# Consistency of Use Flow Improving User Experience of Service-Oriented Websites

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**Abstract.** Based on the theories of user experience and mental model, the paper takes two representative E-banks of China for case study. Method of questionnaire is used to determine research object and contents, observation is used to obtain mental model of users and actual model of E-banks, and path search is applied to verify the relationship between mental model and actual model. An innovative research of E-banks' login, transfer and remittance by usability test has been done to analyze participants' task completion time, task completion rate, heat map, scan path and other indicators affecting user experience, in which case the assumption that consistency of use flow can improve user experience of service-oriented websites is validated.

**Keywords:** Service-Oriented websites · E-bank · Use flow · Consistency · Mental model · User experience

## 1 Introduction

Nowadays people are getting more and more accustomed to the Internet with its popularization. Online shopping, online transfer and online ordering have become a common way of life while websites have gradually become the most important carrier for people to acquire information and to interact with others and the society, which provides a sufficient space for the development of service-oriented websites. Currently, there exist rich theories of interaction design and user experience home and abroad such as user-centered design, goal-oriented design and user mental model. However, studies on website use flow are in great shortage, let alone studies on use flow of service-oriented websites.

In-depth study is needed when users get to the websites at the beginning and several practices will lead to a fixed use flow model. Mental model of user operation, as a fixed using habit, will certainly be constructed after using similar use flow models. Robert Hoekman put forward the concept of user mental model and designed pattern library


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from the perspective of user experience to provide standard solutions for the same or similar issues, thus creating consistent user experience across multiple sites [1].

At present, service-oriented websites in China differ greatly from each other due to different image orientation and cultures of enterprises. Consistent use flow of service-oriented websites makes it possible for the implementation model to be more similar to the user mental model, which requires less cognitive time for users to use websites [1]. Under such circumstances, it will not only save users' cognitive and learning time but also be more in line with the user's habits and psychological expectations. Besides, websites' versatility, re-utilization, efficiency and usability will be greatly enhanced.

### 1.1 Service-Oriented Websites

Websites can be divided into three overlapped types according to their functions: content-based websites, service-oriented websites and e-commerce websites. The service-oriented website, as its name implies, is to focus on providing service. It serves as the main carrier to realize the functions of websites to meet users' demands of seeking particular help or completing special tasks with a very specific purpose, to name a few, Industrial and Commercial Bank of China (ICBC) and China Mobile Online Business Office.

According to the definition of service-oriented website, it mainly aims at providing particular service for users. There are four main features of these service-oriented websites. Firstly, service-oriented websites can provide users with more specific services because the information they contain only relates to one certain field [2]. Secondly, users who visit service-oriented websites usually have a strong sense of purpose [2]. Thirdly, design of service-oriented websites must consider usability. Fourthly, use flow of the same or similar modules in the service-oriented websites tends to be consistent. As Joshua Porter put it, the most appealing application is the one which enables people to accomplish a specific task excellently [3]. And service-oriented website is exactly the application.

### 1.2 User Experience

The concept of user experience was first proposed by Donald Arthur Norman, which has gradually affected all fields of human activity with the infiltration of computer science in mobile and graphics technology [4]. User experience refers to the behavior, thoughts and personal feelings of the user in the use process of a product or a service, including rational and sensible experience provided by the product or service [5]. Design brings both practical products and improved service, experience and value. User experience reflects the user-centered and people-oriented design philosophy [6]. User experience of web interface is the subjective psychological feelings which are formed when the user interacts with the interface, including user's acceptance of the website, the degree of pleasure when using it and the degree of tolerating website vulnerability [7]. When mapped to the web interface design, user experience covers functional design, information structure design, interactive design, visual design and so on. Humanization and rationality of web interface design have a direct impact on user experience [8].

### 1.3 Mental Model

Mind is all the spiritual activity of mankind. Kenneth Craik, a Scottish psychologist, was the first one to put forward mental model in 1943 to explain individual's cognitive process of the operation of something in real world [9, 10]. It was Johnson Laird who started to take mental model into real practice to describe the way of problem-solving and the thinking patterns of deductive reasoning [10]. Mental model is established when the individual is disrupted by external stimuli, then the brain recognizes and picks up needed information to process, and finally rules or experience are preserved.

