ต้นแบบใหม่ของการให้บริการธุรกรรมบนเครื่องรับจ่ายเงินอัตโนมัติของธนาคารในประเทศไทย

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A NEW PROTOTYPE OF AUTOMATED TELLER MACHINE TRANSACTION SERVICE OF

BANKS IN THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Computer Science and Information

Department of Mathematics

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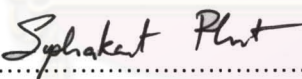
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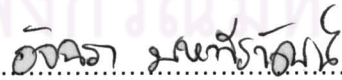
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กมลวรรณ เต่าให้: ต้นแบบใหม่ของการให้บริการธุรกรรมบนเครื่องรับจ่ายเงินอัตโนมัติ
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วิทยานิพนธ์นี้ได้นำเสนอการออกแบบส่วนต่อประสานใหม่สำหรับการให้บริการธุรกรรม
บนเครื่องรับจ่ายเงินอัตโนมัติของธนาคารในประเทศไทย สำหรับการออกแบบส่วนต่อประสาน
ใหม่นี้จะนำเสนอในส่วนของโครงสร้างเมนูนำทางของงาน 7 ประเภทที่มีความถี่ในการใช้งาน
มากที่สุดบนการให้บริการธุรกรรม โดยจะใช้ผู้เข้าร่วมทดสอบทั้งหมด 105 คนในการทดสอบซึ่ง
แบ่งออกเป็น 5 กลุ่มอาชีพหลักของประเทศไทยได้แก่ กลุ่มนักศึกษา, กลุ่มพนักงานเอกชน, กลุ่ม
ข้าราชการหรือรัฐวิสาหกิจ, กลุ่มเกษตรกรรมและกลุ่มแม่ค้า ทั้งนี้การจำลองสถานการณ์ของ
ส่วนต่อประสานใหม่จะทำการทดสอบในสภาพแวดล้อมในห้องปฏิบัติการ อีกทั้งการออกแบบ
ส่วนต่อประสานใหม่จะถูกสร้างเพื่อเปรียบเทียบกับส่วนต่อประสานของเครื่องรับจ่ายเงิน
อัตโนมัติของจริงซึ่งจะเลือกธนาคารที่มีประสิทธิภาพ ประสิทธิผลและความพึงพอใจมากที่สุดมา
ทำการเปรียบเทียบ ในการศึกษานี้จะใช้หลักการของอันตรกิริยาระหว่างมนุษย์กับคอมพิวเตอร์
ในการออกแบบส่วนต่อประสานใหม่และใช้หลักการความสามารถในการใช้งาน 5 ประการเพื่อ
ประเมินผลได้แก่ ประสิทธิภาพ ประสิทธิผล ความพึงพอใจ การเรียนรู้และการจดจำ ผลการ
ทดลองได้แสดงให้เห็นว่าส่วนต่อประสานใหม่สำหรับการให้บริการธุรกรรมบนเครื่องรับจ่ายเงิน
อัตโนมัติสามารถลดอัตราการเกิดความผิดพลาดจากการทำงานและเพิ่มประสิทธิภาพ
ประสิทธิผลและความพึงพอใจได้

ภาควิชา   คณิตศาสตร์............................   ลายมือชื่อนิสิต กมลวรรณ เต่าให้...........

สาขาวิชา วิทยาการคอมพิวเตอร์และสารสนเทศ   ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก...........

ปีการศึกษา 2552............................   ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม...........

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KAMONWAN TAOHAI : A NEW PROTOTYPE OF AUTOMATED TELLER MACHINE TRANSACTION SERVICE OF BANKS IN THAILAND. THESIS ADVISOR : SUPHAKANT PHIMOLTARES, Ph.D., THESIS CO-ADVISOR : ASST. PROF. NAGUL COOHAROJANANONE, Ph.D., 82 pp.

This thesis proposes a new design of ATM interface for banking service in Thailand. This proposed ATM interface is designed in a form of hierarchical menu structure based on seven frequent tasks on transaction service. From the experiment set-up, five occupations, students, employees, government and state enterprises officers, agriculturists, and merchants, of 105 participants were tested. Simulation of the designed interface was adopted for testing in laboratory environment. The ATM interface was established to compare with best existing ATM interface evaluated among five banks in term of effectiveness, efficiency, and satisfaction. In this study, the human-computer interaction principles were considered for designing a new interface. Usability criteria were used as the evaluation: effectiveness, efficiency, satisfaction, memorability, and learnability. The experimental results showed that the proposed ATM design reduced the error rate as well as increased effectiveness, efficiency, and satisfaction.

Department : Mathematics   Student's Signature กมลวรรณ เต่าไข่

Field of Study : Computer Science and Information   Advisor's Signature Suphakant

Academic Year : 2009   Co-Advisor's Signature

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CHAPTER I

INTRODUCTION

1.1   Motivation and Problem Description

In Thailand, there are many kinds of Automated Teller Machine (ATM) which continuously increase corresponding to increasing population and economic growth. ATM interfaces play the important role which directly effect to ATM users. Most of the ATM interfaces have the large number of services serving the needs of the relevant users, where each service contains many of processes. Consequently, an easily use ATM interface design to for the users is the difficult to attain. Other reasons which can also make the design hard are as follows: 1) the users have different attitudes and experiences in using ATM banking. 2) The users are dissimilar in ages and genders. 3) The users have different education levels. 4) The most important reason is that illiterate users, who lack sufficient reading skill and familiar technology, are unpractical to use ATM banking. Designing ATM interface according to Human-Computer Interface (HCI) standard is significant for enhancing the quality of the interface that can improve users' satisfaction.

This thesis describes a the proposed design menu structure of seven frequent tasks of ATM banking service by modifying from the existing ATM interface and developing to fit with the five main occupations in Thailand. The proposed interface is created to compare with existing ATM interface.

1.2   The Objective of Research

In this thesis, designing the proposed interface for ATM banking services aims to suit main occupations in Thailand which are students, employees, government and state enterprises officers, agriculturists, and merchants. Each group has dissimilar capability for using ATMs. Furthermore, the users who are in the same group may have the different potentials. One issue is to compare main function of existing ATM interfaces among banks in Thailand. The advantages and disadvantages of these interfaces from this comparison are applied for improving the proposed ATM interface design. Moreover, Human-Computer interface (HCI) principles [1] are used for designing of the

proposed interface whilst usability criteria [2], [3] are employed for evaluating that interface.

1.3   The Scope of Study

There are many occupations that are the bank's users. It is impractical that the users of the all occupations are employed in experiment. Hence, only five ones are chosen for our study which is students, employees, government and state enterprises officers and agriculturists. Various tasks of ATM banking services emerge to serve the needs of various users. Nonetheless, seven main tasks are considered for proposed research methodology. In the experiment, it is impractical that the participants take the transactions through actual ATM servers. Thus, a simulator is developed and applied for testing under real environment. In this study, the real environment means that the processes and tasks demonstrated in the simulation is related to the actual processes and tasks collected from a real situation survey.

1.4   Expected Outcomes

The expected outcomes for this study are to create a set of various problems of using ATM banking services and to notify that it is not difficult to take a complicated ATM banking service. One of the vital outcomes is to gain a proposed prototype of usability of ATM services which obtained from the study, namely, the advantages and disadvantages of the existing version of banking services.

1.5   The Benefits of Research

The benefits of this research will be as follows: 1) Designers can develop the ATM interface according to the suggestion and methodology to provide the ATM banking system for easy usage and satisfy the users' need.   2) The proposed ATM interface can help illiterate, semi-illiterate, and literate users who are not familiar with technology to operate and use ATM servers more quickly. 3) Less time consuming.

This thesis proposes a menu structure of the proposed design of ATM interface for ATM banking services. Chapter II provides related works, the proposed methodology, experiment designs, and the details of related theory such as usability and human-computer interaction (HCI) criteria. Chapter III discusses the usability testing

of this study. The experiment results and discussion are given in Chapter IV. Chapter V points to conclusion and future works.

CHAPTER II

RELATED WORKS, PRINCIPLES OF EXPERIMENTAL EVALUATION

2.1   Related Works

Many existing researches study on an interface that accommodates the needs of old adults. The study takes the cognitive and physical abilities of older adults into account, which modifies ATM system only cash withdrawal and transfer functions based on the task demands and needs [4]. Another study analyzes at the attitudes towards ATM and alternative ATM interfaces (a speech-based interface and an icon-based interface), which comparisons are made between the semi-literate and literate groups on ATM usage, general attitudes towards ATMs, ATM problems, attitudes towards a speech-based ATM alternative interface and attitudes towards an icon-based alternative ATM interface [5]. This study describes the various user-centered design techniques to involve future use of ATM for illiterate persons, and reports the results of applying the techniques to a group of six Dutch functional illiterate persons [6]. This study describes an overview of the user-centered, work-focused biometric verification of the ATM user interface. Both qualitative and quantitative methodologies were adopted in these laboratory and field based studies [7]. Interestingly, older adults form a significantly different user group when considering the user interface design, and demonstrate that it cannot be assumed that standard user-centered design methods for system development will ensure the provision of usable products for older people [8]. The use of ATMs by older people has been evaluated so as to better understand why some older people prefer not to use ATMs and what problems face the aging users. From all of these studies, it appears that each user group has at least some different requirements and difficulties with using ATMs, so a usability citation is used to solve this problem [9]. The perception of the advantages as well as disadvantages of wall-banking, the factors that determine one's choice of a bank, man-machine problems related to the use of an ATM and demographic factors. The use of ATM's is more pronounced within the younger population which also ties in with findings on the usage of credit cards. Therefore, it has generally been assumed that younger ATM users will have more experience and show a low resistance to this financial management

instrument. The test of this hypothesis is central to this study [10]. The present study was initiated in response to this apparent lacuna on consumer perceptions, and examines the ATM usage patterns of two banking institutions with a view to assess the relative importance of the different perceptual variables in explaining consumer usage patterns [11]. The purpose of the present study was to conduct an in-depth analysis of ATM usage by older adults. This approach consisted of telephone interviews followed by structured individual interviews. The goals were to understand the problems encountered by ATM users, to determine how ATMs might be better designed and to assess the training needs of older individuals. The phone interview data provided information about the relationships between age, sex and ATM usage within the adult sample, as well as information about why some people choose not to use ATMs. The structured interview data provided a more in-depth view of the concerns of both users and non-users, and information about training needs. The training and design implications of the results are discussed [12]. Finally, comparison of ATM interface of five banks in Thailand is carried out based on ISO 9241-11. Three usability evaluations: effectiveness, efficiency, and satisfaction are taken into account [13].

2.2   Overview of ISO Standards

Over decades, several researchers have intended to develop involving interface standards to define the common criteria of user-centered design and proper practice in a field of designing user interface. The International Organization for Standardization (ISO) and the International Electrotechnical Commission (IEC) establish the usability and HCI standards which both are popular and widely adopted. Those standards are described in the various classes, namely, development process, use in context, software interface and interaction, usability capability, and other standards. Table 2.1 illustrates correlated ISO standards along with mentioned classification.

Table 2.1: ISO standards related to HCI and usability [14].

Characteristics	Principles of ISO Standards
Use in Context	ISO/IEC 9126-1: Software Engineering-Product quality-Part1: Quality model
	ISO/IEC TR9126-4: Software Engineering-Product quality-Part4: Quality in use metrics
	ISO 9241-Part11: Guidance on Usability
Software Interface and Interaction	ISO/IEC TR 9126-2: Software Engineering-Product quality-Part2: External metrics
	ISO/IEC TR 9126-3: Software Engineering-Product quality-Part3: Internal metrics
	ISO/IEC 11581-1: Icon symbols and functions (general)
	ISO/IEC 11581-2: Icon symbols and functions (object icons)
	ISO/IEC 11581-3: Icon symbols and functions (pointer icons)
	ISO/IEC 11581-6: Icon symbols and functions (action icons)
	IEC TR 61997: Guidelines for the user interfaces in multimedia equipment for general purpose use
Development Process	ISO 13407: Human-centered design processes for interactive systems
	ISO TR 16982: Usability methods supporting human centered design
Usability Capability	ISO TR 18529: Ergonomics of human-system interaction-Human-centered lifecycle process descriptions
Other Standards	ISO DTS 16071: Guidance on accessibility for human-computer interfaces

2.3   Usability

In this section, usability is introduced and then definitions of both in standards and prior works are discussed.

2.3.1   Introduction to Usability

Currently, most of designers often use usability principles for a good design of the software or systems in the design stage. The usability plays an important role in the design of the systems since it helps the users use the system effectively, efficiently, and satisfactorily. The usability measure is mostly significant for solving the complexity from different attitudes of the user, occupations of the user, and the environment of the usage. There are numerous systems adopt the usability principle to develop the ones that are easy to learn, easy to use, and easy to remember including ATM, mobile phone, pocket pc, computer, ticket machine, and library system. From the

developer's viewpoint of developer, the usability is important because it affects success or failure of the produced system. Moreover, the system, which is high usability, can reduce cost, time, and increase productivity.

2.3.2   Definitions of Usability in Standards

Usability has been defined in different ways from different standards. There are definitions for usability several standards, namely, the ISO 9241-11 (1998) standard identified efficiency, effectiveness, and satisfaction. The ISO/IEC 9126-1 (2001) standard defines five factors including understandability, learnability, operability, attractiveness, and usability compliance. The ISO/IEC 9126-4 (2004) standard defines four characteristics composed of effectiveness, productivity, safety, and satisfaction. IEEE Std.610.12 (1990) defines usability that user can learn to operate, prepare inputs, and interpret outputs of a system or component. These standards provide separate definitions as shown in Table 2.2.

Table 2.2: Usability definitions in standards [14].

Standards	Usability Definition
ISO 9241-11 (1998)	Usability is defined as "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use".
ISO/IEC 9126-1 (2001)	Usability is defined as "A set of attributes of software which bear on the effort needed for use and on the individual assessment of such use by a stated or implied set of users".
ISO/IEC 9126-4 (2004)	Uses the term "Quality in use": the capability of the software product to enable specified users to achieve specified goals with effectiveness, productivity, safety and satisfaction in specified contexts of use.
IEEE Std.610.12 (1990)	The ease, with which a user can learn to operate, prepares input for and interprets outputs of a system or component.
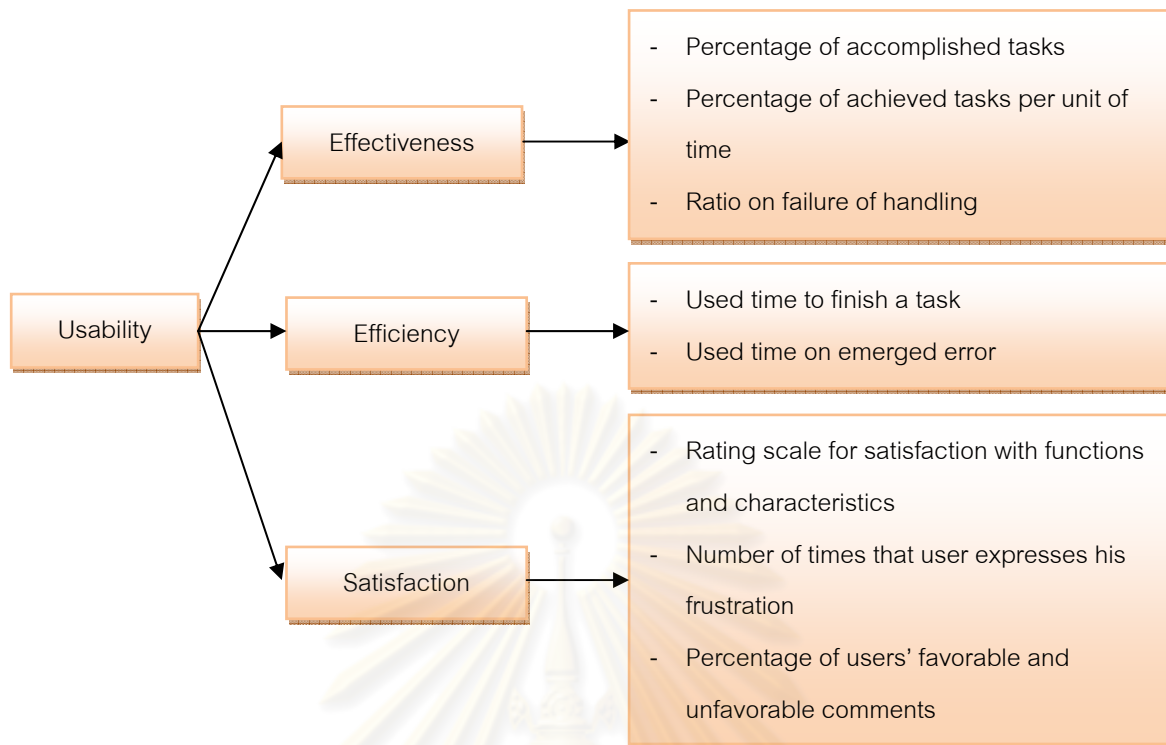
Figure 2.1: Usability Model [2].

2.3.3 Definitions of Usability in the Literatures

A lot of researchers have defined different principle as shown in Table 2.3, namely, Shackel [15] defines usability in term of five components, Dix et al. [16] defines usability in term of four categories, Preece et al. [17] defines usability in term of four components, Constantine & Lockwood [18] defines usability in term of five factors, and Nielsen et al., [3] defines usability in term of four components, namely, effectiveness, efficiency, satisfaction, learnability, and memorability. The details are defined as follows:

- Effectiveness is how well the user is able to accomplish and can be measured in terms of completeness.
- Efficiency is the number of resources required to complete the considered task.
- Satisfaction is the individual feeling of the user about using the system.
- Learnability refers to how easy the system is for first time users to understand.
- Memorability mentions to how well it is for recall users to remember.

In this study, ISO 9241-11 and Nielsen principles are pointed for usability evaluation to improve complexity the system.

Table 2.3: Usability definitions from authors.

