal innovativeness positively influences technology use intention. For example, R. Thakur et al. verified that personal innovativeness positively influences the intention to use mobile payments for shopping [24], and A.Y.L. Chong verified that personal innovativeness positively influences mobile e-commerce user intention [25], leading to our sixth hypothesis: Personal innovativeness has a positive effect on user willingness to use public library makerspaces (H6).

Use intention can be measured through three aspects: willingness to use the makerspace (UI1), willingness to use it frequently (UI2), and willingness to recommend it to others (UI3) [9, 14].

3. Empirical Analysis

3.1 Questionnaire Design and Data Collection

Based on the above research hypotheses and measurement items, we designed a questionnaire using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The survey targeted users of three well-known domestic public library makerspaces: Changsha Library's New Triangle Makerspace, Shanghai Library's Innovation Space, and Shenzhen Public Library Makerspace. We employed a combined online and offline random sampling approach. To ensure the validity and reliability of both online and offline surveys, the online survey involved sending QQ messages individually to members of the "New Triangle Makerspace Activity Group" (with 1,864 members) to confirm their usage status and request questionnaire completion. The offline survey involved randomly approaching users around Shenzhen Library Makerspace and Shanghai Library Innovation Space on weekends and distributing electronic questionnaires to willing participants. The survey was conducted from July 1 to August 16, 2017, with 221 questionnaires distributed and 203 valid questionnaires collected.

3.2 Scale Reliability and Validity Testing

Scale validity is primarily measured through content validity, convergent validity, and discriminant validity [26]. All measurement items in this study were derived from mature scales used in previous research and were reviewed by users and experts, indicating good content validity.

Average Variance Extracted (AVE) is the mean variance extracted. It is gener-

ally believed that an AVE greater than 0.5 indicates ideal convergent validity for a latent variable [26]. As shown in Table 1 , the AVE values for latent variables are greater than 0.663, indicating good convergent validity for our scale. In Table 2 , the square roots of AVE for latent variables are all greater than the correlation coefficients between that variable and other latent variables (highlighted in bold), indicating good discriminant validity for our scale [26].

Reliability can be tested through composite reliability (CR) and Cronbach's alpha coefficient. Generally, CR and Cronbach's alpha values of 0.7 or above indicate good scale reliability. In Table 1, CR values are greater than or equal to 0.855 and Cronbach's alpha values are greater than or equal to 0.851, far exceeding 0.7, indicating good scale reliability.

Since the correlation coefficients between latent variables in Table 2 are relatively high, potentially causing multicollinearity issues, a collinearity diagnosis is necessary. Using SPSS linear regression for collinearity diagnosis of independent variables, we found tolerance values between 0.248 and 0.649, meeting the requirement of being greater than 0.1, and Variance Inflation Factor (VIF) values between 1.541 and 4.036, meeting the requirement of being less than 10, indicating no multicollinearity among latent variables [27].

3.3 Structural Equation Model Analysis and Validation

This study employed maximum likelihood estimation in AMOS 22.0 for structural equation model analysis and validation. We constructed a conceptual model of library user willingness influencing factors in AMOS, imported the data, and performed path estimation for the model. After multiple revisions to the conceptual model, we obtained the final validated model diagram and its main fit indices, as shown in Figure 2 [Figure 2: see original paper].

3.3.1 Model Fit Assessment Model fit assessment examines the degree of correspondence between the covariance matrix implied by the hypothesized model and the covariance matrix implied by the actual data. The main fit indices of our model, their recommended values, and evaluation results are shown in Table 3 .

As shown in Figure 2 and Table 3, the chi-square test p-value is $0.131 > 0.05$, not reaching a significant level, accepting the null hypothesis that the model fits the sample data well. Moreover, absolute fit indices (CMIN/DF, RMSEA, and GFI), relative fit indices (CFI, NFI, TLI), and comparative fit indices (PNFI, PGFI) all meet recommended value standards, indicating that the model overall fits the sample data well.

3.3.2 Model Testing In Figure 2, latent variables are represented by ellipses, observed variables by rectangles, and the standardized path coefficient values between them are equivalent to factor loadings in factor analysis, ranging from 0.75 to 0.97, meeting the standard requirement of being greater than 0.7, indicating

that these observed variables effectively reflect their constructs. The numbers on paths from latent independent variables to latent dependent variables are standardized regression coefficients, with positive or negative signs indicating positive or negative effects, and the magnitude indicating the strength of influence. Whether these path coefficient values are supported by the data model requires significance testing.

From the test results of unstandardized path coefficient estimates (see Table 4), the critical ratio (C.R.) is the ratio of parameter estimate to standard error, equivalent to a t-test value. When the absolute value of C.R. is greater than 1.96, the parameter estimate reaches the 0.05 significance level; when greater than 2.58, it reaches the 0.01 significance level. This study adopts a 0.05 significance level, and paths with significant parameter estimates at this level are supported by the model data. Table 4 lists the significance tests for hypotheses regarding relationships between the six independent variables (PE, EE, SI, PEN, PSQ, PI) and use intention (UI), as well as relationships between the seven latent variables (PE, EE, SI, PEN, PSQ, PI, UI) and their observed variables. Paths with coefficients set to 1 are not tested.