Mental model of service-oriented websites can be divided into macro and micro levels. Macro-level refers to the users' cognitive structure and content on attitude and activity level, including key concepts, product expectations, task flows and related models of service-oriented websites [9]. Micro-level refers to the prospective cognition when users complete a specific operation or task. It is an internal concept record when users interact with the websites [11]. It is also an indispensable part of website design to study its internal mental model through observation and analysis of users objective behaviors [12].

### 1.4 The Effect of Mental Model on User Experience of Service-Oriented Websites

Norman proposed three models in interaction design: (1) Mental model. It is the cognition of function and behavior on service-oriented websites that users should have in their brains. (2) Represented model. It is the way that the designer chooses to present the service-oriented websites to users [13]. (3) Implementation model. It is a real working model of websites when service-oriented websites are in use. During the whole designing process of service-oriented websites, mental model determines design direction of web interface. Represented model of clear and concrete service-oriented websites which correspond to users' mental model should be developed by investigating needs of target users [14]. It will be much easier for users to accept it when final implementation model matches well with mental model [15].

Generally speaking, effects on user experience of service-oriented web interface by mental model involve three parts. Firstly, it removes learning and cognitive burdens of users. Secondly, it improves the efficiency of the user to complete the task. Thirdly, it promotes user satisfaction. However, there are still some limitations when mental model functions on service-oriented websites due to its own restrictions. For instance, mental models differ from one another in that every environment is unique, which results in complicated research contents as well as high requirements for researches.

## 2 Research on Mental Models of Service-Oriented Websites: Taking E-Banks as an Example

We may infer from the effects of mental model on user experience of service-oriented websites that such user experience can be improved when implementation model is consistent with mental model. Therefore, it is deduced that consistent design may

contribute to better user experience of the website. Similarly, consistency of use flow can enhance user experience of service-oriented websites.

In order to know whether the reference is feasible or not, the study takes E-banks as an example from the perspective of user experience to analyze the function of consistent use flow by means of researching implementation model and mental model of E-banks.

### 2.1 Identification of Target Users and Research Contents of E-Banks

According to the study on mental model of E-banks, we have distributed a questionnaire entitled *Personal Use of E-Banks* online and totally received 102 valid copies. On the basis of the data obtained, people aged under 30 with bachelor degree or above have been chosen to be our target users for observation and interviews. Then we take Industrial and Commercial Bank of China (ICBC) and Agricultural Bank of China (ABC) as research objects and we set transfer, remittance, registration and login as research contents.

### 2.2 Acquisition of User Mental Information of E-Banks

**Interview to Obtain User Mental Model.** According to investigation results, three users with obvious characteristics were selected to have an in-depth interview with the results recorded to acquire users' subjective demands for e-banks and to establish mental models to complete the three tasks. Based on the correspondence between user mental model and user experience elements, specific needs of users are respectively matched with five levels of user experience proposed by Jesse James Garrett [6] (Table 1).

**Table 1.** User requirements corresponding to user experience elements

| User experience elements | User's specific requirements |
|---|---|
| Surface | Clear website interface; Consistent performance style |
| Skeleton | Accurate and reasonable navigation classification; Accurate and consistent language expression |
| Structure | Timely feedback; Provide boot and helpful information; Allow undo action |
| Scope | With account inquiries, transfer and remittance, shopping, payment, wealth management and other functions |
| Strategy | Provide users with financial services |

Based on the above analysis, mental models of user completing registration, login and transfer and remittance are extracted, including key page jumps and operation behavior, as shown in Figs. 1 and 2.