Usability Classification From Diverse Researchers		
Researchers	Number of types of Classification	Description
Shackel [15]	Five	Effectiveness (Speed)
		Learnability (Time to learn)
		Learnability (Retention)
		Effectiveness (Errors)
		Attitude
Dix et al. [16]	Four	Effectiveness
		Efficiency
		Satisfaction
		Learnability
Preece et al. [17]	Four	Learnability
		Throughput
		Flexibility
		Attitude
Constantine & Lockwood [18]	Five	Efficiency in use
		Learnability
		Rememberability
		Reliability in use
		User Satisfaction
Nielsen et al. [3]	Five	Effectiveness
		Efficiency
		Satisfaction
		memorability
		Learnability
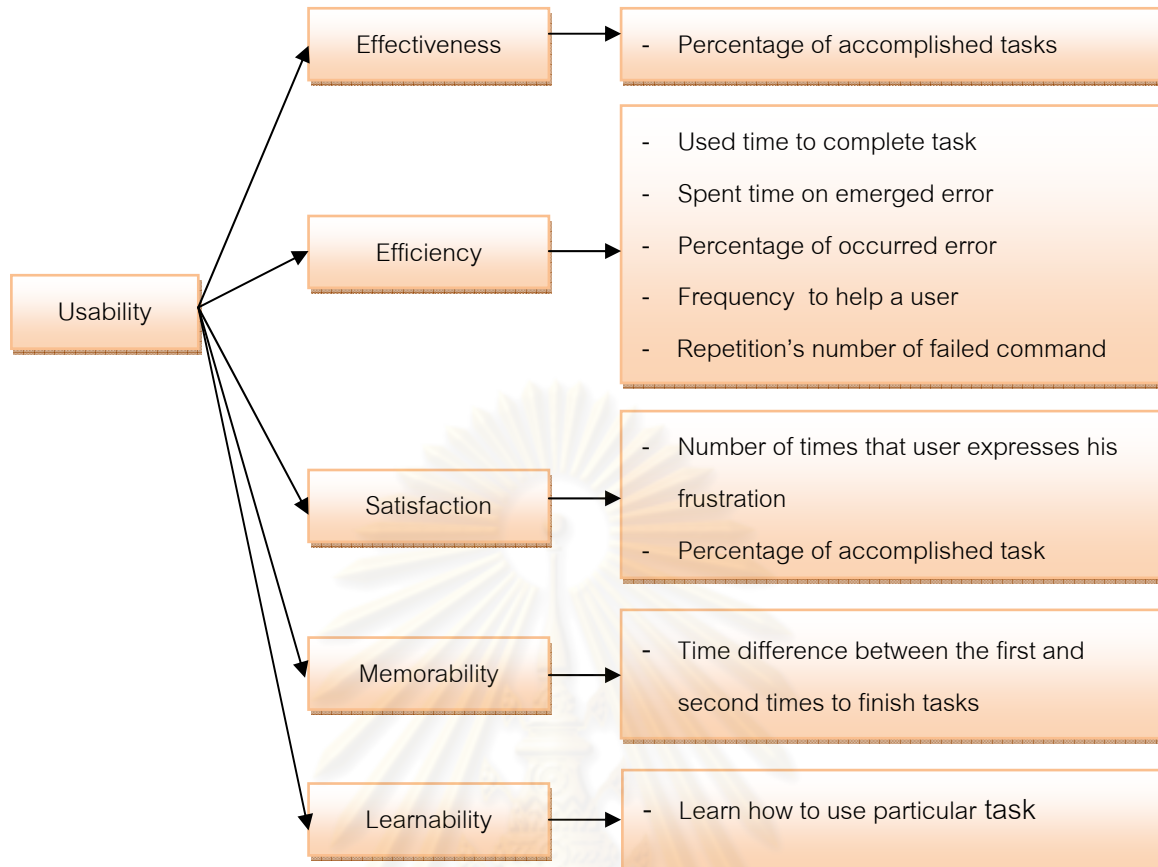
Figure 2.2: Usability Model by Nielsen [3].

2.4 Human-Computer Interaction (HCI)

In this section, human-computer interface is introduced and then any factors in HCI and principle of HCI for design are discussed.

2.4.1 Introduction to HCI

Human-Computer Interaction (HCI) is the study of interaction between people and computers. Three components of HCI include the user, the computer, and the ways they work together. There are obviously dissimilarity between humans and computers. The major aims of HCI are to produce usable systems, safe systems, functional systems, and well usability systems. Consequently, developers must attempt to perceive the factors that determine interaction between the user and the machine.

2.4.2 Factors in HCI

There are a large number of factors which should be considered in the analysis and design of a system using HCI principles. Many of these factors interact with

each other, namely, input devices, output devices, dialogue structures, use of color, icons, navigations, graphics, button, and screen. Human factor is one of the important factors such as attitudes, education levels, and ages. They directly affect to the interaction with the computer.

2.4.3 Principles of HCI for interface design

Formal design is an important in human-computer interaction (HCI). Dix et al., defined design as "The process of designing product so that they can be used by as many people as possible in as many situations as possible." The Royal National Institute for the Blind defined design as "without the need for special adaptation or specialized design." Other guidelines for the use of text compose of the following topic:

- **Font style**: Using both upper and lower case characters are more readable than either all upper or all lower case characters. Italic character is difficult to read because poor font quality and underlines also reduce readability.

- **Font size**: Users, who is less able to read, require larger font size. Some users require smaller font size. Thus, it is important to allow for customizable the font size in an application. For larger font size, most visually impaired users benefit from having white or yellow font on a dark background. It is better when the users use black font on a white background of small font size.

- **Text leading**: Spacing between lines of text should be 25-30% of the point size. Partial vision of numerous people has difficulty finding the beginning of the next line.

- **Letter spacing**: Condensed fonts are less readable than widely spaced fonts.

- **Background**: Text is hard to read when the background has a pattern.

- **Moving text**: Flashing text can attract attention but it can be difficult to read. If this is employed, the text can flash few times then stop. Moving text also emerges vital vision problems for people.

2.5 Techniques for usability evaluation

There are many techniques for usability assessment. Accordingly, each research paper proposes a different technique for evaluation depending on suitability of each task. These methods can be categorized into two main areas, namely, field

evaluation and laboratory evaluation. These two evaluations are described in details bellow:

2.5.1 Field evaluation

Evaluation of technology in the field focused on realistic settings and the real users taking their tasks in the real context of use that provides a very dissimilar kind of information. The users can walk, stand, sit or do whatever that they would normally do while performing the tasks. It is especially helpful for identifying not only what makes a product or software easy to use, but also what will make it useful to users. The advantages of field usability evaluation can be usefulness and the user feeling during a task is like real situation. The disadvantage of field usability evaluation is difficulties for the evaluation and use circumstances such as travel time for test, not to mention high expenses.

2.5.2 Laboratory evaluation

Laboratory tests were conducted in a typical usability test environment. The setting is well controlled: there are no unexpected external interruptions, disturbing noises, and varying lighting conditions. The advantages of laboratory test are that a large number of usability information is collected, costs are lower than field tests, and higher quality usability information are collected. Even though laboratory testing is widely and effectively utilized in the evaluation of application interfaces, it has some limitations. Laboratory based usability studies capture a snapshot of the use in a simulated use environment. Simulating the use setting is very hard, time consuming, expensive and sometimes impossible to attain. The disadvantage of laboratory evaluation was claimed that the feeling during a task was unlike in the real world.

CHAPTER III

EXPERIMENTAL DESIGN AND METHODOLOGY

The proposed design of Automated Teller Machine (ATM) interface focuses on hierarchical menu structure in seven main functions of ATM banking services. This study divides into two experiments. The first experiment compares seven main tasks for ATM service of the top-five banks in Thailand. The second experiment is to solve the problem of using ATM banking service of five user groups which have different life styles, and design of the ATM interface of seven main functions for ATM banking service aim at easy access and learn. Overviews of the experimental procedures are depicted in Figure 3.1.
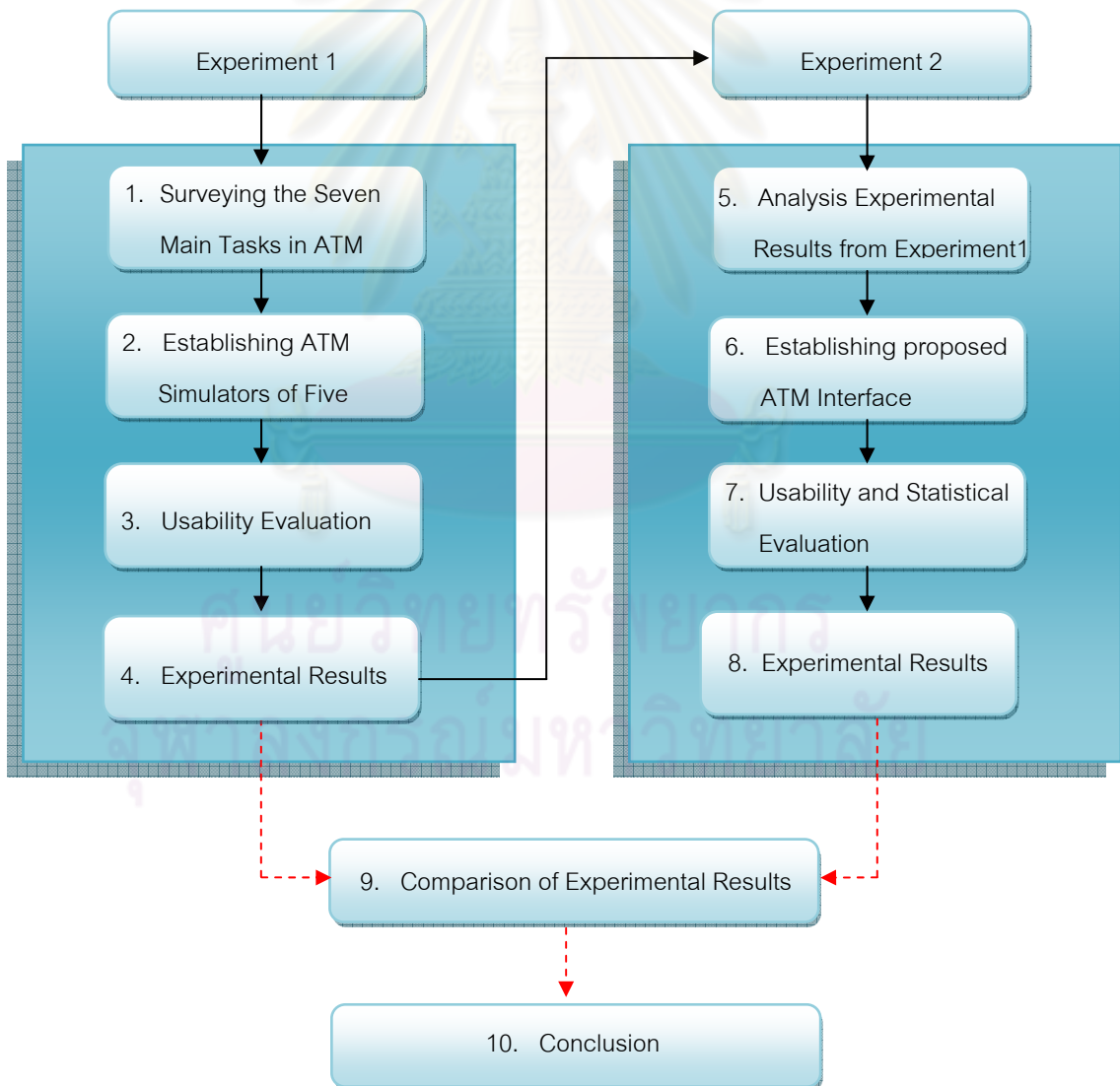
Figure 3.1: Framework of the experimental procedure.

3.1   Experiment 1: Usability Comparison of Seven Main Functions for Automated Teller Machine (ATM) Banking Service of Five Banks in Thailand

The objective of this experiment is to compare the seven main functions of ATM banking services from five banks in Thailand. The selection of the five ATM banks is based on the fact that they are popular in Thailand. In the research, 200 participants are separated into two parts. 116 participants for first group are required to complete a questionnaire in order to identify the seven main tasks of ATM banking, whilst 84 participants of second group are required to perform the experiment on the ATM simulator. The second group is subdivided into four groups, namely, students, employees, government and state enterprises officers and agriculturists. To compare seven major functions, a simulator of each of the five banks' ATM machines is developed and then tested in the laboratory environment. Usability is evaluated in terms of effectiveness, efficiency, satisfaction, and occurred error. The results suggest that different menu structures will affect the usability of ATM banking. Moreover, the different types of user provide a different score based on usability measurement. Only one bank received the highest score on most of the usability criteria for all the different user groups.

This experiment contains four main groups of participants with different occupations and different lifestyles, Hence it is assumed that they have a different experience of using the ATM. Methodology of the first experiment is divided into three parts. (1) Evaluating by survey, what the seven main tasks of ATM banking are, (2) designing and establishing the representative ATM simulators of the five selected banks, and (3) testing the ATM simulator with the four participant groups.

3.1.1   Survey of the Seven Main Tasks in ATM Banking Services

In the first part, the seven main tasks are studied and reported. The results of the survey are subsequentially incorporated into the design of the ATM simulators.

3.1.1.1 Participants

116 participants are used in the experiment, comprising of 33 males and 83 females, using purposive sampling. The age ranges are: 32 participants between 16 and 25 years old, 58 participants between 26 and 35 years old, and 26 participants above 35 years old.

3.1.1.2 Questionnaire

The questionnaire includes ten questions. The average time for completion is 5 minutes per participant.

3.1.1.3 Surveying

The ten most frequently used tasks were evaluated from the questionnaire answers as shown in Table 3.1, and the top seven frequently used tasks are selected for developing a simulator. The other three less common tasks in the top ten are barcode payment, pin code changing, and changing withdrawal limit.

Table 3.1: The Most Frequently Performed Tasks on the ATM Banking Service.

Rank	Services	Percentage
1	Withdrawal	76.7
2	Statement Inquiry	65.5
3	Transfer	61.2
4	Mobile Top-Up	52.5
5	Credit Card Payment	43.1
6	Electric Bill Payment	34.4
7	Insurance Payment	24.1
8	Barcode Payment	20.5
9	Pin Code Changing	18.2
10	Changing the Limitation of withdrawing money	8.3

3.1.2 Establishing ATM Simulators of Five Banks

Good ATM simulator must have characteristics similar to real ATM such as button layout, instructions, and hierarchical menu structure. The following paragraphs describe hierarchical menu structure and the development of the ATM simulator of all five banks.