As shown in Table 4, all path coefficient estimates between latent variables and their corresponding observed variables pass the test, indicating that these relationships are supported by the sample data. Among the tests of path coefficients between latent variables, except for "UI←EE" with a significance level of 0.630 and "UI←SI" with a significance level of 0.444 (both greater than the 0.05 significance level), the path coefficient estimates for "UI←PE," "UI←PEN," "UI←PSQ," and "UI←PI" all pass significance tests, indicating that H1, H4, H5, and H6 are supported by the sample data. In the AMOS output, the squared multiple correlation for the use intention variable is 0.847, indicating that the model's overall explanatory power reaches 84.7%.

4. Results and Discussion

Based on the analysis and validation of the influencing factors model for public library makerspace user willingness, we can analyze and discuss the relationships between latent variables and path coefficients.

The data analysis results show that performance expectancy, perceived enjoyment, service quality, and personal innovativeness have significant positive effects on public library makerspace user willingness, while effort expectancy and social influence do not have significant effects on public library makerspace user willingness. Thus, H1, H4, H5, and H6 are supported, while H2 and H3 are not.

Performance expectancy has a significant positive effect on makerspace use intention, which aligns with the characteristic that user behavior is purposeful. Users have various needs in learning, work, and life, and needs generate behavioral motivation. If library makerspaces can meet users' goal-oriented needs, users will develop willingness to use them. Zhang et al.'s research partially validates this conclusion [7]. Perceived enjoyment has a positive effect on mak-

erspace use intention, which may be related to the activity characteristics of library makerspaces. Many handicraft making and mechanical/electronic product creation activities in public library makerspaces require users to use both hands and brains and collaborate with others. Users can feel pleasure and relaxation in this process and obtain spiritual satisfaction, which positively influences their use intention. Perceived service quality has a positive effect on makerspace user willingness. If public library makerspaces can provide rich, diverse, and personalized services that meet users' diversified and personalized needs, they will bring good user experiences and promote use intention. Ming et al.'s research also partially validates this conclusion [8]. Personal innovativeness has a positive effect on public library makerspace use intention, possibly because users with stronger individual innovativeness have greater curiosity, sensitivity, and acceptance of new concepts, technologies, and services, making them more likely to use new technology services. Therefore, personal innovativeness positively influences public library makerspace user willingness, and Ming et al.'s research also partially validates the effect of personal innovativeness on makerspace use intention [8].

Effort expectancy does not have a significant effect on public library makerspace use intention, a conclusion different from research on university library makerspaces [7]. This may be because university library makerspace users are primarily faculty and students whose purposes are academic learning and research. The space environment, layout, tools, equipment, materials, training, and activities provided by university library makerspaces all serve these purposes. Additionally, university users have relatively high educational levels and learning abilities, and may have prior experience with the tools, equipment, and materials before using the university library makerspace, making it relatively easy for them to use these spaces. Moreover, university libraries implement a one-card system, and some makerspace services requiring user reservations can be self-booked through campus accounts. Overall, the process for university users to access library makerspaces is very convenient. These factors reduce the difficulty for university users to access library makerspaces, making ease of use an influencing factor for university library makerspace use. However, the situation for public library makerspaces is more complex.

On the one hand, public library users come from diverse groups including civil servants, experts, scholars, engineers, programmers, students, and stay-at-home mothers. Their ages, knowledge backgrounds, education levels, occupations, incomes, learning abilities, and needs all differ, leading to different expectations regarding the functions and value of public library makerspaces and different costs they are willing to incur. On the other hand, public library makerspaces provide diversified services for these diverse users, including handicraft making, mechanical/electronic product creation, robot programming, maker salons, maker exhibitions, study rooms, and seminar rooms. The perceived difficulty and time required for different users to use different services may vary greatly. Additionally, public library makerspace activities are often held on weekends with limited spots, creating a situation where demand exceeds supply and users'

participation desires are not fully satisfied. These factors cause different users to have different standards for measuring the effort required to use public library makerspaces, resulting in effort expectancy not significantly influencing public library makerspace user willingness.

Social influence does not have a significant effect on public library makerspace use intention, which differs from the conventional situation where opinion leaders' approval can drive faculty and students to use university library makerspaces. First, compared to university users, public library makerspace users have limited usage frequency and no pressure from academic learning or research, and may even have no clear purpose for use. Their usage behavior cannot fully demonstrate the value of public library makerspaces and cannot generate strong persuasion to drive their social circles to use them. Second, there is insufficient social connection between public library makerspace users and non-users, and users' experiences are not widely disseminated among public library user groups, failing to leverage word-of-mouth effects. Third, the use of public library makerspaces is purely voluntary, and many studies have shown that under voluntary (as opposed to mandatory) usage conditions, social influence does not significantly affect use intention. Additionally, since public library makerspaces have only recently emerged with a limited user base, they have not yet formed a social trend that can drive potential new users. These factors result in social influence not significantly affecting public library makerspace use intention.