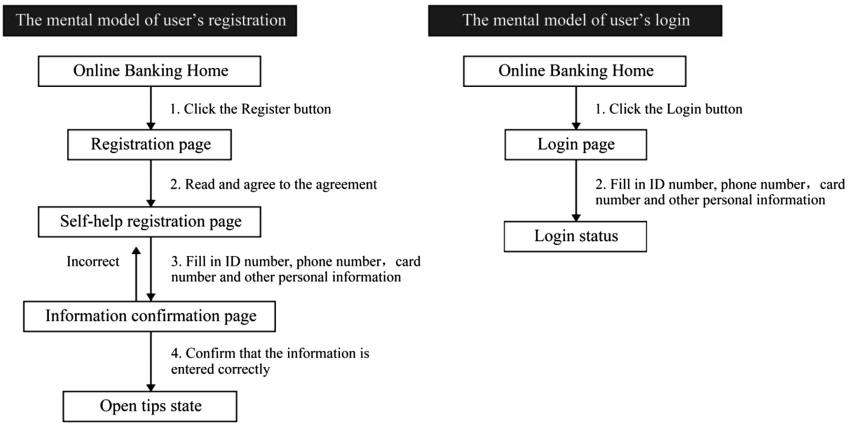


**Fig. 1.** The diagram of mental model of user's e-bank registration and login

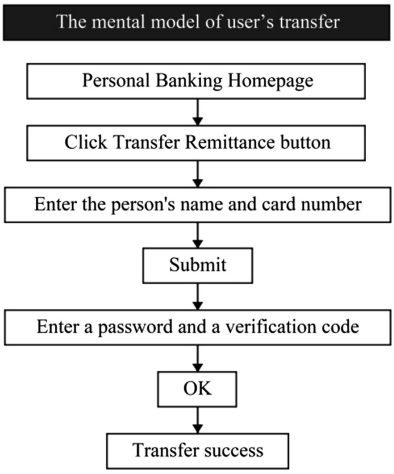


**Fig. 2.** The diagram of mental model of user's transfer and remittance

**Observation to Obtain Implementation Model of E-banks.** 20 people among target users were invited to respectively use ICBC and ABC to complete three tasks including registration, login, and transfer and remittance. The implementation models of three tasks were concluded by observing and recording the users' operation process (including key pages and operation behavior). (1) The diagram of implementation model of ICBC and ABC registration (Fig. 3). (2) The diagram of implementation model of ICBC e-bank login (Fig. 4). The diagram of implementation model of ABC e-bank login (Fig. 5). (3) The diagram of implementation model of ICBC and ABC e-bank transfer and remittance (Fig. 6).