3.1.2.1 Hierarchical Menu Structure

Figure 3.2-3.6 shows flow diagrams of the process for seven main tasks of Bank A, B, C, D, and E, respectively. Because each bank uses different process, usability is different accordingly.
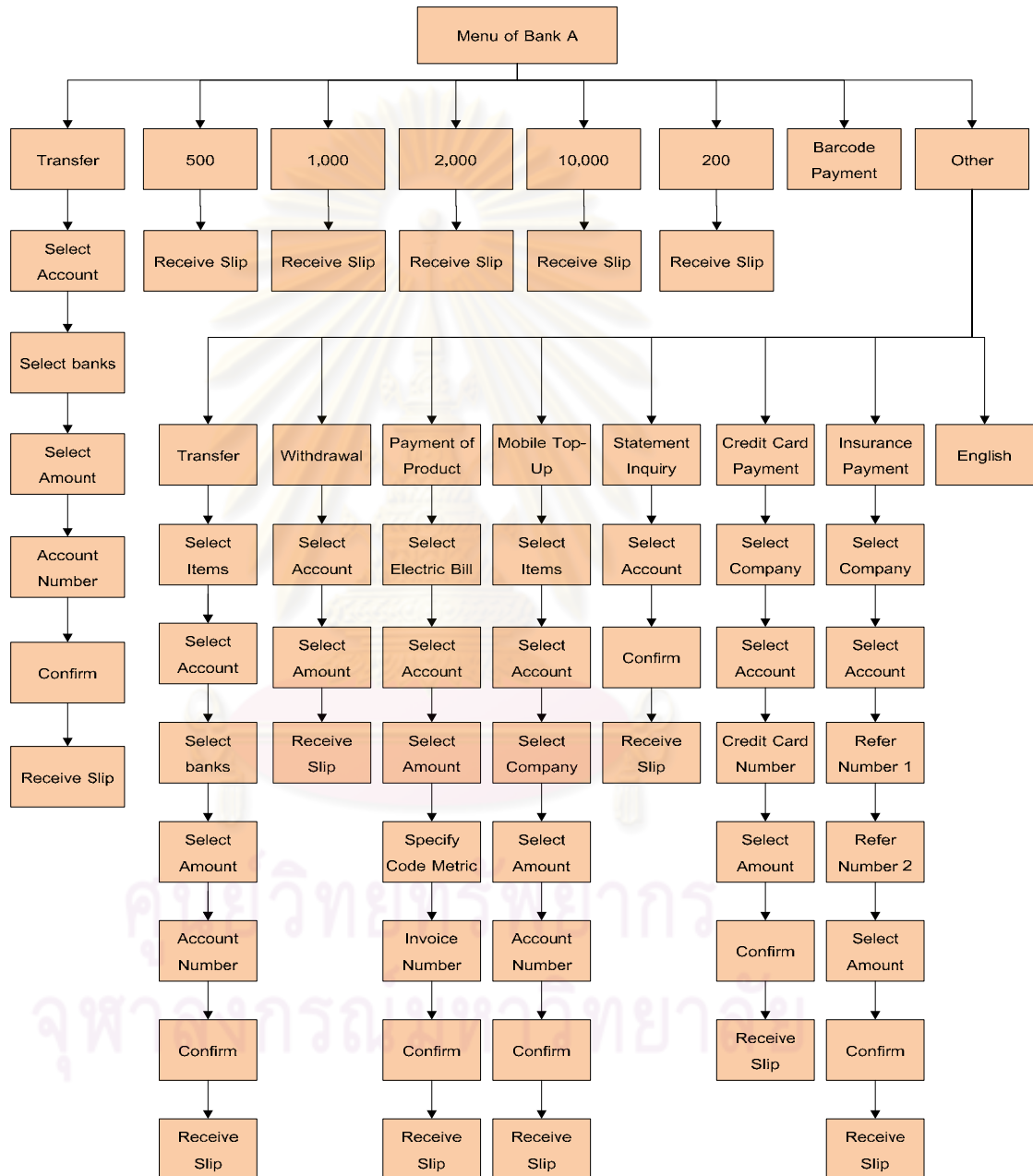
Figure 3.2: Flow diagram of the process for seven tasks of Bank A.
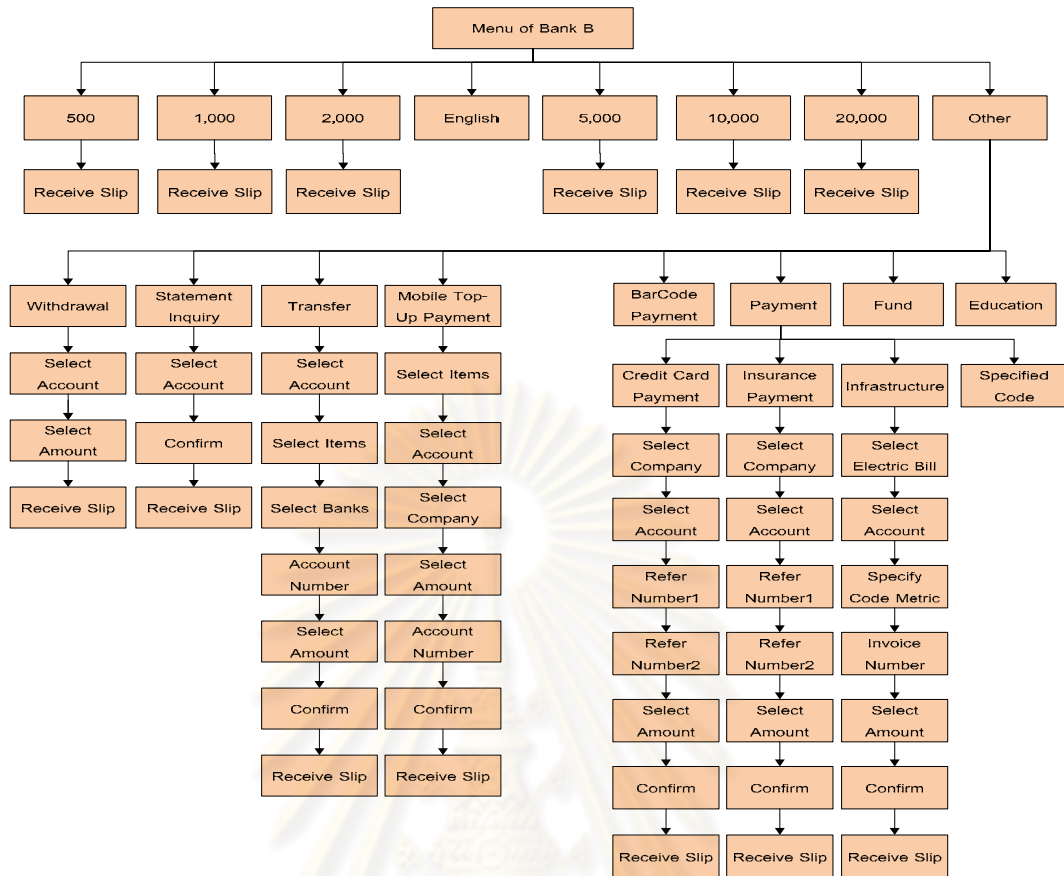
Figure 3.3: Flow diagram of the process for seven tasks of Bank B.
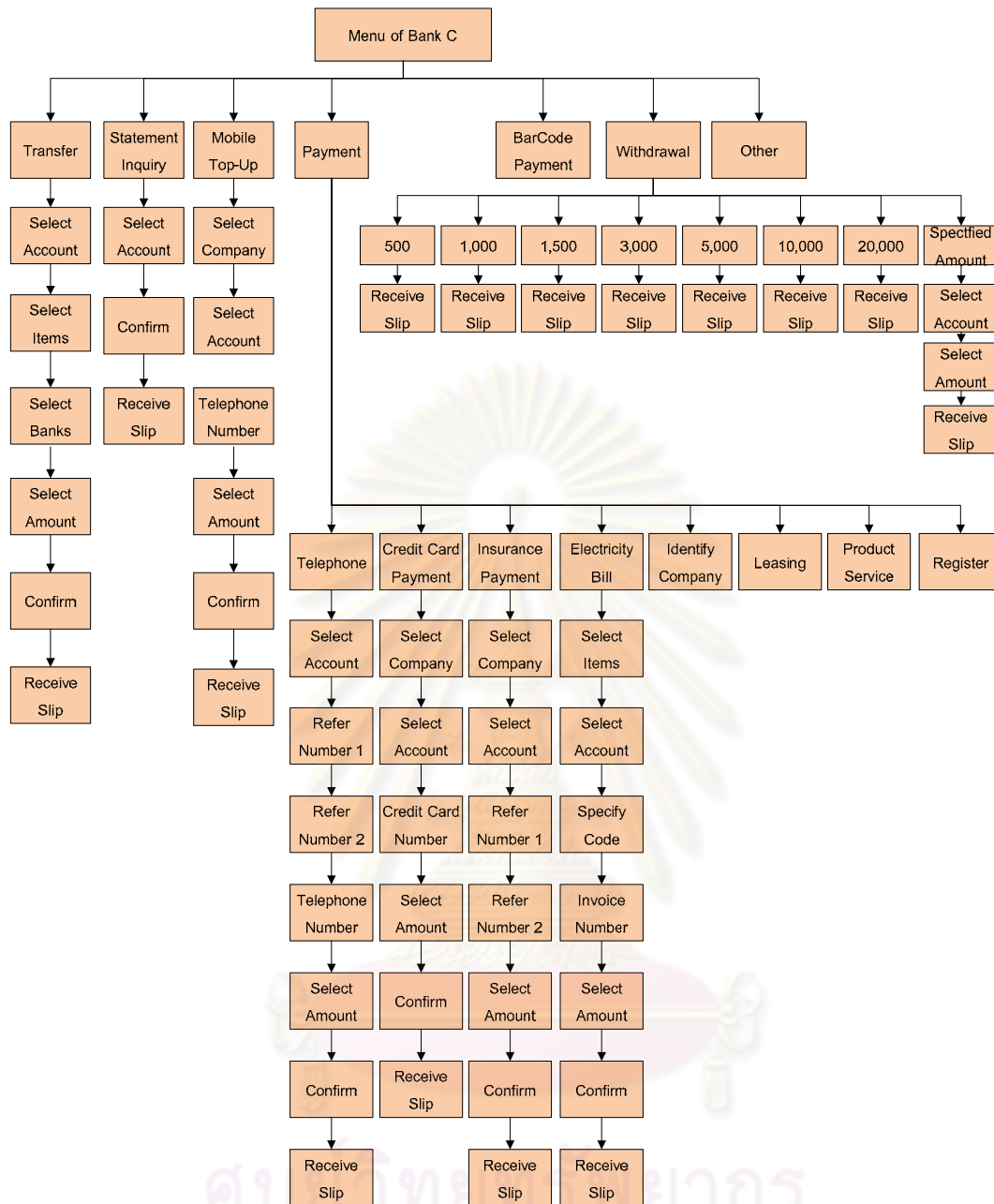
Figure 3.4: Flow diagram of the process for seven tasks of Bank C.
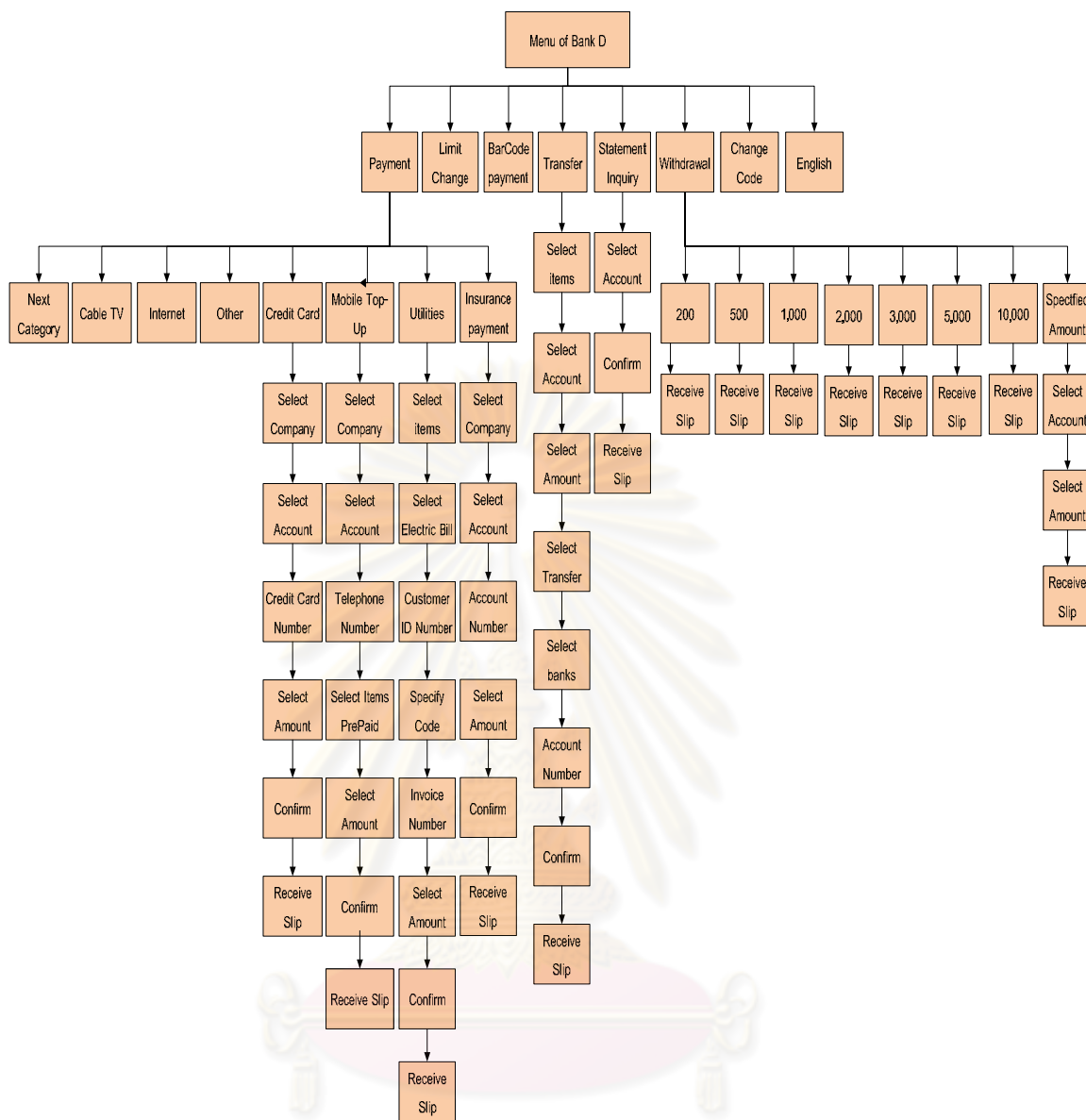
Figure 3.5: Flow diagram of the process for seven tasks of Bank D.
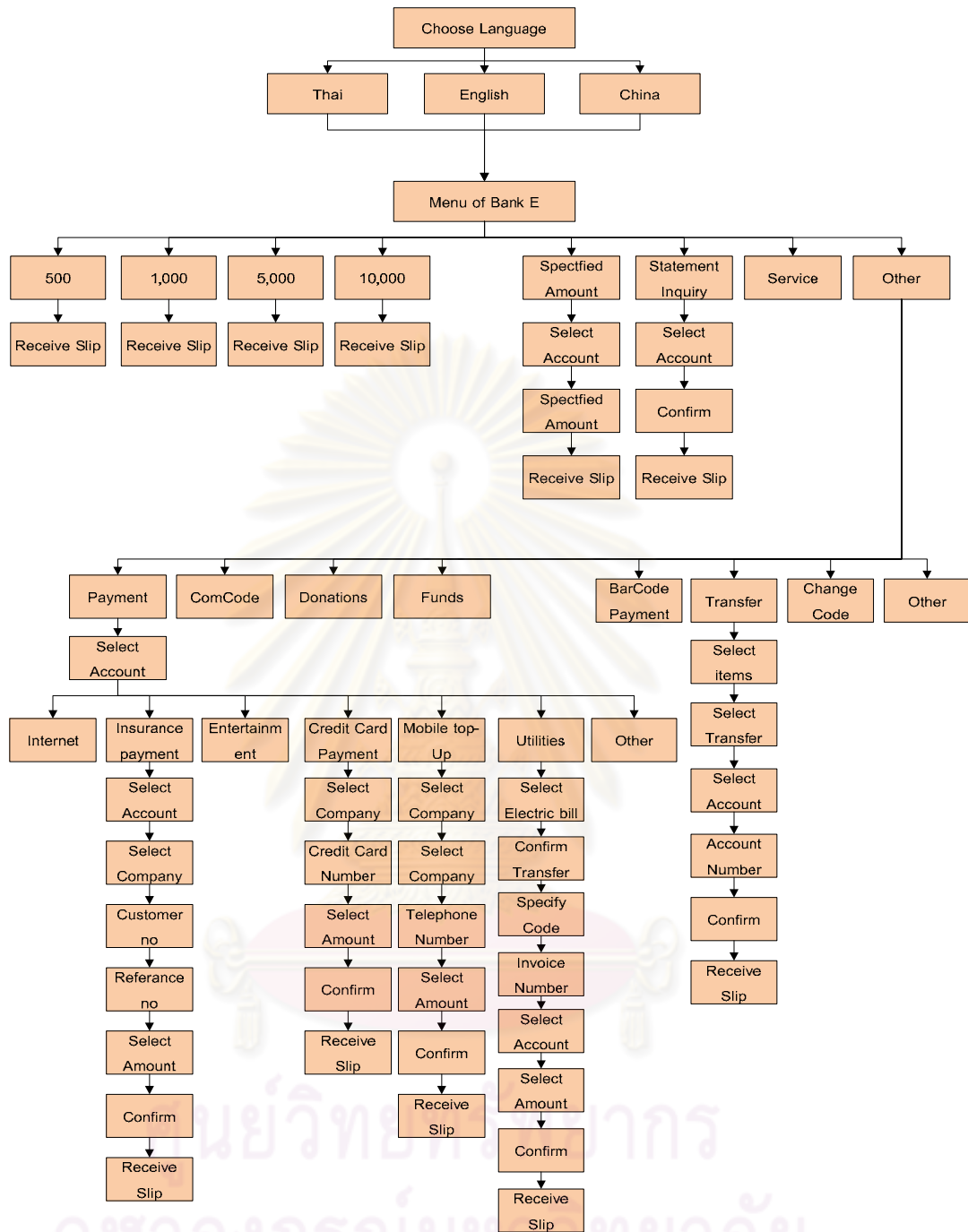
Figure 3.6: Flow diagram of the process for seven tasks of Bank E.

The difference between the number of mouse clicks and steps is as follows: mouse clicks are derived from user clicks from menu key pad. Steps refer to the number of instructions in each function. For example, "Please select company", "Please enter credit card number", and "Please enter amount of money". Each step can contain

several mouse clicks. Thus, it is possible that there are a large number of mouse clicks per one step.

Table 3.2 indicates a number of steps in each task for the five banks summarized from Figure 3.7-3.13, i.e., Bank C has the lowest number for the first six tasks while Bank E has the highest number for all seven tasks.

Table 3.2: Number of steps in each task for five banks.

Items	Tasks	Number of steps in each task for five banks				
		Bank A	Bank B	Bank C	Bank D	Bank E
1	Withdrawal	5	5	5	5	6
2	Statement Inquiry	5	5	4	4	6
3	Transfer	9	9	7	9	10
4	Mobile Top-Up	9	10	7	9	12
5	Credit Card Payment	8	10	8	8	11
6	Electric Bill Payment	9	9	9	10	14
7	Insurance Payment	9	9	9	8	13

Table 3.3 indicates possible minimum number of clicks to complete the task summarized from Figure 3.7-3.13, i.e., statement inquiry has the lowest number from all five banks. Bank C has the lowest number for first six tasks.

Table 3.3: Possible minimum number of clicks to complete a task.

Items	Tasks	Possible minimum number of clicks to complete a task				
		Bank A	Bank B	Bank C	Bank D	Bank E
1	Withdrawal	13	13	13	13	13
2	Statement Inquiry	8	8	7	7	8
3	Transfer	30	28	25	28	27
4	Mobile Top-Up	23	23	23	23	24
5	Credit Card Payment	32	38	25	31	37
6	Electric Bill Payment	32	34	28	34	37
7	Insurance Payment	27	21	25	31	26

3.1.3 Establishing ATM Simulators

ATM simulators of the five selected banks are developed using C#.NET programming language. For each ATM simulator, vocabularies, buttons layout, and the hierarchical menu structures are similar to the actual ATM in Thailand. Prior work comparing between laboratory and field testing showed that field testing was not worth the time and expenses [19]. For instance, flexible testing location can be held; there is safety of the system from the participants; every participant is in the same context; and simulation is less expenses. An example of the simulator is shown in Figure. 3.7.

Bank A   Bank B   Bank C

Bank D   Bank E
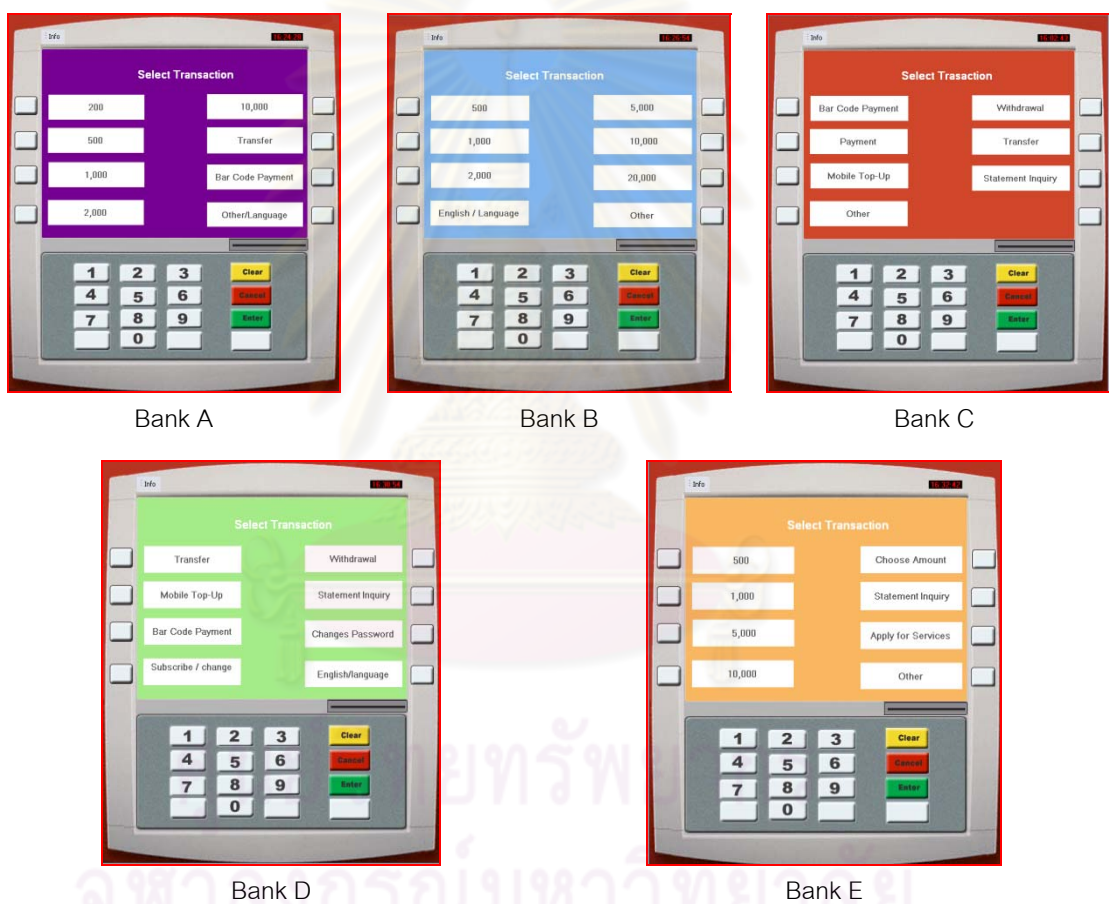
Figure 3.7: An example of an ATM simulator.

- **Main Menu**: Figure 3.8 shows all main menus in each transaction of all five banks. Each bank has different hierarchical menu structure, screen, and button design. Moreover, access procedures are different.

Bank A   Bank B   Bank C

Bank D   Bank E
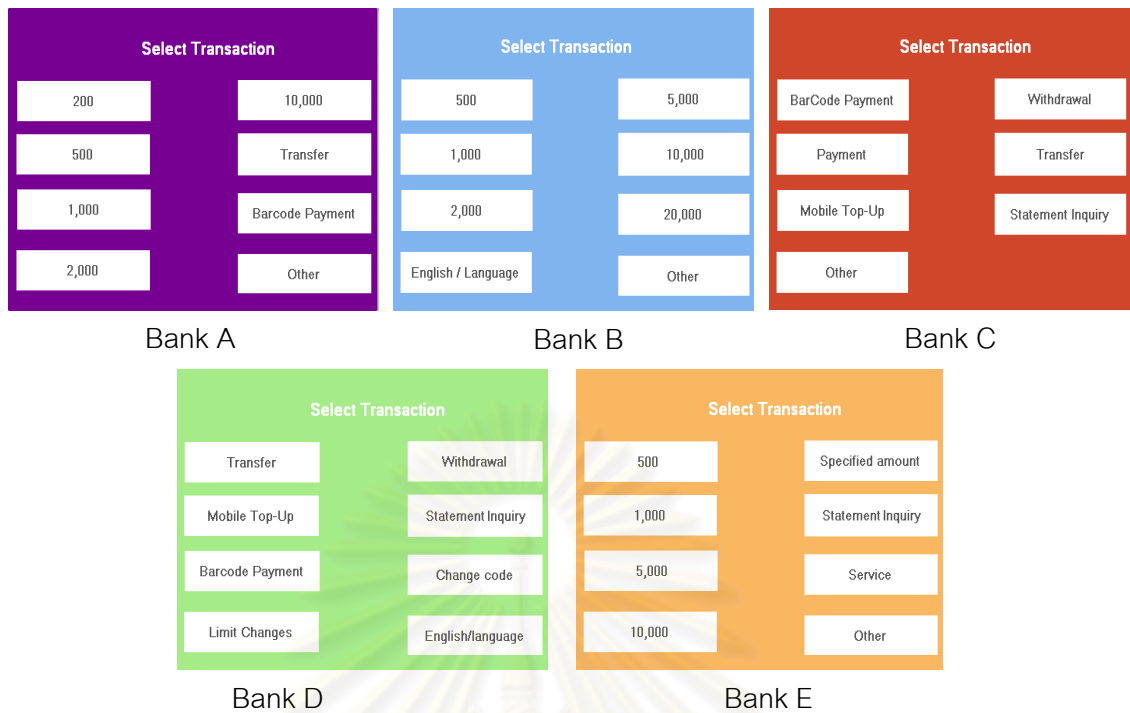
Figure 3.8: An example of different main menu screens.