In Figure 2, the standardized path coefficients between use intention and performance expectancy, perceived enjoyment, service quality, and personal innovativeness are 0.29, 0.25, 0.19, and 0.36, respectively, indicating that personal innovativeness has the strongest influence on makerspace user willingness. This may be because activities in public library makerspaces such as handicraft making, robot programming, and mechanical/electronic product creation are inherently creative, attracting users with innovative characteristics more strongly. Therefore, the positive effect of personal innovativeness on use intention is more pronounced compared to other factors.

5. Conclusions and Recommendations

The above research demonstrates that performance expectancy, perceived enjoyment, service quality, and personal innovativeness positively influence public library makerspace user willingness. Therefore, we propose that future improvements to public library makerspaces should focus on four aspects: meeting user performance expectations, enhancing user enjoyment perception, improving service quality, and fostering innovativeness.

To meet user performance expectations, public library makerspaces should organize different types of makerspace activities targeting user needs such as enriching life, finding inspiration, improving literacy, realizing creative ideas, and project incubation, thereby meeting diverse user needs. They should strengthen

connections with academia and industry, jointly organize makerspace 成果展览, maker salons, maker competitions, and maker lectures, compile user directories to recommend collaborators for users, and fully leverage their platform role to facilitate connections for maker project incubation, industry-academia-research integration, and industrialization of maker 成果.

To enhance user enjoyment perception, public library makerspaces should organize rich and colorful activities tailored to individual user characteristics and needs to attract diverse users. They should develop activities of varying difficulty levels based on users' knowledge backgrounds, learning abilities, and needs to avoid the impact of difficulty-related anxiety on user mood. They should emphasize activity diversity, 趣味性, and novelty, allowing users to choose activities they are interested in, encouraging them to bring partners, and helping users form collaborative groups to complete activity tasks, thereby enhancing their enjoyment perception during participation. For example, they can organize simple and interesting handicraft making series for stay-at-home mothers with children and handicraft enthusiasts, and organize robot competitions, maker contests, and maker projects to provide platforms for users passionate about programming and creation to showcase their talents and achieve accomplishments. Additionally, the makerspace environment should be designed to create a relaxed and pleasant atmosphere, and makerspace staff should communicate with users warmly and generously to ensure participants have a pleasant mood.

To improve service quality, first, public library makerspaces should secure sufficient funding through fiscal appropriations, social crowdfunding, and donations to purchase advanced materials, tools, equipment, and related resources, and organize user training. Second, they should optimize the timing and frequency of makerspace activities, emphasizing continuity and serialization of activity content. Through user surveys and behavioral data analysis, they should understand users' personalized needs and provide customized activity services, ensuring that makerspace activities meet user needs in terms of frequency, timing, spots, and content. Third, they should improve the comprehensive quality and service awareness of makerspace management personnel. Managers should possess strong organizational planning, interpersonal communication, coordination skills, enthusiastic service attitudes, and dedication. To this end, qualified makerspace users can be developed as volunteers to assist with makerspace management, allowing managers to integrate with users, grasp user needs and trends, and continuously optimize service quality.

To highlight the innovative characteristics of makerspaces, public library makerspaces should innovate in both service forms and content, examining diverse services provided by domestic and international makerspaces combined with library strengths and specialties, and offering customized services based on users' personalized and dynamic needs. Possible services include: (1) providing space services such as study rooms and seminar rooms; (2) providing training, guidance, and usage services for makerspace tools and equipment such as electronic building blocks, rainbow cube kits, electronic sewing machines, 3D printers,

3D scanners, CNC engraving machines, laser cutters, laser drilling machines, laser welding machines, precision machine tools, multimedia devices, Arduino, and Raspberry Pi; (3) providing activity services such as maker sharing sessions, making activities, competitions, salons, and 成果展览 that connect innovation and entrepreneurship; (4) providing professional information services such as sci-tech novelty searches, literature consultation, and reading recommendations; (5) providing personalized customization services. Moreover, ideal makerspace usage is a long-term process. To this end, highly-rated makerspace services should be normalized and systematized, with regular evaluations of service effectiveness. For example, interest classes, training courses, competitions, project incubation, and 成果展览 should be organized regularly as serialized activities, with activity effectiveness evaluated and improved to enhance user experience, increase user stickiness, and improve makerspace resource utilization.

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Author Contributions

Gao Yan: Responsible for data collection, questionnaire survey, and paper writing;
Sheng Xiaoping: Responsible for topic selection and paper revision.

Note: Figure translations are in progress. See original paper for figures.