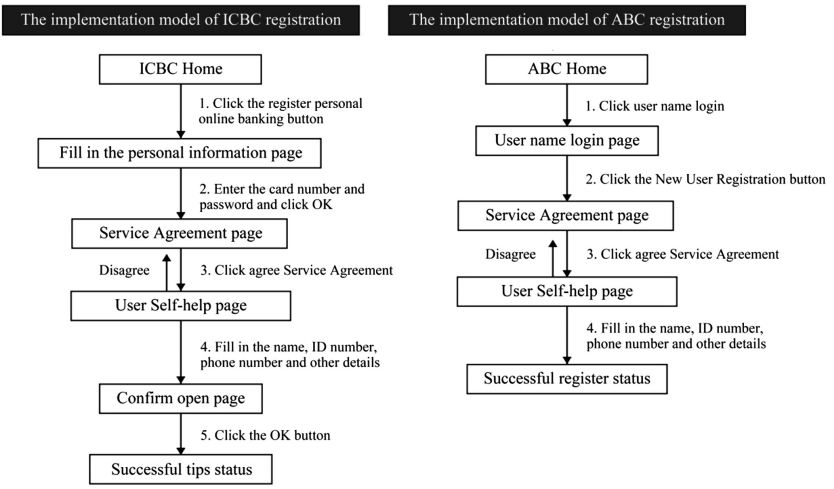


**Fig. 3.** The diagram of implementation model of ICBC and ABC registration

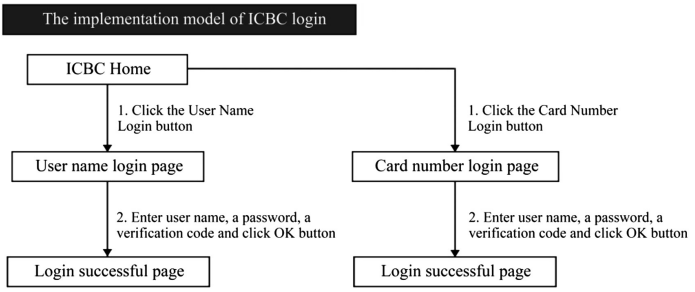


**Fig. 4.** The diagram of implementation model of ICBC e-bank login

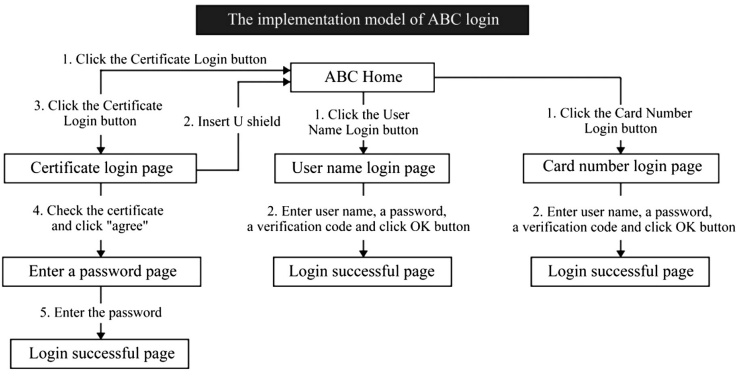


**Fig. 5.** The diagram of implementation model of ABC e-bank login

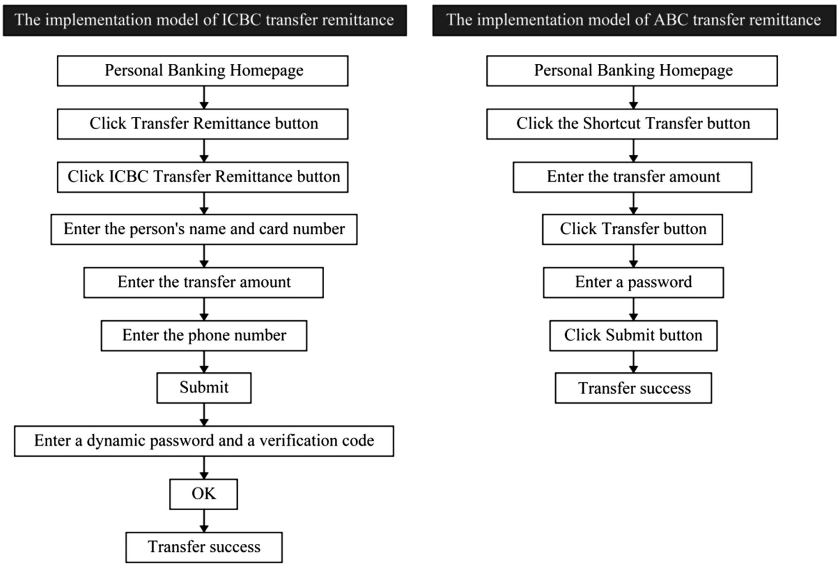


**Fig. 6.** The diagram of implementation model of ICBC and ABC e-bank transfer and remittance

## 2.3 Analysis of User Mental Information of E-Banks

Mental model of user is assumed to be the optimal path to accomplish the task and is compared with implementation models of ICBC and ABC, in which case method of path search is applied to analyze relevance between the two ones. First of all, the key pages and operation behavior of user mental models are numbered as shown in Table 2. Then the distance matrix of GT-PD algorithm is used to represent each model. The vector of mental models of the users' registration and login is represented as $A_1$ = (1 2 3 4 1 2 1 2 3 2 3 1 2 3 4 1 4 5 5 6 1). The vector of mental model of transfer and remittance is represented as $B_1$ = (1 2 3 4 5 6 1 2 3 4 5 1 2 3 4 1 2 3 1 2 1). We can calculate $\bar{a}_1$ = 2.667 and $\bar{b}_1$ = 2.667 (Table 3).

**Table 2.** Numbers of key pages and operation behaviors of mental model

| | |
|---|---|
| 1. E-bank Homepage | 8. Personal E-bank Homepage |
| 2. Service Agreement page | 9. Click the Transfer button |
| 3. User Self-help Registration page | 10. Enter the transfer amount |
| 4. Registration Confirmation page | 11. Click the Submit button |
| 5. Tips of Successful Registration page | 12. Enter password and verification code |
| 6. Login page | 13. Click Submit button |
| 7. Successful Login page | 14. Successful Transfer |

Matrix vector of ICBC for registration and login is calculated as $A_2$ = (2 3 4 5 1 2 1 2 3 3 4 1 2 4 5 1 5 6 6 7 1); matrix vector of ICBC for transfer and remittance is