- **Keypad**: In designing ATM simulator, a keypad for all five banks includes 0-9 digits button, "Clear" button for clearing data, "Cancel" button for either back to the prior screen or back to the main menu or receiving a card, and "Enter" button for confirming the process and then go to the next process as shown in Figure 3.9.

Figure 3.9: Keypad of an ATM simulator.

3.1.4 Design of Testing

For this section, participant allocation, questionnaire design, and procedure for testing existing ATM interface of all five banks are discussed.

3.1.4.1 Participant Allocation

84 participants, including 49 males and 35 females, are used to test the simulator. The age ranges are 22 participants between 16 and 25 years old, 36 participants between 26 and 35 years old, and 26 participants above 35 years old.

3.1.4.2 Questionnaire Design

Designing the questionnaire was fundamentally based on the Human-computer interaction (HCI) [1] which is "The comfort and acceptability of the work system to its users and other people affected by its use" (ISO 9241-11, 1998) [2]. To obtain this, designers should consider the concepts of the ease to learn and attractive, the ease to use the interface, useful functionality, enjoyment level, and the efficiency of service. Satisfaction score is based on 5 points likert – scale [20] encompassing strongly agrees, agree, neutral, disagree, and strongly disagree. The questionnaire is comprised of 21 questions and the average spent time each participant on the questionnaire is 30 ± 5 minutes (range of 25 - 35).

In appendix A shows the satisfaction questionnaire for the participants for five banks in Thailand.

3.1.4.3 Procedure

The procedures for this study are four stages. In the first stage, a participant randomly selects just one of the seven tasks. In the second stage, the participant randomly selects any bank from the given five banks. In the third stage, the participant performs the task on the appropriate simulator for the selected bank. The participant can perform the selected task any times until that task is completed. In the fourth stage, the participant must complete the questionnaire for the task completed. The participant carries out stage 2 to stage 4 until the participant finishes testing the task on all five banks. The procedure is summarized in Figure 3.10.
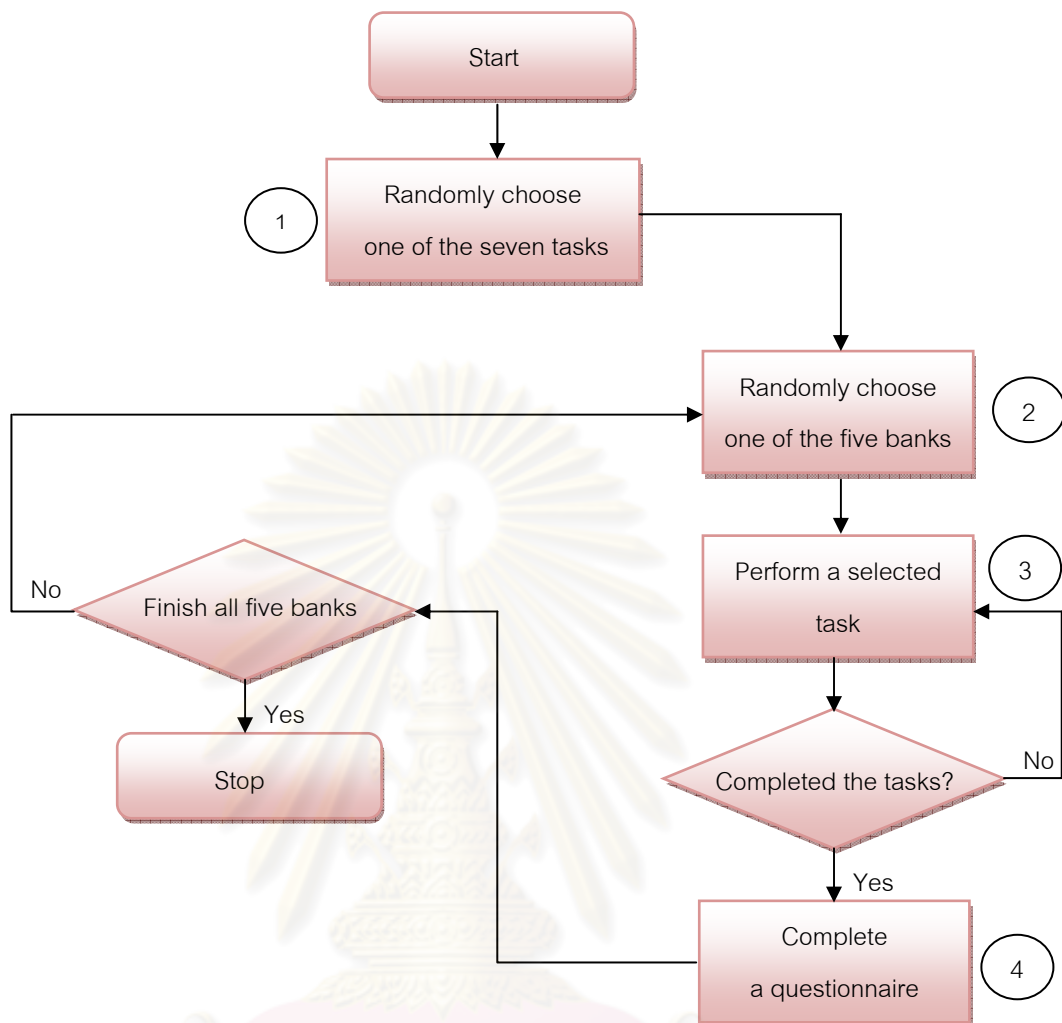
Figure 3.10: The proposed model for the testing process.

3.1.5 Usability Evaluation of Comparison

Four components are employed for usability evaluation as shown in Table 3.4. Three components derive from ISO standard including effectiveness, efficiency, and satisfaction. Another component is an error measured which can be computed by Equation (1).

$$e = \left| \frac{x - y}{y} \right| \times 100. \tag{1}$$

where e is percentage of error, x is the actual number of mouse clicks, and y is the possible minimum number of clicks.

Table 3.4: Usability Criteria for evaluation.

Usability criteria	Measurements
1. Effectiveness	- Percentage of tasks accomplished - The number of mouse clicks to complete the task
2. Efficiency	- Time to complete the task
3. Satisfaction	- Satisfaction score
4. Error	- Percentage of error

There are two aspects for effectiveness evaluation including percentage of tasks accomplished and the number of mouse clicks to complete the task. For efficiency, satisfaction, and error include time to complete the task, satisfaction score, and percentage of error, respectively. The following is the detail of each aspect.

- **The percentage of tasks accomplished**: a number of participants which couplet a task in first time divided by the total number of the participants and then multiplied by one hundreds.

- **The number of mouse clicks to complete the task**: a number of clicks from the participants which use the mouse to click the button appearing the screen.

- **Time to complete the task**: time consumed by the participants to complete the considered task.

- **Satisfaction score**: Rating scale for user's satisfaction with functions and characteristics.

- **Percentage of error**: percentage of difference between actual number of clicks and the possible minimum number of clicks to complete the task as shown in (1).

3.1.6 Experimental Results of Comparison

The following is the given results from measuring usability criteria. Tables 3.5-3.7 illustrate total average values measured the usability criteria for Bank A, B, C, D, and E, correspondingly.

Table 3.5: Total average values measured from usability criteria in Each Bank.

Measured Parameters	Bank				
	A	B	C	D	E
Effectiveness					
● Success rate (%)	90.9	90.9	95.0	92.3	80.0
● Average of number of clicks	29.1	25.8	24.6	27.4	30.9
Efficiency					
● Consumed time to complete the task (second)	63.9	59.2	56.3	57.9	72.0
Satisfaction					
● Satisfaction score (Range 0-5)	4.29	4.16	4.44	4.14	3.97
Error					
● Percentages of errors	22.1	8.81	14.8	11.7	27.4

From Table 3.5, Bank C gives the best result in effectiveness, efficiency and satisfaction. However, it shows a high percentage of errors be the third high error rate of the five banks. Bank E is the worst results in every measured parameter when compared to other four banks.

From Table 3.6, it is clear that the payment of an electric bill has a poor usability since it shows the highest number of clicks and consumed time to complete the task. On the other hand, cash withdrawal is the best usability with the lowest error rate and number of clicks to complete the task.

From Table 3.7, the agriculturist group has lowest ability to use the ATM since it has the lowest effectiveness and efficiency whilst has the highest error. In contrast, the employee group had the most powerful capability to use the ATM because it provides the highest effectiveness and efficiency whilst provides the lowest error.

Appendix B demonstrates screen of bank given the best and the worst results of usability evaluation in Thailand whilst appendix C depicts the comparison of the hierarchical menu structure of bank given the best and the worst results of usability evaluation.

Table 3.6: Total average values measured from usability criteria for Each Task.

Measured Parameters	Tasks						
	Withdrawal	Statement Inquiry	Transfer	Mobile Top-up	Credit Card Payment	Electric Bill Payment	Insurance Payment
Effectiveness							
● Successive rate (%)	100	100	91.7	91.7	83.3	86.7	90.0
● Average of number of clicks	13.7	8.70	29.4	30.0	37.9	38.5	35.0
Efficiency							
● Consumed time to complete the task (second)	35.1	24.1	56.8	72.6	75.6	86.4	83.2
Error							
● Percentages different of error	5.63	9.04	6.29	28.9	17.0	17.0	34.8

Table 3.7: Total average values measured from usability criteria for each user group.

Measured parameters	User group			
	Students	Employees	Government and state Enterprises officers	agriculturists
Effectiveness				
● Successive rate (%)	92.0	95.3	93.3	88.7
● Average of number of clicks	27.0	25.6	28.2	29.5
Efficiency				
● Consumed time to complete the task (second)	54.3	45.4	57.3	90.4
Error				
● Percentages different of error	16.0	9.16	19.8	22.9

3.2   Experiment 2: A Proposed Design of ATM Interface for Banking Service

This experiment proposed a proposed design hierarchical menu structure of seven frequent tasks of ATM banking service by modifying from the existing ATM interface and developing to fit with the five main occupations in Thailand. A proposed interface is created to compare with existing ATM interface. From the experiment, five occupations of 105 participants are used for testing. Participants are asked to the use of a proposed design and an existing design. Simulators of the proposed interface are adopted for testing in laboratory environment. The paper describes a study of human-computer interaction (HCI) [1] in developing the proposed design methodology and creates a user-interface to be easy to understand. Five perspectives of usability evaluations are classified as follows: effectiveness, efficiency, satisfaction, memorability, and learnability.

The purpose of this experiment is to design a proposed interface for ATM banking services that is suitable for people and to compare main functions of existing ATM interfaces in main occupations in Thailand.

3.2.1   Establishing a Proposed ATM Interface

The proposed design interface was created from the emerged disadvantage of the existing ATM interface which is summarized in Table 3.8.

Table 3.8: Emerged problem derived from comparison of five banks and their solutions.

Problems from existing ATM interface	Problem Solutions
1. Alignment of main menu is not appropriate to be used	Design main menu by frequency of selecting function
2. Process Redundancy For example, in credit card payment, user must enter reference number twice to identify oneself	Merge two steps into one step
3. Difficult to go back to prior step	Add back button on the key pad
4. Difficult to go back to main menu	Add return to main menu button
5. Many pages per task	Multiple functions per page and multiple steps per page
6. Difficult to use for illiterate and semi-literate user	Add icon button to simply the process

Seven main tasks of each bank are employed for comparison. The existing ATM interface, which is the most efficiency and effectiveness from first our experiment, is selected to compare with a proposed design interface. In the proposed design interface, a number of steps to complete seven tasks are reduced as shown in Table 5.1 of chapter V. In this experiment, Human-Computer Interaction (HCI) [1] principle is used for designing of the proposed interface for ease to use and to access.

3.2.2 Design of Keypad

A keypad is designed by using the principles of HCI in part of accessibility to improve accessing using keypad button. In addition, the problems given from comparison five banks are improved in proposed ATM interface. These problems are listed in Table 3.8. The keypad can help the user for recovery from mistake. The components of the keypad including 0-9 digits for an entry [21], "Return card" button for returning a card, "Return to main menu" button for go back to the main menu, "Clear" button for clearing data, and "Back" button for returning to a previous page. Figure 3.11 depicts an example of keypad of the proposed interface design.

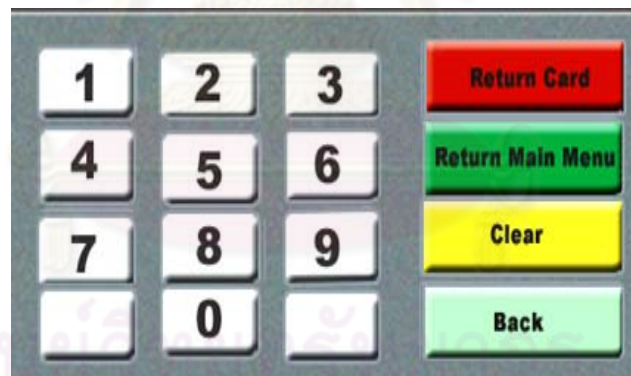Table 3.11: Keypad of the proposed interface design.

3.2.3 Design of Menu Structure

There are many components for the proposed interface design composed of button layout, logo, many menus per a page, many steps per a page, and logo associate with the menu. Appendix D shows screen of the process of the proposed ATM interface for seven main tasks. The following is the details of the components concerned.

3.2.3.1 Touch Screen

A Touch screen interface is used for designing because it is easier to use than other input devices and saves time in the operation.

3.2.3.2 Button layout

The location of each button is considered based on the frequency of the use according to [22]. The most frequent task and the second most frequent task are located on the top-right and top-left as shown in Figure 3.12.
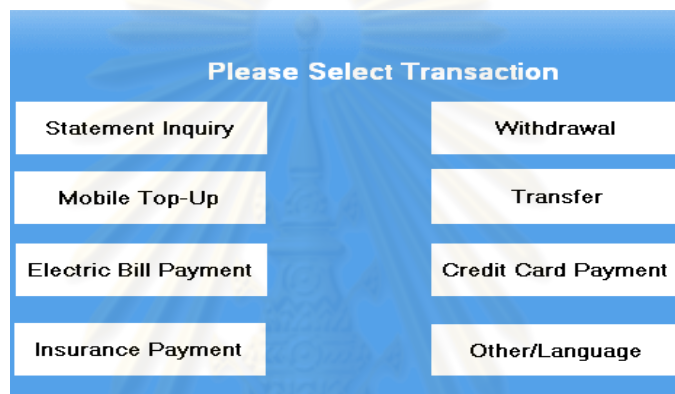

Figure 3.12: An example of the proposed design main menu.

(a)   (b)

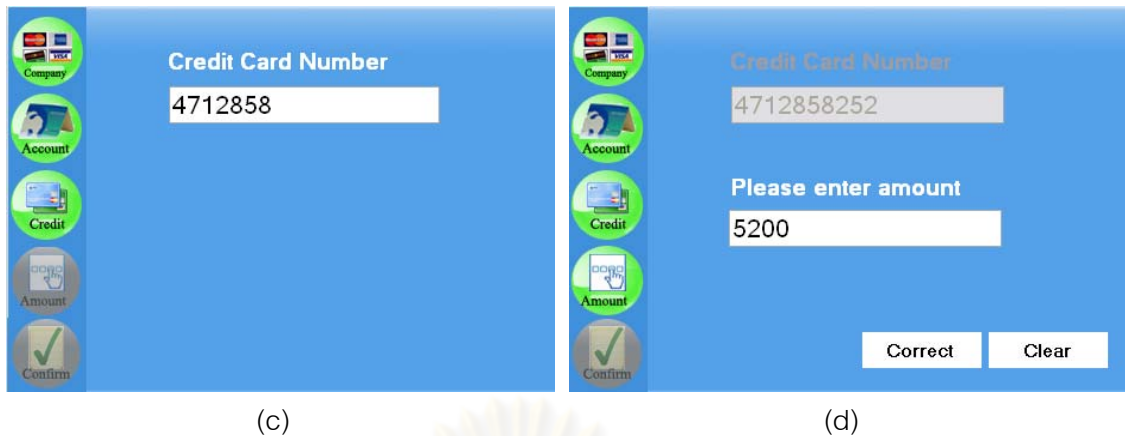(c)   (d)

Figure 3.13: The proposed ATM interface in each process (a) Example of process of selecting credit card companies, (b) Example of process of specifying money amounts, (c) Example of process of complete credit card number, (d) Example of process of specifying amount.
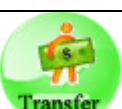
3.2.3.3 Logo: It can be displayed within a small area. Figure 3.13 (a) illustrates example of logo appearing on the left side of a page these symbols represent desired logo of credit card companies. The logo can enhance brand recognition.

3.2.3.4 Multiple functions per page: For Withdrawal of the proposed ATM design, a participant can withdraw by either selecting or specifying the amount on the same page as shown in Figure 3.13 (b).

3.2.3.5 Multiple steps per page: In some processes, there are many steps on the same screen. Figure 3.13 (c) - (d) show two steps per screen. When a participant specifies credit card number, the participants can enter the amount of money immediately.

3.2.3.6 Logo button: The button appearing in left side of the screen is designed by encompassing the icon to demonstrate a step of each task for ease to understand. The logo can be named as icon. The icon size is 32x32 pixels. Users are able to know the total number of steps for each task in advance and the button can be pressed in order to go back to the previous step as shown in Table 3.9.

Table 3.9: Examples of logo buttons.

Icon	Instruction
	Confirm the process
	Select Telephone Number
	Select Amount
	Select Credit Card Company
	Select Account Number
	Select Credit Card Number
	Select Transfer Items
	Select Insurance Company
	Select Mobile Top-Up Company
	Select Account
	Show Statement Inquiry Items
	Select Credit Card Company
	Enter Amount

	Select Bank
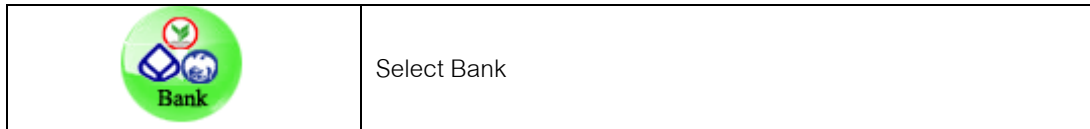
3.2.4 Design of Testing

This study is tested in the laboratory environment. The reason is that none participants agree to open account to testing because of the security issue. In addition, Kaikkonen, et al [19] found the same problem in both environments from comparison between laboratory and field testing. Hence, testing in the laboratory environment is chose because it is more convenience for participants to test without worrying about limited time. Three stages for the usability testing methods, namely, participant allocation, questionnaire design, and procedure.