**Table 3.** Numbers of model distance matrix

| | User mental model | ICBC | ABC (Card number or user name login) | ABC (Certificate Login) |
|---|---|---|---|---|
| Registration and login | $A_1$ | $A_2$ | $A_3$ | $A_4$ |
| Transfer and remittance | $B_1$ | $B_2$ | $B_3$ | $B_4$ |

calculated as $B_2$ = (1 4 6 7 8 9 3 5 6 7 8 2 3 4 5 1 2 3 1 2 1). Then conclusion is drawn as $\bar{a}_2 = 3.2381$ and $\bar{b}_2 = 4.1905$. Matrix vector of ABC when the user registers and selects the card number or user name to login is calculated as $A_3$ = (2 3 4 5 1 2 1 2 3 1 2 1 2 2 3 1 3 4 4 5 1); matrix vector of ABC when the user registers and selects certificate login is calculated as $A_4$ = (2 3 4 5 3 5 1 2 3 5 6 1 2 6 8 1 7 9 8 10 2); matrix vector of ABC for transfer and remittance is calculated as $B_3$ = (1 3 4 5 6 7 2 3 4 5 6 1 2 3 4 1 2 3 1 2 1). Then conclusion is drawn as $\bar{a}_3 = 2.4762$ $\bar{a}_4 = 4.4286$ and $\bar{b}_3 = 3.1429$.

SPSS is used to calculate global correlation coefficient between $A_1$ and $A_2$, $A_1$ and $A_3$, $A_1$ and $A_4$ and to analyze the correlation between various distance matrices. The conclusion comes out as $N_1 > N_3 > N_2$, which indicates that implementation model of ICBC when completing registration and login is the closest to user mental model and can most satisfy users' psychological expectations. According to researches mental model's effect on user experience of service-oriented websites, it is predicted that users will be most satisfied using ICBC to register and log in (Table 4).

**Table 4.** Global correlation coefficients between registration and login models

| | ICBC $A_2$ | ABC (Card number or user name login) $A_3$ | ABC (Certificate Login) $A_4$ |
|---|---|---|---|
| User mental model $A_1$ | $N_1 = 0.9789$ | N2 = 0.8731 | $N_3 = 0.9167$ |

SPSS is used to calculate global correlation coefficient between $B_1$ and $B_2$, $B_1$ and $B_3$ to ensure accuracy. The conclusion comes out as $M_1 < M_2$, which indicates that implementation model of ABC when completing transfer and remittance is the closest to user mental model. According to researches on mental model's effect on user experience of service-oriented websites, it is predicted that users will be most satisfied using ABC to complete transfer and remittance (Table 5).

**Table 5.** Global correlation coefficient between each model of transfer and remittance

| | ICBC $B_2$ | ABC $B_3$ |
|---|---|---|
| User mental model $A_1$ | $M_1 = 0.9231$ | $M_2 = 0.9723$ |

# 3 Assumption and Experimental Verification on Use Flow Consistency of E-Banks

## 3.1 Experimental Hypotheses and Experimental Purposes

**Experimental Hypotheses.** The previous research has revealed that a consistent design of service-oriented websites can provide a better user experience. If implementation model of e-bank is consistent with users' mental model, whether it can be inferred that implementation models of all e-banks are also consistent, which means use flow of all e-banks needs to be consistent.

E-banks serve as an example to solve the problem above and to verify the correctness of the inference objectively by means of usability test, which shows whether the assumption of "use flow consistency of e-banks" is valid.

**Experimental Purposes.** The usability test studies for specific operations of e-banks. It mainly analyzes completion degree, completion efficiency, completion time and user satisfaction degree of the given task through the information recorded by the eye movement apparatus, the experiment video and the post-experiment interview, with the aim to analyze whether the consistency of use flow is conducive to enhancing user experience of e-banks (Figure 7).

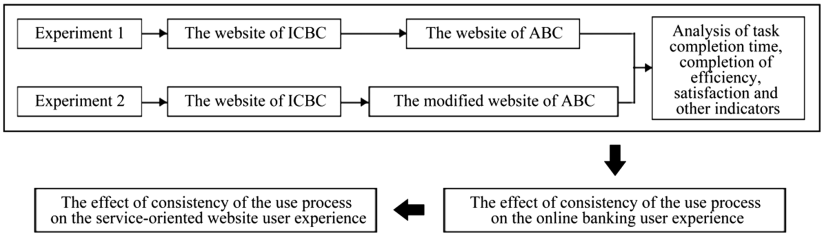


**Fig. 7.** Usability test of e-banks use flow consistency

## 3.2 Experimental Design

**Determination of the Experimental Subjects, Objects and Tasks.** The test involves 39 participants who have used two or more kind of e-banks and are familiar with the interface. Experimental scope is determined as follows (Table 6):

**Experimental Tasks.** Contrast test method is adopted in the experiment: Usability tests are respectively conducted using consistent flow and inconsistent flow as a comparison. Experiment 1 is to test on the original website interface, that is prototype interface with inconsistent flow (Prototype A and Prototype B). While in experiment 2, the modified web interface is tested using a consistent flow prototype (Prototype A 'and Contrast Prototype B').

Registration of personal account of e-banks and transfer and remittance are included in the experimental tasks. Each is required to complete the experimental task in order.

**Table 6.** Summary of experimental subjects, objects and test tasks

| Factors | Results | Determine the scope |
|---|---|---|
| Age and education of subjects | (1) 51.8% of the surveyed users were under 30<br>(2) 82.4% of the users education is undergraduate or above | (1) Aged 30 or below<br>(2) Bachelor degree or above |
| Objects | (1) ICBC accounted for 50%<br>(2) ABC accounted for 26.2% | (1) ICBC<br>(2) ABC |
| Testing tasks | (1) E-bank operations first need to log in personal accounts<br>(2) Transfer and remittance accounted for 25.22% | (1) Log in a given personal account<br>(2) Transfer to an account |

Note: Testers are those who have used two or more kind of e-banks and are familiar with use flow of them.

### 3.3 Experimental Prototype Design

The first experiment is to operate the existing websites of ICBC and ABC, which differ greatly from each other. There is only one way to log in ICBC by account while three different login methods are allowed in ABC (Figure 8).


**Fig. 8.** Comparison of login method between prototype A and prototype B

The premise of experiment 2 is to make operation flow of the test object remain consistent. According to the preceding analysis of user mental model of e-banks—implementation model of ICBC is the closest to user's login mental model, the prototype A'—use flow of ICBC website, is set to remain unchanged. And Dreamweaver is used to produce a prototype B' which is the same as prototype A' in use flow. That is to assimilate the operation process of ICBC into ABC on the basis of original use flow of ABC. In order to make experimental results not affected by other factors, this change is under the premise that other aspects remain unchanged. The interface of the final prototype B' is shown in Figs. 9 and 10.


**Fig. 9.** Modified login interface of ABC


**Fig. 10.** Modified transfer interface of ABC

### 3.4 Analysis of Experimental Results

**Task Completion.** As is shown in the experiment result, there are altogether 20 people going through the experiment, among which only 14 experiments are valid ones. Eight participants have completed all the tasks which accounts for 57.14% and two participants succeeded nothing. Task completion rates of prototype A and prototype B are 71.43% and 64.29%, respectively. In experiment 2, 19 people took part in the test with 16 experiments in the end turning out valid ones. Task completion rate of prototype A' and prototype B' are 93.75% and 100%, respectively. To conclude, original website interface of experiment 1 has more usability problems than those of experiment 2.

**Task Completion Time.** Firstly, SPSS is used to analyze time samples of each task to verify if the emergence of experimental data can be promoted to the overall scope of service-oriented websites. Then, according to the significant variance and the average value of task completion time, it is analyzed whether the changes of use flow will affect task completion, and whether the user's experience with ICBC (the former operation of the test object) will affect the user's later use of ABC (the latter operation of the test object).

Assuming that there is no big difference of task completion time between prototype A' and prototype A, and the average time prototype A took for task 1 $\bar{N} = 52.21$. The results of the single-sample T test for prototype A' task 1 (Table 7) show significant value $p = 0.979 > 0.05$ with the SPSS calculation to set the test value = 52.21 and the confidence interval to 95%. Therefore, it is reasonable to accept the null hypothesis that the completion time of prototype A' task 1 has no significant difference from that of prototype A task 1. Similarly, there is no significant difference as is shown in Table 8 significant value $p = 0.707 > 0.05$.