3.2.4.1 Participant Allocation

A total of 105 participants were divided into five groups of occupation. The age ranging from 16 to 25 years old are collected from 33 participants while the range of age from 26 to 35 years old are collected from 49 participants and above 36 years old are collected from 36 participants.

3.2.4.2 Questionnaire Design

HCI principles are used to guideline questionnaire design. A total of 21 questions are created. The first part of the questionnaire is focus on user background including gender, age range, and occupation. The second part questionnaire survey about satisfaction of using ATM banking interface. The average time of each participant spending on the questionnaire is 30 ± 5 minutes (range of 25 - 35). Appendix E illustrates comparison of the questionnaire satisfaction between the existing and the proposed ATM interface.

3.2.4.3 Procedure:

There are three procedures of usability testing. First step, a participant randomly chooses just one of the seven tasks. Next, each participant performs the task on the simulator of the proposed ATM interface. In case the participant cannot finish the task on the first time, the participant must continuously perform until the task is

completed. Final step, the participant is asked to complete the questionnaire as shown in Figure 3.14.
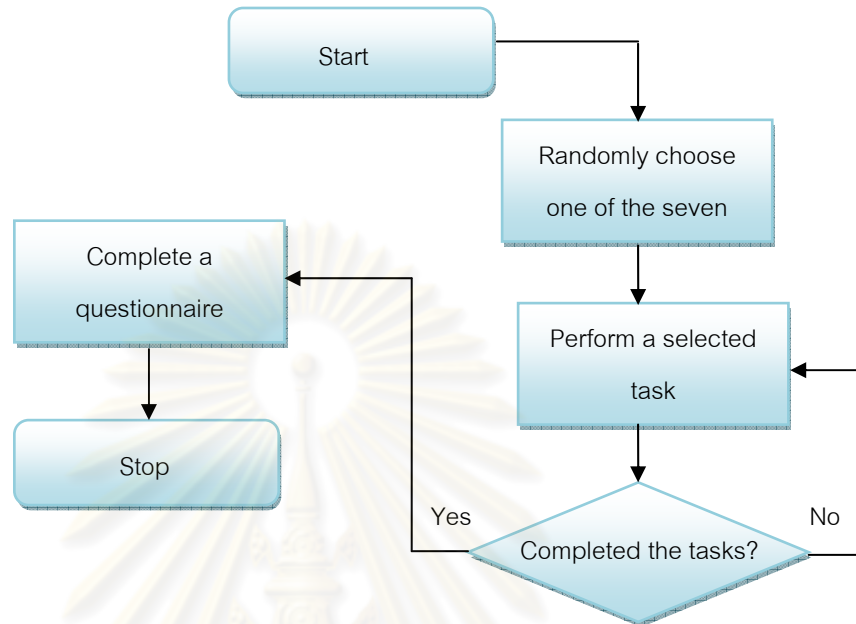
Figure 3.14: A framwork for procedure of usability testing.

CHAPTER IV

EVALUATIONS AND EXPERIMENTAL RESULTS

This chapter discusses evaluation not only in usability but also in statistics to assess the existing and the proposed ATM interface. In the last of this chapter shows experimental results.

4.1 Usability Evaluation

The usability is an importance for evaluation of software and system because given results from the evaluation can illustrate characteristics of considered ones. Many researchers have defined in different criteria as shown in Chapter II. However, five components of usability evaluation are used to measure effectiveness, efficiency, satisfaction, memorability, and learnability derived from Nielsen et al [3] as shown in Table 4.1.

Table 4.1: Usability Criteria Used for our evaluations.

Usability criteria	Measurements
Effectiveness	- Percentage of tasks accomplished
	- The number of mouse clicks to complete the task
Efficiency	- Time to complete the task
	- Percentage of emerged error
Satisfaction	- Satisfaction score
Memorability	- Difference of time used to finish the task between the first and the second time
Learnability	- Users must be able to learn the system easily and shortly

4.2 Statistical Evaluation

Z-test is comparison between two mean values of both samples derived from the same population to recognize a significant difference each other. The z-test is used when a number of samples are more than or equal 30 samples. The z-test is better applied when the variance of populations is known and always uses normal distribution. However, the variance of population can estimate from the variance of sample.

The t-test is properly applied when the variance of populations is not known, as well as a number of samples are less than 30 simples. If t-test is used in large

samples, the t-test is very similar to the z-test. The t-test is divided into three groups. First, single sample t-test is a statistical technique used to compare mean value of a sample and known mean value. Second, Paired sample t-test is a method of statistical measurement that is adopted to compare two mean values of both samples that are correlated. The paired sample t-test can be used in terms of either first-second or before-after testing. Third, two independent sample t-test is comparison between two mean values of both samples that are not correlated. There are two variations on the two sample t-test. First, two means of both samples have not equal variances called pooled variance. Second, two means of both samples have equal variances called separate variance.

4.3 Experimental Results

In this part, given results from both usability measurement and statistical measurement are discussed. The z-test (z), t-test (t), and paired t-test (t) are applied to statistically evaluate the usability results to recognize a significant difference between the existing ATM interface and the proposed ATM interface. Three given hypotheses are investigated in this study as follows:

H1:   There is a significant difference of effectiveness criteria between the existing and the proposed ATM interface.

H2:   There is a significant difference of efficiency criteria between the existing and the proposed ATM interface.

H3:   There is a significant difference of satisfaction criteria between the existing and the proposed ATM interface.

The purpose of hypotheses H1-H3 is to know significant differences of effectiveness, efficiency, and satisfaction between the existing ATM interface and the proposed ATM interface.   A significant level as 0.05 is selected for comparative analysis. For investigating, if probability value is less than five percents (P-value<0.05), there is the different that is accepts the hypothesis. In contrast, the hypothesis is rejected. For this evaluation, the z-test is used to know a significant difference between the existing and the proposed ATM interface for success rate, the number of mouse clicks, time used to complete the task, and percentage of error. The paired t-test is used

for the difference of time used to finish the between the first and the second time while the t-test is applied for satisfaction score and three perspectives, namely, ranges of age, occupations, and tasks, respectively.

4.3.1 Evaluation of Effectiveness

There are two aspects for effective evaluation to accept hypothesis H1 including success rate, and the number of mouse clicks.

4.3.1.1 Success rate (%)

The results of evaluation from success rate of 105 participants is depicted the success rate for existing ATM interface is less than the success rate for the proposed ATM interface that is 67.67 and 87.62, respectively. For analyzing z-test, there is a significant difference between the existing and the proposed ATM interface for success rate (z=3.98, p<0.05). The results from t-test imply that there is the different between the existing and the proposed ATM interface for students in occupations and statement inquiry, transfer, credit card payment, electric bill payment, and insurance payment in tasks and the ranges of age of 16-25 years old as shown in Table 4.2.

Table 4.2: Evaluation of success rate for effectiveness.

Task	Existing ATM interface Mean	The proposed ATM interface Mean	t-test	p-value	Significant difference (Yes = different, No = no different)
Ranges of Age					
1. 16-25	71.43	90.47	8.50	0.05	Yes
2. 26-35	75.61	95.12	8.61	0.05	Yes
3. Above 35	58.14	88.37	4.84	0.05	Yes
Occupations					
1. Students	76.19	90.47	11.67	0.05	Yes
2. Employees	80.95	95.24	12.33	0.05	No
3. Government Officers	71.43	95.24	7.00	0.05	No
4. Agriculturists	61.90	80.95	7.49	0.05	No
5. Merchants	52.38	76.19	5.40	0.05	No
Tasks					
1. Withdrawal	80	100	9.00	0.05	No
2. Statement Inquiry	86.67	100	14.00	0.05	Yes
3. Transfer	73.33	86.7	11.96	0.05	Yes
4. Mobile Top-Up	60	86.7	5.49	0.05	No
5. Credit Card Payment	53.33	80	4.99	0.05	Yes

6. Electric Bill Payment	66.67	80	11.00	0.05	Yes
7. Insurance Payment	53.33	80	4.99	0.05	Yes
Average of 105 participants	67.67	87.62			

4.3.1.2 A number of mouse clicks

The results of evaluation from a number of mouse clicks of 105 participants is shown an average of a number of mouse clicks for existing ATM interface is greater than that average for the proposed ATM interface that is 31.65 and 21.96, respectively. For analyzing z-test, there is a significant difference between the existing and the proposed ATM interface for the number of mouse clicks (z=3.59, p<0.05).The results from t-test imply that most of aspects are different between the existing and the proposed ATM interface excepting employees in occupation and mobile Top-Up in task as shown in Table 4.3.

Table 4.3: Evaluation of a number of mouse clicks for effectiveness.

Task	Existing ATM interface Mean	The proposed ATM interface Mean	t-test	p-value	Significant difference (Yes = different, No = no different)
Ranges of Age					
1. 16-25	30.56	21.19	3.65	0.05	Yes
2. 26-35	28.62	20.86	2.45	0.05	Yes
3. Above 35	34.34	23.34	2.89	0.05	Yes
Occupations					
1. Students	28.62	20.86	2.45	0.05	Yes
2. Employees	25.24	20.71	2.24	0.05	No
3. Government Officers	30.48	25.95	2.89	0.05	Yes
4. Agriculturists	31.19	22.05	2.12	0.05	Yes
5. Merchants	40.19	27.76	2.27	0.05	Yes
Tasks					
1. Withdrawal	21.13	11.93	2.54	0.05	Yes
2. Statement Inquiry	9.86	7.20	2.31	0.05	Yes
3. Transfer	38.67	26.33	6.01	0.05	Yes
4. Mobile Top-Up	31.13	26.73	1.25	0.05	No
5. Credit Card Payment	49.87	29.60	4.24	0.05	Yes
6. Electric Bill Payment	34.53	24.73	5.15	0.05	Yes
7. Insurance Payment	63.93	27.20	2.19	0.05	Yes
Average of 105 participants	31.65	21.96			

The results are summarized that the proposed ATM interface is the effective more than the existing ATM interface. Hypothesis H1 is accepted since both success rate and a number of mouse clicks between the existing and the proposed ATM interface are significant different to each other. This cause indicates that there is the significant difference between the existing and the proposed ATM interface for effective evaluation.

4.3.2 Evaluation of Efficiency

There are two aspects for effective evaluation to accept hypothesis H2 composed of time used to complete the task and percentage of error.

4.3.2.1 Time used to complete the task

The results of evaluation from time used to complete the task of 105 participants is shown an average of a number of mouse clicks for existing ATM interface is greater than that average for the proposed ATM interface that is 72.06 and 47.53, respectively. For analyzing z-test, there is a significant difference between the existing and the proposed ATM interface for time used to complete task (z=9.03, p<0.05).

The results from t-test imply that most of aspects are the different between the existing and the proposed ATM interface excepting employees in occupations and mobile top-up in tasks as shown in Table 4.4.

Table 4.4: Evaluation of time used to complete the task for efficiency.

Task	Existing ATM interface Mean	The proposed ATM interface Mean	t-test	p-value	Significant difference (Yes = different, No = no different)
Ranges of Age					
1. 16-25	72.12	48.86	3.009	0.05	Yes
2. 26-35	64.48	44.68	3.002	0.05	Yes
3. Above 35	75.88	49.60	2.310	0.05	Yes
Occupations					
1. Students	64.48	48.86	1.844	0.05	Yes
2. Employees	48.53	33.19	2.682	0.05	No
3. Government Officers	61.43	48.57	1.436	0.05	Yes
4. Agriculturists	89.81	53.14	2.007	0.05	Yes
5. Merchants	96.05	53.90	2.457	0.05	Yes
Tasks					
1. Withdrawal	57.13	25.20	3.367	0.05	Yes

2. Statement Inquiry	32.13	19.13	2.117	0.05	Yes
3. Transfer	63.93	46.87	2.363	0.05	Yes
4. Mobile Top-Up	81.47	53.33	1.632	0.05	No
5. Credit Card Payment	80.20	78.40	1.916	0.05	Yes
6. Electric Bill Payment	96.07	50.87	1.967	0.05	Yes
7. Insurance Payment	96.53	58.93	1.084	0.05	Yes
Average of 105 participants	72.06	47.53	9.03	0.05	Yes

4.3.2.2 Average of Error

The given results of evaluation from percentage of error of 105 participants is shown an average of percentage of error for existing ATM interface is greater than that average for the proposed ATM interface that is 11.65 and 10.9, respectively. For analyzing z-test, there is a significant difference between the existing and the proposed ATM interface for percentage of error ($z=9.72$, $p<0.05$).

The results from t-test mean that most of aspects are the different between the existing and the proposed ATM interface excepting employee in occupations and mobile top-up in tasks as shown in Table 4.5.

Table 4.5: Evaluation of percentage of error for efficiency.

Task	Existing ATM interface Mean	The proposed ATM interface Mean	t-test	p-value	Significant difference (Yes = different, No = no different)
Ranges of Age					
1. 16-25	0.30	0.07	4.78	0.05	Yes
2. 26-35	0.27	0.06	5.93	0.05	Yes
3. Above 35	0.31	0.16	3.64	0.05	Yes
Occupations					
1. Students	0.31	0.07	4.780	0.05	Yes
2. Employees	0.26	0.04	5.952	0.05	No
3. Government Officers	0.28	0.08	3.335	0.05	Yes
4. Agriculturists	0.30	0.13	3.49	0.05	Yes
5. Merchants	0.42	0.19	3.61	0.05	Yes
Tasks					
1. Withdrawal	0.93	0.29	4.084	0.05	Yes
2. Statement Inquiry	0.34	0.06	4.095	0.05	Yes
3. Transfer	0.29	0.08	4.417	0.05	Yes
4. Mobile Top-Up	0.18	0.12	1.045	0.05	No
5. Credit Card Payment	0.30	0.15	5.052	0.05	Yes
6. Electric Bill Payment	0.31	0.06	6.989	0.05	Yes

7. Insurance Payment	0.49	0.10	5.052	0.05	Yes
Average of 105 participants	11.65	10.9			

The evaluation results are summarized that the proposed ATM interface is more efficient than the existing ATM interface. Hypothesis H2 is accepted since both time used to complete the task and percentage of error between the existing and the proposed ATM interface are significant different to each other. This cause indicates that there is the significant difference between the existing and the proposed ATM interface for efficiency evaluation.

4.3.3   Evaluation of Satisfaction

For this evaluation, z-test is not used since each user group contains less than 30 samples. The t-test was used to analysis for questionnaire measuring satisfaction level of the participants as shown in Figure 4.1. There is a significant difference between the existing ATM interface and the proposed ATM interface in students (t=1.710, p<0.05), employees (t=3.019, p<0.05), and agriculturists (t=3.050, p<0.05) whilst there is no significant difference in state enterprises officers (t=0.965, p<0.05) and merchant (t=1.802, p<0.05). The given results show that the satisfaction score of the proposed ATM interface is clearly higher than the existing ATM interface particular to student, employees, and agricultures.
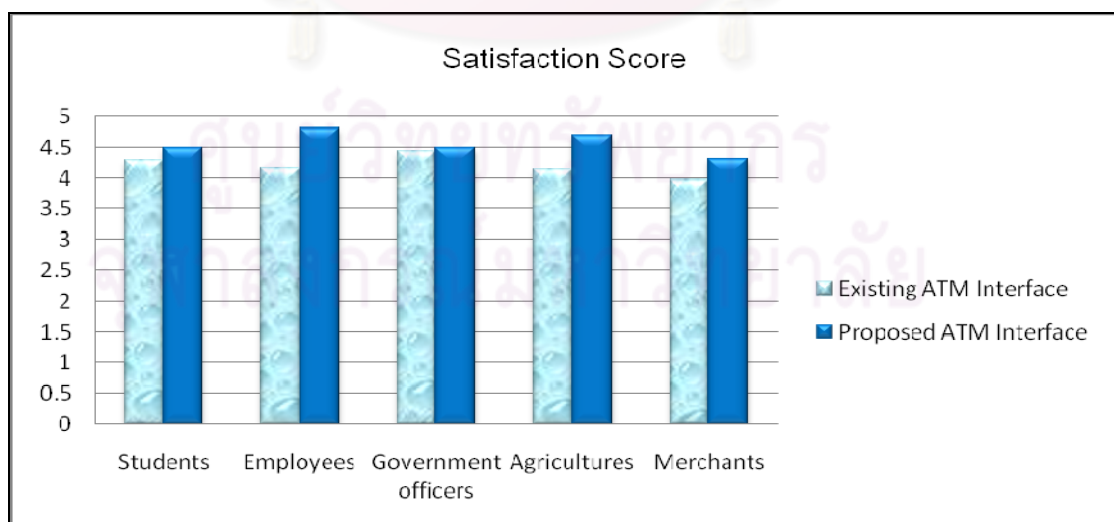

Figure 4.1:   Evaluation of satisfaction score.

The evaluation results are summarized that the proposed ATM interface is the satisfactory more than the existing ATM interface. Hypothesis H3 is accepted since three aspects (student, employees, and agricultures) are significant different between the existing and the proposed ATM interface are significant different to each other. This cause indicates that there is the significant different between the existing and the proposed ATM interface for satisfactory evaluation.

4.3.4 Evaluation of Memorability

Time used to finish the task for the first and second time of 105 participants is used for memorability evaluation.

The evaluation from paired t-test illustrates there is significant difference between the first time and the second time used to complete the task for the existing ATM interface (t=4.39, p<0.05) and for the proposed ATM interface (t=5.45, p<0.05).

From experimental results, an average of time used to finish the task for the first and the second time as 72.06 and 57.09 for the existing ATM interface and as 47.53 and 30.79 for the proposed ATM interface. This indicates that the proposed ATM interface has more memorability than the existing ATM interface since the difference of average of time used between the first and the second time is more than that of the existing one. This implies that the users can well remember any processes from first time.

4.3.5 Evaluation of Learnability

Time used to finish the task for the first is used for learnability evaluation. From experimental results, an average of time used to finish the task for the first as 72.06 for the existing ATM interface and as 47.53 for the proposed ATM interface. This indicates that the proposed ATM interface has more learnability than the existing ATM interface since the average of time used for the first is less than another. This implies that the users can easily use, to understand, and to access.

CHAPTER V

CONCLUSIONS AND DISCUSSIONS

5.1   Conclusions

New ATM interface design in seven main functions of ATM banking service for the main occupation group have been performed by applying the human-computer interaction (HCI) principle [1] and then adopted usability criteria [2, 3] to measure the usability of the new ATM interface. Moreover, statistical analysis, including z-test, t-test, and paired t-test, is used to evaluate usability results to know significant difference between the existing and the new ATM interface.

Before designing the new ATM interface, exiting ATM interfaces of seven major tasks on ATM Banking services from the five banks in Thailand were compared so that the advantage and disadvantage, derived from comparing the exiting ATM interfaces, are used for designing the new ATM interface. The usability results of all seven tasks for Bank C had the highest effectiveness, efficiency and satisfaction scores measured in the usability criteria [2, 3]. However, it demonstrates a low accuracy value of clicks. In terms of the occupation, the agriculturists gave the lowest number of completed tasks and the largest number of clicks to complete the task. They spend more time, and get a higher percentage difference in their number of clicks. In the other hand, the employees have the highest value of effectiveness and efficiency.

The results from the evaluation of both usability criteria and statistical analysis indicate new proposed ATM interface can well improve effectiveness, efficiency, satisfaction, memoability, and learnability in point of view of usability criteria. Besides, there is the significant different between the existing and the new ATM interface for effective, efficient, and satisfactory evaluation. The results indicate that employees mostly prefer proposed ATM interface whilst other ones are quite prefer. This thesis can be useful for designers for ATM interface and other related fields.