**Table 7.** Results of the single-sample T-test for prototype A 'task 1

| | Test value = 52.21 (time average of prototype A task 1) | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig.(Bilateral) | Mean difference | 95% confidence interval of the difference | |
| | | | | | Lower limit | Upper limit |
| Prototype A 'task 1 | .027 | 15 | .979 | .16500 | −12.6841 | 13.0141 |

**Table 8.** Results of the single-sample T-test for prototype A 'task 2

| | Test value = 185.27 (time average of prototype A task 2) | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig.(Bilateral) | Mean difference | 95% confidence interval of the difference | |
| | | | | | Lower limit | Upper limit |
| Prototype A' task 2 | −.384 | 14 | .707 | −7.07000 | −46.5498 | 32.4098 |

One-sample T-test analysis is also used to verify whether task 3 and task 4 of prototype B' are significantly different from those of prototype B. As is shown in Tables 9 and 10, the significant difference between Task 3 and Task 4 is less than 0.05, so there is a 95% or more possibility that significant difference of task completion time exists between Prototype B' and Prototype B.

**Table 9.** Results of the single-sample T-test for prototype B 'task 3

| | Test value = 98.80 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (Bilateral) | Mean difference | 95% confidence interval of the difference | |
| | | | | | Lower limit | Upper limit |
| prototype B' task 3 | −16.788 | 15 | .000 | −50.86250 | −57.3201 | −44.4049 |

**Table 10.** Results of the single-sample T-test for prototype B 'task 4

| | Test value = 98.80 | | | | | |
|---|---|---|---|---|---|---|
| | t | df | Sig. (Bilateral) | Mean difference | 95% confidence interval of the difference | |
| | | | | | Lower limit | Upper limit |
| Prototype B' task 4 | −8.937 | 15 | .000 | −120.92000 | −149.7580 | −92.0820 |

The experimental results are not accidental according to the analysis above and they can be extended to a larger scale of service-oriented websites, while changes to use flow will affect the time for users to complete the tasks. Combined with the above data and eye movement experimental video analysis, the following conclusions can be drawn.

### 3.5 Experimental Results

According to the experimental results, the following conclusions can be reached:

Users' operation can be affected by previous experience.

Consistent use flow can significantly improve users' operating efficiency. To further explain this phenomenon, SPSS is used to calculate the global correlation coefficient between the corresponding tasks in the two experiments respectively, with results shown in Table 11. It can be inferred that the global correlation coefficient $N_1 = -0.439$ (negative correlation) between task 1 and task 3 in experiment 1, while the global correlation coefficient $N_2 = 0.305$ (positive correlation) for task 1 and task 3

**Table 11.** Global Correlation Coefficients for Login Tasks in Two Experiments

| | Prototype A (ICBC) | Prototype B (ABC) | Correlation coefficient |
|---|---|---|---|
| Login (inconsistent) | Task 1 | Task 3 | $N_1 = -0.439$ |
| | Prototype A' (ICBC) | Prototype B' (Modified ABC) | |
| Login (consistent) | Task 1 | Task 3 | $N_2 = 0.305$ |

in the second experiment. It is thus possible to determine that a consistent login flow facilitates the users' operation while inconsistent login flow hinders it.

User experience of e-banks can be improved by recording the account information automatically.

When it comes to the same or similar functional modules, users tend to choose a consistent using method to reduce cognitive and learning time. From the perspective of e-banks, the consistency of use flow can help users successfully complete the task, improve their efficiency and finally enhance the availability and user experience of e-banks.

## 4 Summary and Discussion

In this study, the problem of how to improve user experience of websites is refined to the research es on use flow of web site under the premise of ensuring the functions of service-oriented websites. Combined with the theory and research method of user mental model, it is verified that consistency of use flow is helpful to enhance user experience of websites by taking e-banks as an example.

Although this study summarizes the usability problems related to login and transfer and remittance of ICBC and ABC, there are many types of websites in service-based websites and e-bank is only one of them. Therefore, more research subjects will be considered into test in future researches and research scope will be extended to many other types of websites.

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