5.2   Discussions

In this part shows the comparison of existing ATM interface given the best usability results and a proposed ATM interface, and then discuss the causes of appeared results from proposed ATM interface.

Both interfaces have the differences of hierarchical menu structures, button layout, and a number of command buttons. Therefore, usability results are different. The following shows comparison of a number of steps in each task between the existing ATM interface and the proposed ATM interface. The ATM interface of Bank C is selected from existing ATM interface of all five banks since it is the best from evaluating usability.

Table 5.1: A number of steps in each task for the existing and the proposed ATM interface.

Items	Tasks	A number of step in each task for five banks		Step difference
		The existing ATM interface (Bank C)	New ATM interface	
1	Withdrawal	6	3	3
2	Statement Inquiry	4	3	1
3	Transfer	8	8	0
4	Mobile Top-Up	7	7	0
5	Credit Card Payment	10	7	3
6	Electric Bill Payment	10	7	3
7	Insurance Payment	10	7	3

In hierarchical menu structure, the total number of the steps for the proposed ATM interface is less than the total number of steps for the existing ATM interface. However, transfer task is not different in the number of steps as shown in Table 5.1.

Both existing and the proposed ATM interface for statement inquiry have the best results measured by usability criteria. However, the results of this the proposed ATM interface is better than this existing ATM interface. As a result, a number of steps and minimum number of mouse clicks of this the proposed ATM interface are less than ones of this existing ATM interface. Flow diagrams of two tasks are shown in Figure 5.1.
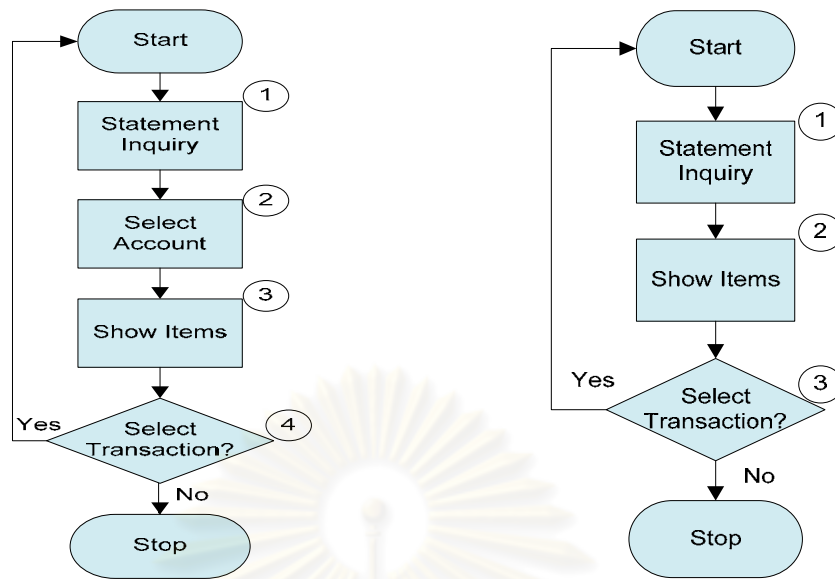
(a) Diagram of statement inquiry for existing ATM (Bank C)

(b) Diagram of statement inquiry of new ATM

Figure 5.1: Flow diagram of tasks which is the best usability for existing and the proposed ATM interface.
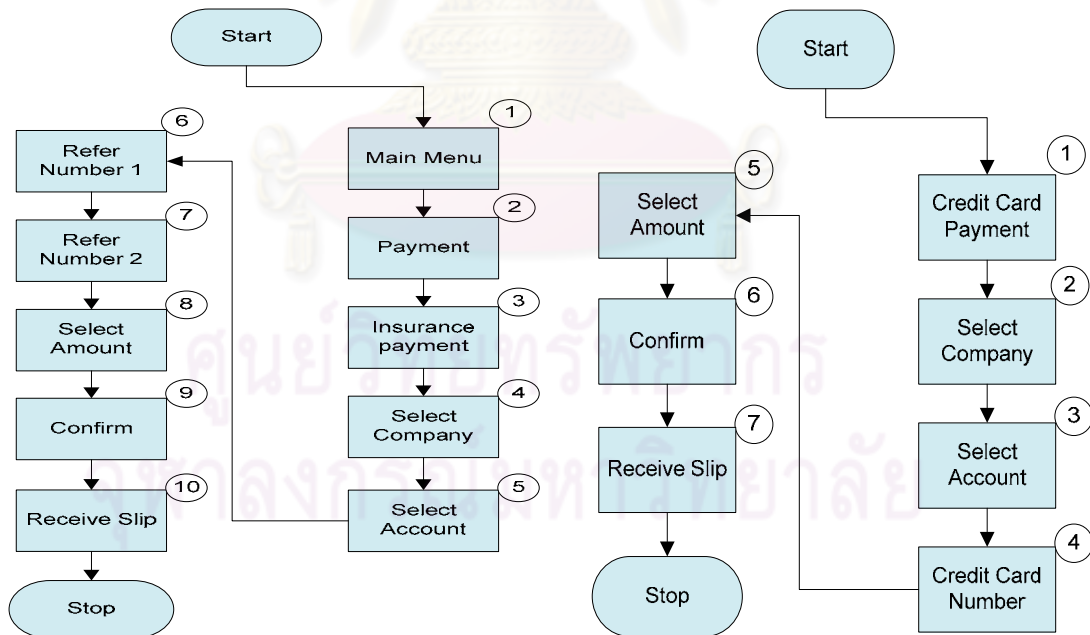
(c) Diagram of insurance payment for existing ATM (Bank C)

(d) Diagram of credit card payment for the proposed ATM interface

Figure 5.2: Flow diagram of tasks which is the worst usability for existing and the proposed ATM interface.

From Figure 5.2, Insurance payment for existing ATM has the worst results whilst credit card payment for exiting ATM has the worst results. Nevertheless, the results of this credit card payment is better than the results of insurance payemnts which a number of steps and minimum number of mouse clicks can be cause of this results.

From this study found that, the merchant and agriculturist groups are less effectiveness, efficiency, satisfaction, memorability, and learnability than other groups because most participants of these groups were illiterate and semi-illiterate. Nevertheless, they can operate in new ATM interface better than the existing ATM interface. In contrast, the employee and government groups are high effectiveness, efficiency, satisfaction, memorability, and learnability since most of them are literate and often use the ATM server.

One of founding is that age range of 26-35 years gives the best results in effectiveness and efficiency because the users of this rage can good learn and understand to new technology. Additionally, they often use ATM banking service too. In contrast, the range of above 35 years give the worst results both effectiveness and efficiency since they is less able to learn to new technology.

The results of statistical analysis indicate that mobile top-up task of proposed ATM interface has measured usability better than that of existing ATM interface. However, they are not significantly different. The cause may come from a total number of steps of both are equal. There is no significant difference of usability result from employee group between the existing and the proposed ATM interface. The reason may be that users of this group often use the ATM and well learn to use technology, so there is the least error in both of the existing and the proposed ATM interfaces from this group.

During new ATM interface design, most of participants can conveniently operate to the task. When they have some mistakes such as choosing incorrect account type or bank, they can go back to recently prior step to correct and then continue that mean they have not to press cancel button to go to main menu which is cause to decreasing number of clicks and time to complete the task. Besides, the step button can note the number of step of each task and used for go back to specified step too.

Figure 5.3 reveals comparison usability results in each perspective of usability principle. A proposed ATM interface is better than an existing ATM interface in every perspective, namely effectiveness (success rate and a number of clicks), efficiency (time used to complete the task and average of error), satisfaction score, learnability, and memorability. These results indicate that new hierarchical menu structure and increasing of the command buttons, such as return to main menu button, back button, return card button, and logo buttons of the proposed ATM interface can help the participants of all five groups for ease to use, to learn, to remember, and to recover from the emerged error of operations quickly.
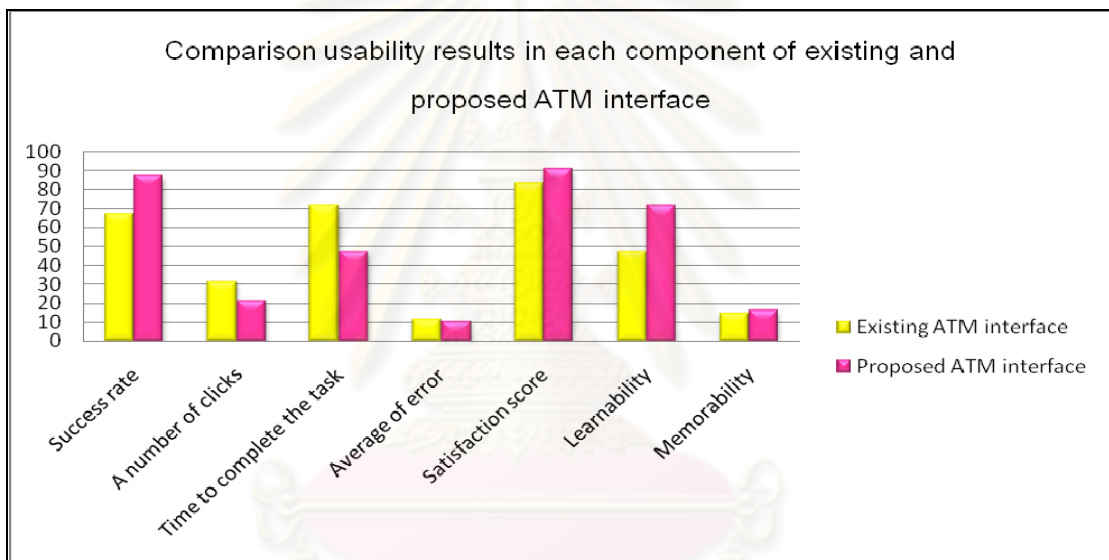
Figure 5.3: Comparison usability results in each component of existing and proposed ATM interface.

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APPENDICES

Appendix A

A satisfaction questionnaire for the participants for five banks in Thailand.

Agreements

5 = Strongly Agree

4 = Agree

3 = Neutral

2 = Disagree

1 = Strongly Disagree

1. General Data

   - Sex   [] Male   [] Female

   - Age   [] 16 – 25 year old   [] 26 – 35 year old   [] Above 35 year old

2. Level of satisfaction : Make √ on the your satisfaction level according to above agreements

คำถาม	Bank A					Bank B					Bank C					Bank D					Bank E				
	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1	5	4	3	2	1
1. Do you think hierarchical menu structure is easy to make mistakes?																									
2. Hierarchical menu structure is easy to get where you wanted to go?																									
3. Do you think screen is easy to learn?																									
4. Do you think the system unnecessarily complex?																									
5. Do you think text on user interface short and direct so that users can absorb it quickly and easily?																									
6. Do you think hierarchical menu structure is easy to get started and not take a long time to learn to use the system?																									
7. Do you think interface on the screen is easily visible and accessible?																									
8. Hierarchical menu																									

structure is easy to access?																					
9. I can easily find an ATM when I need one?																					
10. The bank provided me with enough information to use an ATM?																					
11. The bank should offer training or practice in ATM use?																					
12. I easily recover error during conducting task?																					
13. It is easy for me to go to the next screen?																					
14. The layout of the hierarchical menu structure is consistent from screen to screen?																					
15. I enjoy operating this bank?																					
16. I feel easy to operate this bank and I have never had a problem with it?																					
17. I like the visual appearance of icons and colors on this bank interface?																					
18. It is easy to get started with this bank?																					
19. I believe that ATM are more reliable than bank tellers?																					
20. I prefer using ATM than going into a bank?																					
21. I not read text on screen?																					

Appendix B

A screen of bank given the best and the worst results of usability evaluation in Thailand.

1. Withdrawal

   - A screen of withdrawal of bank C

Select Transaction

Bar Code Payment	Withdrawal
Payment	Transfer
Mobile Top-Up	Statement Inquiry
Other	

(1)

Select Transaction

500 Baht	5,000 Baht
1,000 Baht	10,000 Baht
1,500 Baht	20,000 Baht
3,000 Baht	Specify the amount

(2)

Please select the account

Savings account

Current account

(3)

Please specify the amount

5000

Correct

Incorrect

(4)

- A screen of withdrawal of bank E

Select Transaction

Thai

English

China

(1)

Select Transaction

500 Baht   Enter the amount

1,000   Statement Inquiry

5,000   Service

10,000   Other

(2)

Select Transaction

Savings account

Savings account

Credit card account

(3)

This type of packaging 1,000,500,100 please press

500

Correct

Incorrect

(3)
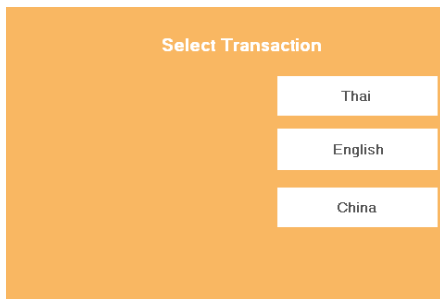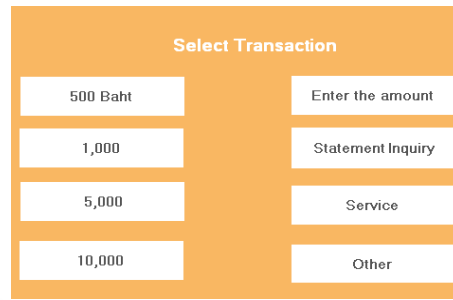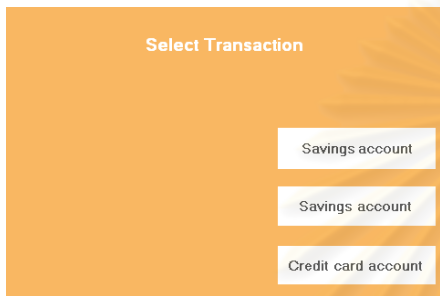
2. Statement Inquiry

- A screen of statement inquiry of bank C

Select Transaction

Bar Code Payment   Withdrawal

Payment   Transfer

Mobile Top-Up   Statement Inquiry

Other

(1)

Select Transaction

Saving Account

Credit Card

(2)

**Balance 4,000 Baht
Amount withdrawn 4,000Baht
Do you want to continue?**

Want

Not want
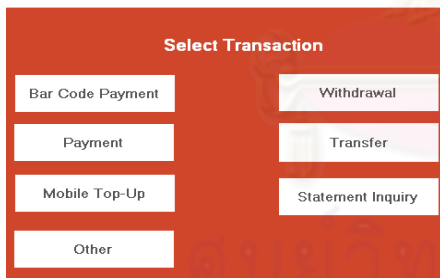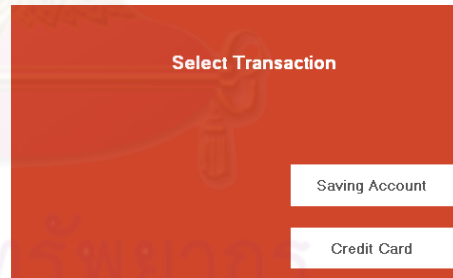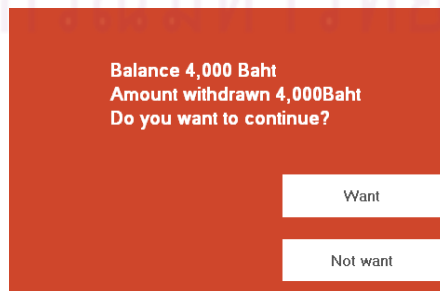
(3)

- A screen of statement inquiry of bank E

Select Transaction
Thai
English
China

(1)

Select Transaction	
500 Baht	Enter the amount
1,000	Statement Inquiry
5,000	Service
10,000	Other

(2)

Account that you use

Request a list saving

I see balance

May I see the current account balance

I see account

(3)

Balance 4,000 Baht
Amount withdrawn 4,000Baht
Do you want to continue?

Want

Not want

(4)

3. Transfer

- A screen of transfer of bank C

Select Transaction	
Bar Code Payment	Withdrawal
Payment	Transfer
Mobile Top-Up	Statement Inquiry
Other	

(1)

Please select the account

Saving Account

Current account

(2)

Please select items to transfer

Transfer the card

Transferred to

Transferred to other

(3)

Please specify the amount to transfer

9000

Correct

Incorrect

(4)

Please enter the account number

2152748859

Correct

Incorrect

(5)

Account Number 2349874423
Transfer to account 2152982234
Kamonwan Taohai
Amount 1,000

Confirm

Cancel

(6)

- A screen of transfer of bank E

Select Transaction

Thai

English

China

(1)

Select Transaction

500 Baht

1,000

5,000

10,000

Enter the amount

Statement Inquiry

Service

Other

(2)

Enter your account number

Payment

Payment to Comp

Donation

Fund

Bar Code Payment

Transfer

Change Password

(3)

Please select the account you want

Saving Account

Current account

(4)

Please select the account you want

Savings account that

The current account card

Bangkok Bank's

Bank account other

(5)

Please click and check amount

6000

Correct

Incorrect

(6)

Enter the account number

2458096632

Confirm

Clear

Cancel

(7)

Account Number 2349874423
Transfer to account 2152982234
Kamonwan Taohai
Amount 1,000

Confirm

Cancel

(8)

4. Mobile Top-Up

- A screen of mobile top-up of bank C

Select Transaction

Bar Code Payment | Withdrawal

Payment | Transfer

Mobile Top-Up | Statement Inquiry

Other

(1)

Select Transaction

one-2-call | the brain

happy | nok air

ok cash | true move

rue move (prepaid)

(2)

Please select the account

Saving account

Current account

(3)

Enter your phone number

0862141044

Correct

Incorrect

(4)

Please specify the amount to top up

500

Correct amount

Incorrect

(5)

Please confirm your prepaid phone

Confirm

Cancel

(6)

- A screen of mobile top-up of bank E

Select Transaction

Thai

English

China

(1)

Select Transaction

500 Baht	Enter the amount
1,000	Statement Inquiry
5,000	Service
10,000	Other

(2)

Enter your account number

Payment	Bar Code Payment
Payment to Comp	Transfer
Donation	Change Password
Fund	

(3)

Account that you use

Saving Account

Current account

Credit card

(4)

Please select the service you want to pay

Internet	Credit card /
Insurance	Mobile phone
Direct Selling /	Utility / tax
	Other

(5)

Please select a service

DTAC	ONE-2-CALL
HAPPY	AIS (GSM Advance)
GSM 1800	PCT BUDDY
True Move	Other

(6)

Please select a service

one-2-call 50 Baht	one-2-call 250 Baht
one-2-call 100 Baht	one-2-call 300 baht
one-2-call 150 Baht	one-2-call 350 Baht
one-2-call 200 Baht	one-2-call person

(7)

Please dial the phone and check the accuracy

0862141044

Correct

Incorrect

(8)

5. Credit Card Payment

- A screen of credit card payment of bank C

Select Transaction

Bar Code Payment	Withdrawal
Payment	Transfer
Mobile Top-Up	Statement Inquiry
Other	

(1)

Select Transaction

4-digit company ID	Credit / Loan for
Insurance Payment	Telephone / internet
Leasing	Registered
Products / services	Tax / electricity /

(2)

Select Transaction

citibank card / credit	TMB-บัตรเครดิต
Capital	HSBC-บัตรเครดิต
Standard Chartered -	Easy buy
Standard nations	Other

(3)

Please select the account

Saving account

Current account

(4)

Enter your customer ID / reference number. 1

528091447

Correct

Incorrect

(5)

Enter your customer ID / reference number. 2

589007412

Correct

Incorrect

(6)

Please specify the amount needed

9000

Correct

Incorrect

(7)

- A screen of credit card payment of bank E

Select Transaction

Thai
English
China

(1)

Select Transaction

500 Baht	Enter the amount
1,000	Statement Inquiry
5,000	Service
10,000	Other

(2)

Enter your account number

Payment	Bar Code Payment
Payment to Comp	Transfer
Donation	Change Password
Fund	

(3)

Account that you use

Saving Account
Current account
Credit card

(4)

Please select the service you want to pay

Internet	Credit card /
Insurance	Mobile phone
Direct Selling /	Utility / tax
	Other

(5)

Select Transaction

Corporation	Bangkok Bank credit
Eastern Commercial	American Express Sue Place
Internet BCP	citibank card
Tesco Loans	Other

(6)

Please press the credit card number

8056931477085123

Correct
Incorrect

(7)

Please press the amount of the invoice

9000

Correct
Incorrect

(8)

6. Electric Bill Payment

- A screen of electric bill payment of bank C

Select Transaction

Bar Code Payment	Withdrawal
Payment	Transfer
Mobile Top-Up	Statement Inquiry
Other	

(1)

Select Transaction

4-digit company ID	Credit / Loan for
Insurance Payment	Telephone / internet
Leasing	Registered
Products / services	Tax / electricity /

(2)

Select Transaction

Revenue Department	MEA
	True Vision DFTV
	True Vision CPV

(3)

Please select the account

Saving account

Current account

(4)

Enter your customer ID number

5809632221475

Correct

Incorrect

(5)

Press the 9-digit invoice number

258096325

Correct

Incorrect

(6)

Please press the desired amounts

5600

Correct

Clear

Cancel

(7)

7. Insurance Payment

- A screen of electric bill payment of bank E

Select Transaction

	Thai
	English
	China

(1)

Select Transaction

500 Baht	Enter the amount
1,000	Statement Inquiry
5,000	Service
10,000	Other

(2)

Enter your account number

Payment	Bar Code Payment
Payment to Comp	Transfer
Donation	Change Password
Fund	

(3)

Account that you use

Saving Account
Current account
Credit card

(4)

Please select the service you want to pay

Internet	Credit card /
Insurance	Mobile phone
Direct Selling /	Utility / tax
	Other

(5)

Please select a service

Tax Revenue	MEA
CAT Telecom	TOT Company Limited
Department of Land	Phone companies. /

(6)

Warnings The bank will accept the amount

Accept
Cancel

(7)

Please Enter 9-digit meter

805221474

Correct
Clear
Incorrect

(8)

(9)

(10)

(11)

Appendix C

The comparison of the hierarchical menu structure of bank given the best and the worst results of five banks for usability evaluation.

1. The hierarchical menu structure of withdrawal for Bank C and E.

   - Menu of Withdrawal of Bank C

- Menu of Withdrawal of Bank E

2. The hierarchical menu structure of transfer for Bank C and E.

- Menu of transfer of Bank C

- Menu of transfer of Bank E

3. The hierarchical menu structure of mobile top-up for Bank C and E.

- Menu of mobile top-up of Bank C
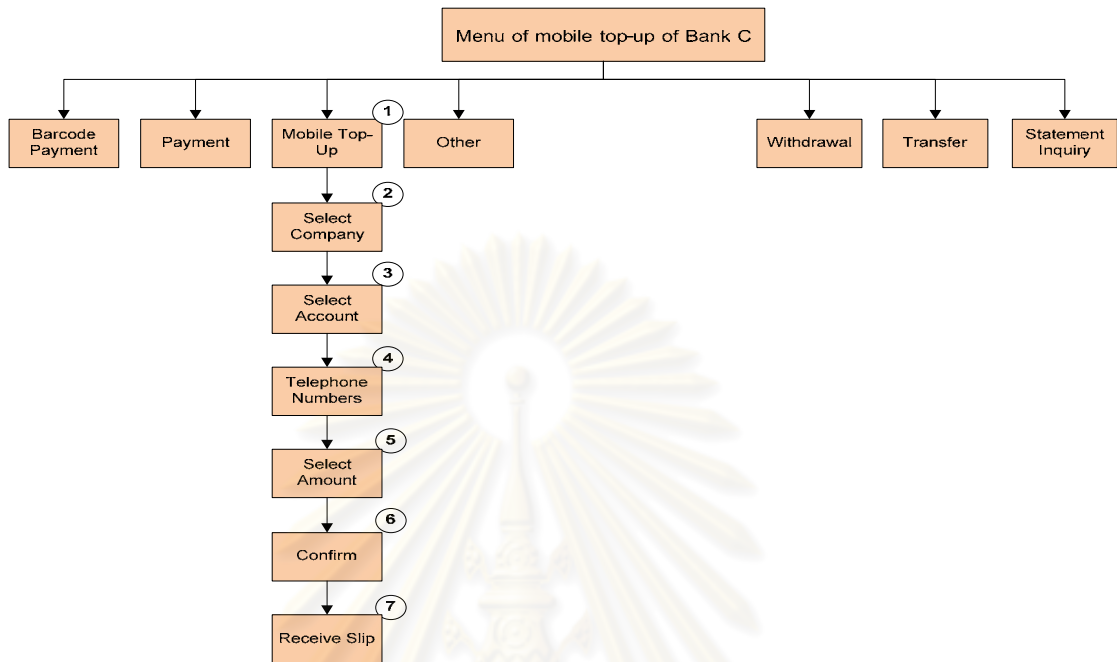
- Menu of mobile top-up of Bank E
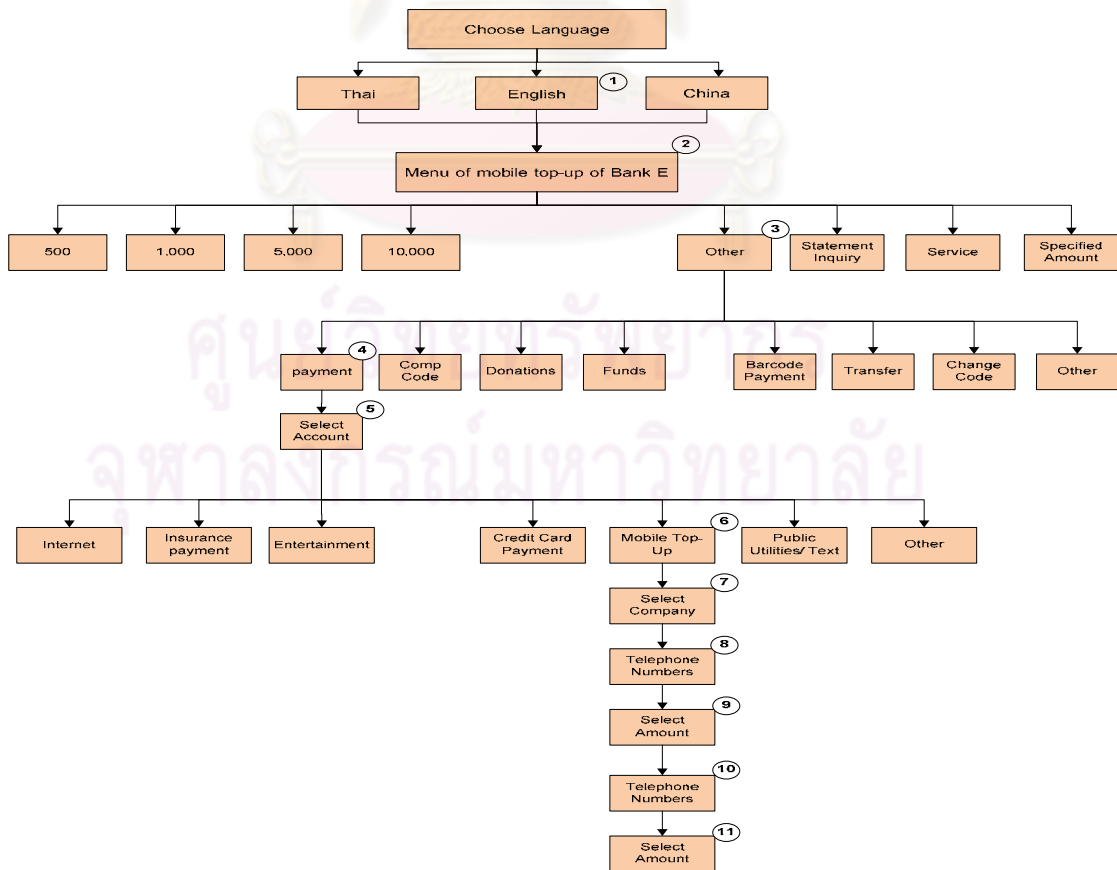
4. The hierarchical menu structure of credit card payment for Bank C and E.

- Menu of credit card payment of Bank C
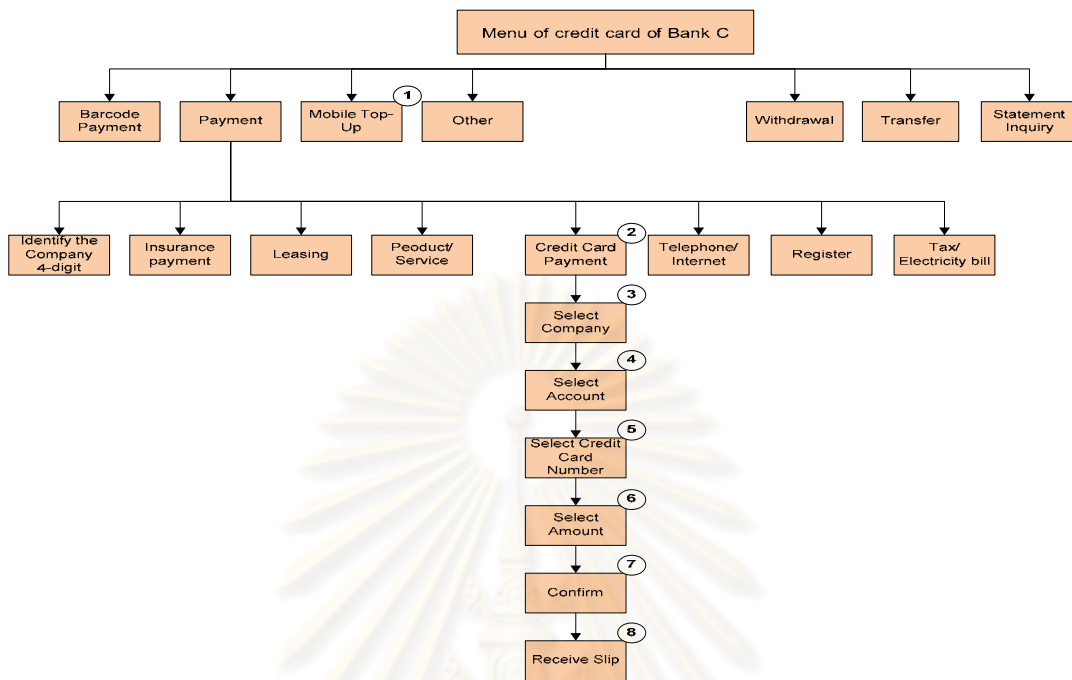
- Menu of credit card payment of Bank E
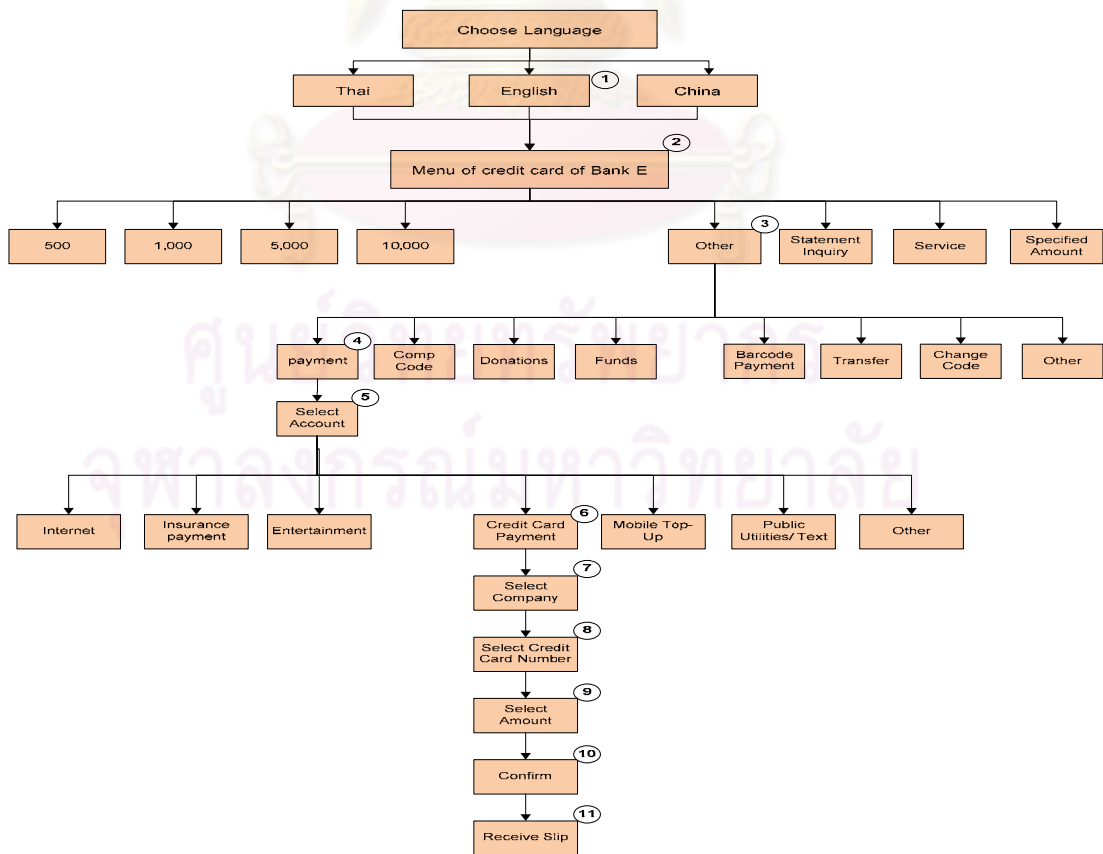
5. The hierarchical menu structure of insurance payment for Bank C and E.

- Menu of insurance payment of Bank C
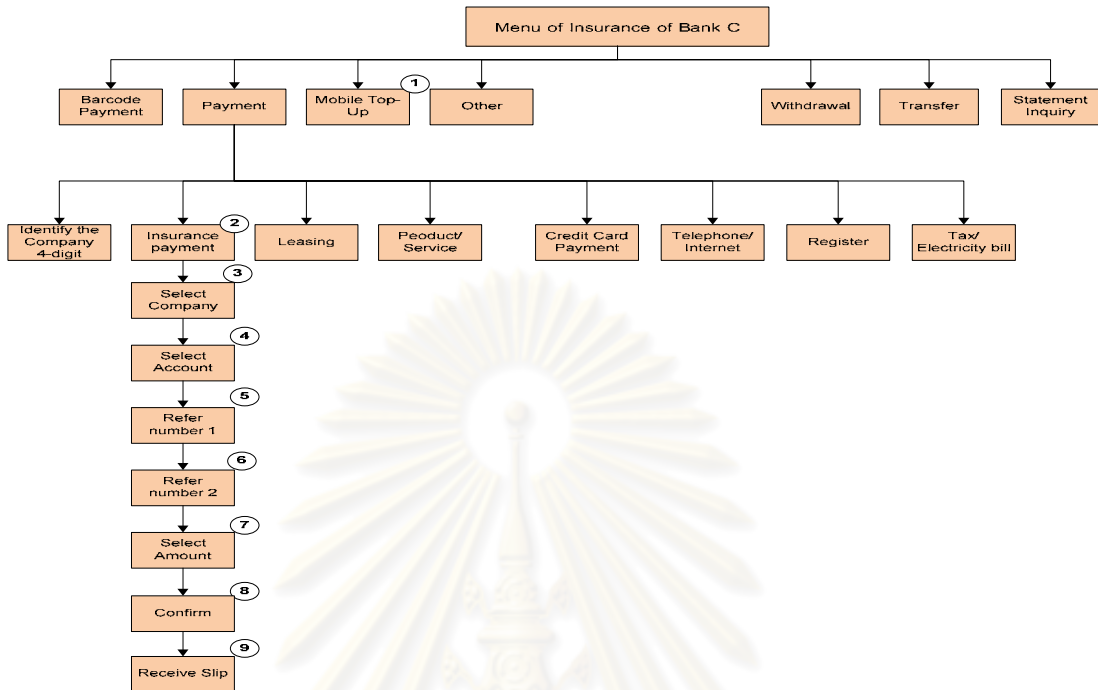
- Menu of insurance payment of Bank E
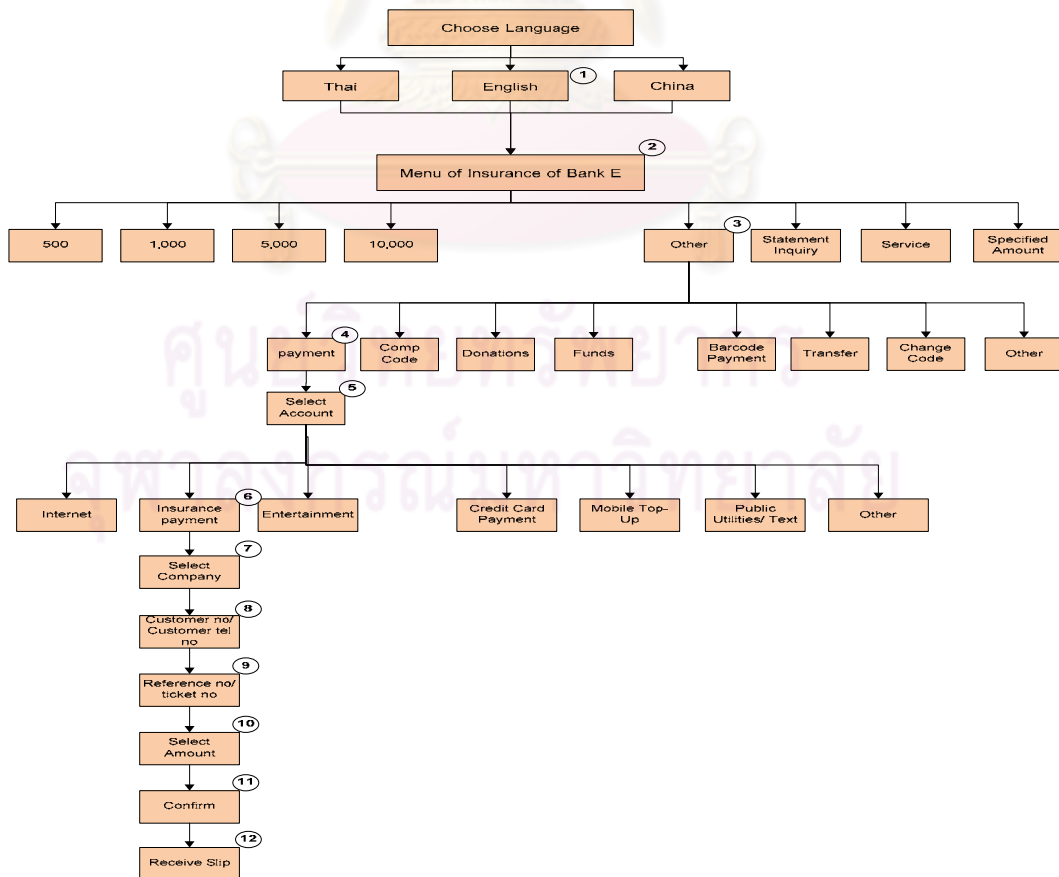
6. The hierarchical menu structure of electric bill payment for Bank C and E.

- Menu of electric bill payment of Bank C
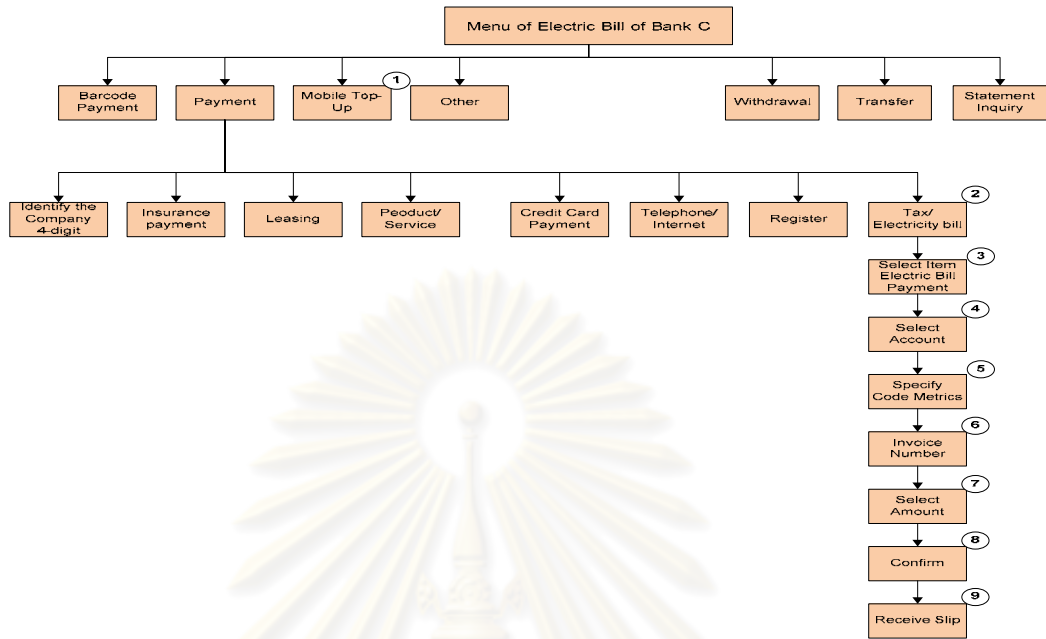
- Menu of electric bill payment of Bank E
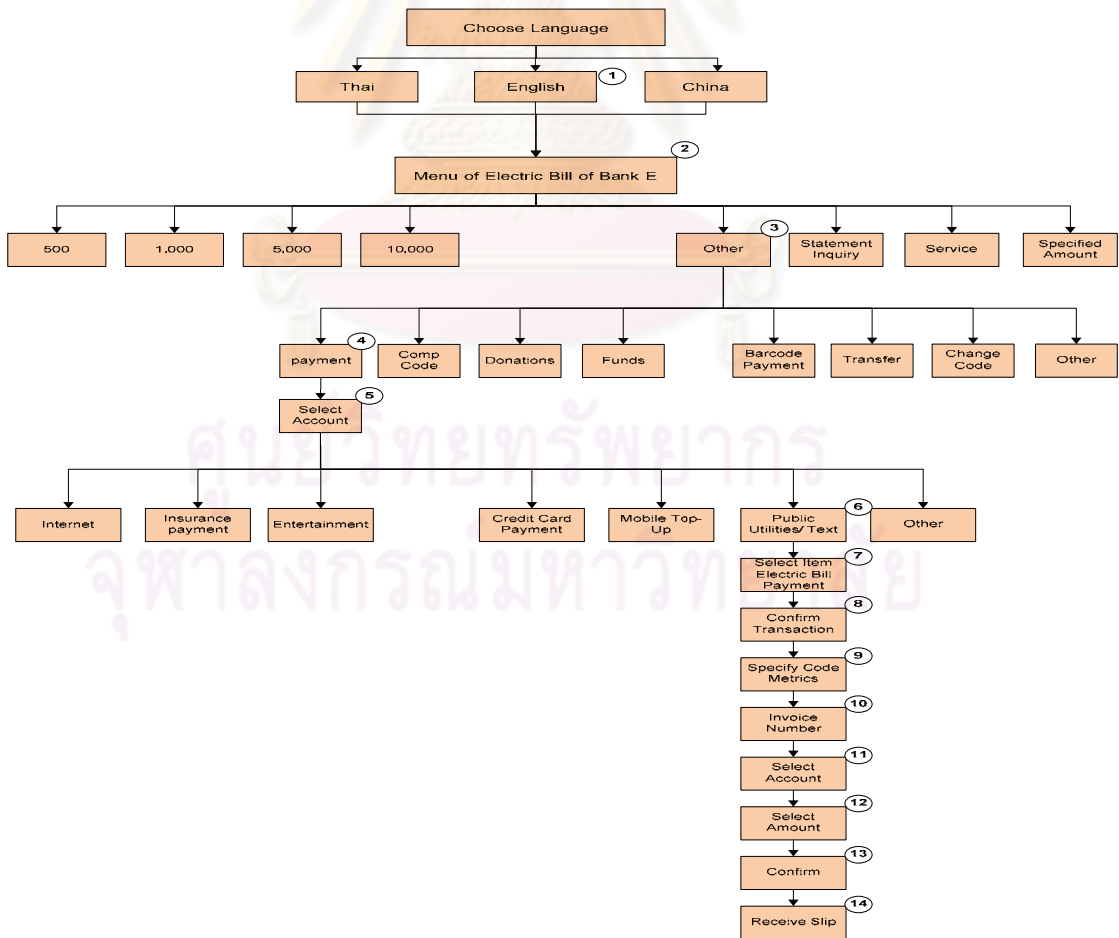
7. The hierarchical menu structure of statement inquiry for Bank C and E.

- Menu of statement inquiry of Bank C
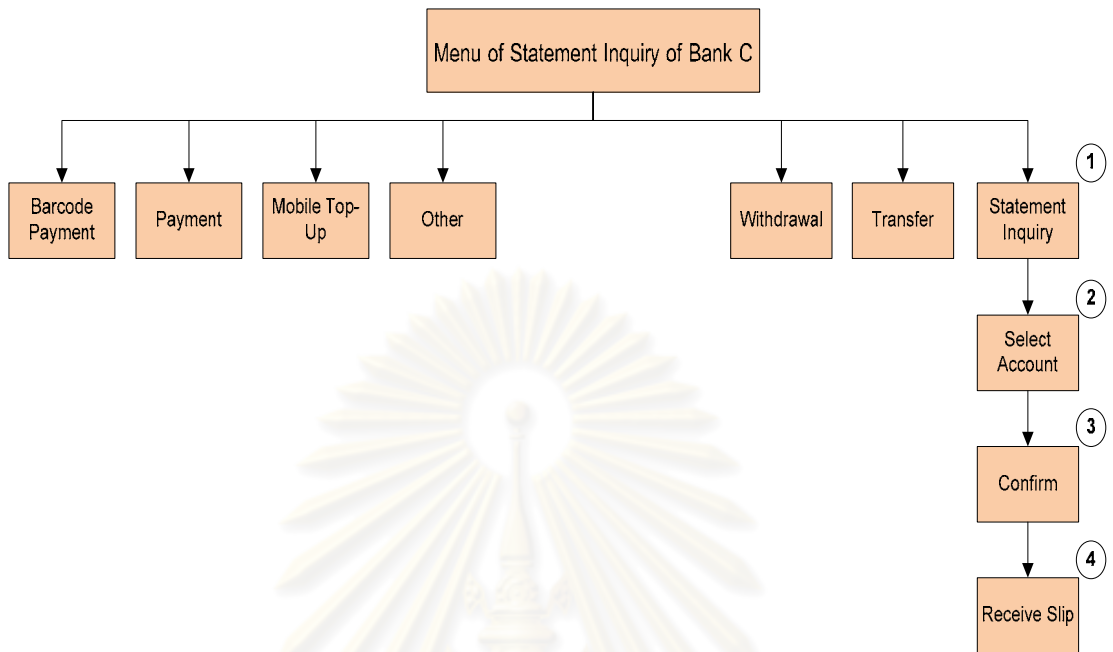
- Menu of statement inquiry of Bank E
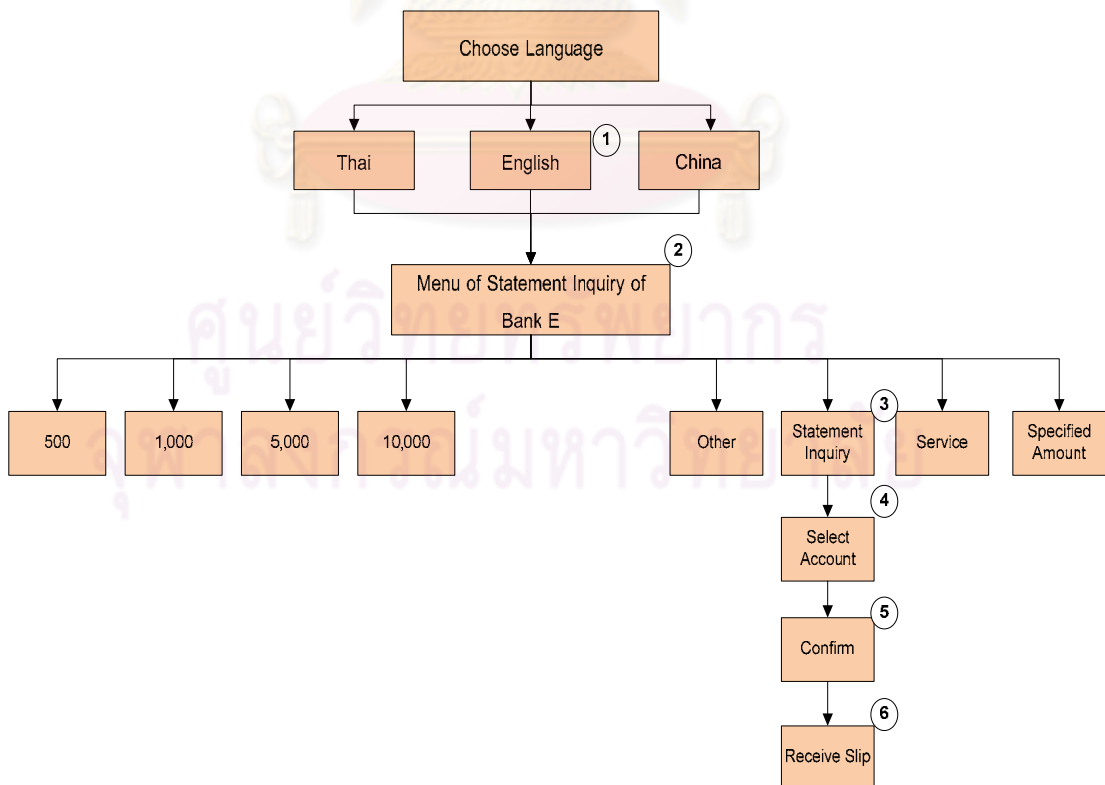
Appendix D

A screen of the process of the proposed ATM interface for seven main tasks.

1. Withdrawal

2. Statement Inquiry

3. Transfer

(1)

(2)

(3)

(4)

4. Mobile Top-Up

(1)

(2)

(3)

(4)

5. Credit Card Payment

(1)

(2)

(3)

(4)

6. Electric Bill Payment
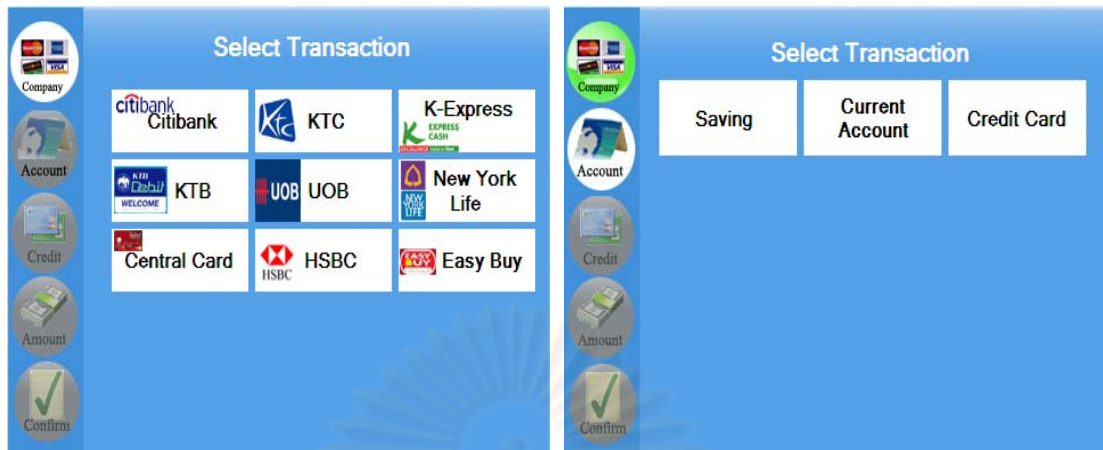
(1)
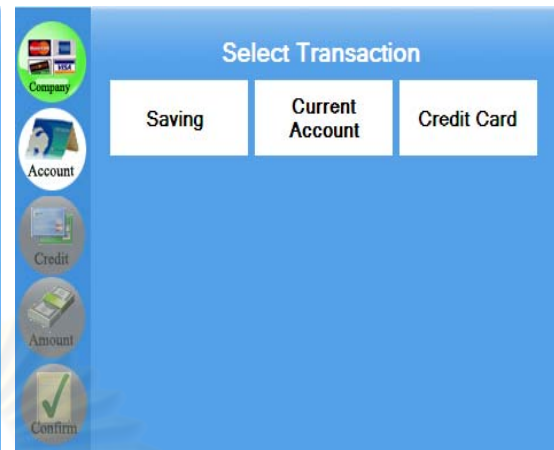
(2)
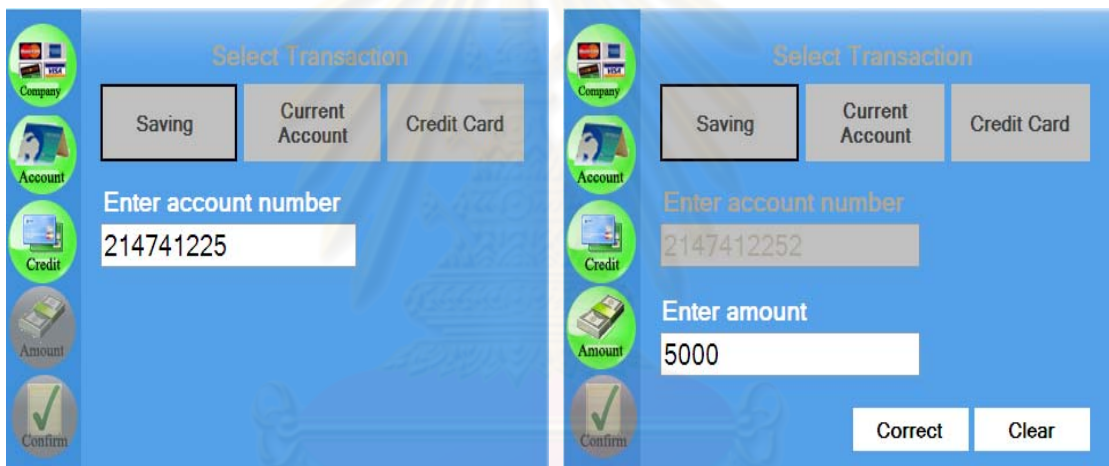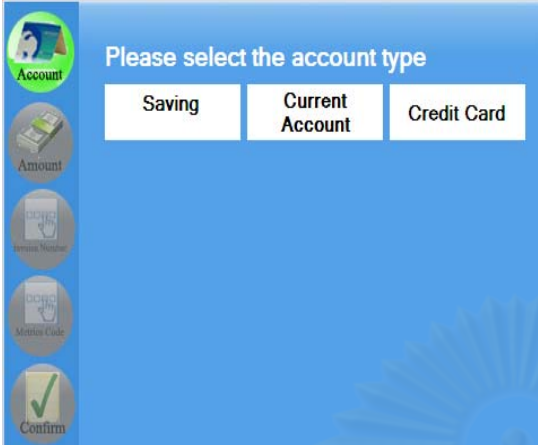
(3)
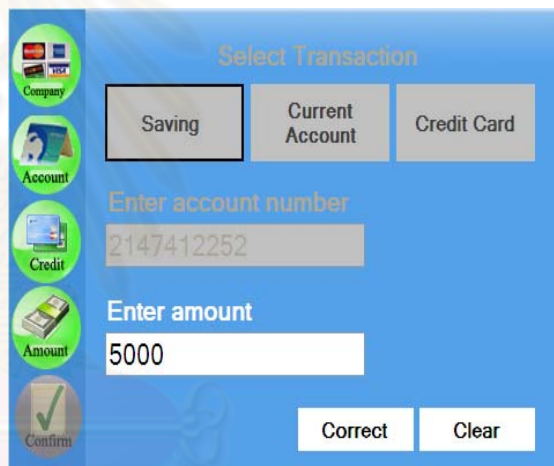
(4)

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7. Insurance Payment

(1)

(2)

(3)

(4)

Appendix E

The comparison of the questionnaire satisfaction between the existing and the proposed ATM interface.

Agreements

5 = Strongly Agree

4 = Agree

3 = Neutral

2 = Disagree

1 = Strongly Disagree

1. General Data

   - Sex   [] Male   [] Female

   - Age   [] 16 – 25 year old   [] 26 – 35 year old   [] Above 35 year old

2. Level of satisfaction : Make √ on the your satisfaction level according to above agreements

Question	The existing ATM interface					New ATM interface				
	5	4	3	2	1	5	4	3	2	1
1. It is easy to get started with this function?										
2. The hierarchical menu structure of this ATM banking service is attractive?										
3. I feel quite easy to operate this navigation menu and I have never had a problem with it?										
4. I like an emergence of the icon and step represent status on this screen?										
5. I feel comfortable to operate in this function?										
6. This function is easy to get back to where I want to be, when I make a mistake?										
7. This function has several options of data entry. I can choose the style I prefer and I feel it is comport to use?										
8. I feel layout button is easy to understand?										
9. It is easy for me to go to the next screen?										
10. It is easy for me to go back to the previous screen?										
11. I am sure that I can complete this task after a period of non-user?										
12. I can recall the icon location and information presented on the screen after a period of non-use?										
13. I think the names of icons or labels are important so that I feel easy to remember?										
14. If I made some mistakes, it is always possible to cancel prior to completion?										
15. The grouping and ordering of menu options is consistent?										
16. This function is easy to get started?										
17. The text on screen is always short and direct so that I can understand quickly?										
18. The text on the screen is easy to read?										
19. I can easily understand how to input data and output by using this function to perform this task?										

20. The items and information on the screen are grouped understandably?										
21. The icons of menu options are easy to understand and recognize?										

VITAE

Miss Kamonwan Taohai was born on January 22th, 1983, in Chainat, Thailand. She obtained her Bachelor's Degree in Political Science from the Faculty of Political Science, Ramkhamhaeng University in 2005 and has worked at Thanapat Property Development Company for two years.

Research paper

1. "Usability Comparisons of Seven Main Functions for Automated Teller Machine (ATM) Banking Service of Five Banks in Thailand" presented at Fukuoka, Japan and published in IEEE-Computer Society.

2. "A New Design of ATM Interface for Banking Services in Thailand" presented at Seoul, KOREA, and published in IEEE-Computer Society.