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An Improved Usability Evaluation Model for Point-of-Sale Systems

Md Alamgir Kabir, Bo Han

International School of Software, Wuhan University, Wuhan, 430079, China
Corresponding Author: Bo Han, Email: bhan@whu.edu.cn

Abstract

Point-of-sale (POS) systems are popular in developing countries because they provide fast and convenient ways of transactions for business. These systems contain vital tasks such as online transactions, ecommerce facilities, security, taxes, various management reports and others. Thereby, it is important to ensure their software quality and grantee the effective usages of business functions. Among multiple software quality attributes, usability is highlighted for POS software since the user interfaces are directly linked to cashiers' behaviors, customers' satisfactions and market profits. However, the usability evaluation of POS systems is not easy since they are generally featured with multi-functions, multiple configurations and complex interfaces. Many available quality models have failed to evaluate the usability of POS systems because any of them just cover partial view of usability. In this paper, we investigated ten well-known quality models and extracted the usability related factors from each of these models. By integrating these factors together, we proposed an improved usability evaluation model with a comprehensive view of usability for POS systems. Following the model, we designed usability scenarios for each factor and thus provided the corresponding questionnaires. A case study of evaluating a POS system in Bangladesh has demonstrated that the proposed model can provide a comprehensive evaluation of POS from 12 usability factors. Also, different demands from different type of customers are also be revealed by the model.

***Keywords**: Usability Models, Point-of-Sale, Quality Model, Usability Evaluation*

1. Introduction

Nowadays, Point of Sale (POS) systems are popular in developing countries because they provide fast and convenient ways of transactions for business. These systems contain vital tasks such as online transactions, ecommerce facilities, security, taxes, various management reports and many more [1]. Therefore, with large volume of customers in supermarkets and the growing competitive business environment in developing countries, ensuring the software quality becomes very important for them.

Among multiple software quality attributes, usability is highlighted for POS software since the user interfaces are directly linked to cashiers' behaviors, customers' satisfactions and market profits [2, 4-6]. A friendly user interface will provide effective helps to cashiers and faster checkout of customers, decreased in-store customer traffic, increased management reporting capacity, and also access to more consumers [3, 31]. According to Len Bass *et al.*[8], usability depends that how easy a system accomplishes users' tasks and to what extend users support system functions. According to Nielsen [9], usability is a quality attribute that assesses how easy user interfaces are to use. Usability depends on the match between a software product and its users under the particular constraints of the environment and tasks being performed with the product [7 -22]. Accordingly, usability of POS systems examines the interaction between users and POS software [10-11].

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However, the usability evaluation of POS systems is not easy since they are generally featured with multi-functions, multiple configurations and complex interfaces. Researchers worldwide have made efforts to evaluate usability of POS systems by using popular quality models. But many of such quality models have failed to access and evaluate the usability of these applications because they just cover partial view of assessment for POS systems.

In this paper, we investigated ten well-known quality models and extracted the usability-related factors from each of these models. By integrating these factors together, we developed an improved usability evaluation model with a comprehensive view of usability for POS systems. Following the model, we designed scenarios for each factor and thus provided corresponding questionnaires. Finally, we performed a case study of POS software evaluation by using a questionnaire and customer responses in Bangladesh. The results demonstrated the effectiveness of our proposed model.

The rest of the paper is organized as follows: Section 2 contains related work; Section 3 discusses the investigation of usability factors from ten well-known quality models; Section 4 proposes an improved usability evaluation model for POS systems; Section 5 shows a case study of a POS system evaluation by using the improved usability model. Finally, section 6 concludes the paper.

2. Related Work

The usability assessment for software applications has been widely investigated over the last few years [22-30]. Rajesh Kulkarni *et al*. evaluated SUMI (Software Usability Measurement Inventory) model that assist users to understand the usability of inventory software [23]. It summarized users' experience to software in quantification. Ruth Medina-Flores *et al*. developed a proposal for evaluating a learning management system by experts. They designed general evaluation criteria for usability assessment from Nielsen Model [24]. Wai-Peng Wong *et al*. investigated usability factors for Enterprise Resource Planning (ERP) systems developed by SAP [25]. They found two prominent factors, training and communicativeness, are responsible for ensuring usability. After analyzing the usages of SAP-ERP software in the context of textile industries of Bangladesh, they collected user response data from survey questionnaire and next determine the criteria to measure the usability of the ERP software. Nur Razia Mohd Suradi *et al*. applied ISO 9126 usability matrix for evaluation of web based educational systems [26]. They discovered that understandability and learnability are the major usability factors for these educational systems. Moreover, they gave guidelines for a new developer to design an application with a friendly user interface. Chrisna Jooste *et al*. discussed usability assessment criteria and provided guidelines to improve usability of business applications after analyzing literature work, users' observation, heuristic evaluation and SUMI model [27]. Amir Bijarchian *et al*. proposed a model to measure the usability of Enterprise Architecture (EA) framework [28]. The model is a modification of the QUIM (Quality in Use Integrated Measurement) model. Tanja arh *et al*. conducted a case study for usability assessment of educational management software [29]. By using SUMI questionnaires [23], they got to know how users interact with the educational management software and further applied usability evaluation. Azham Hussain *et al*. reviewed existing usability measurement models for mobile business applications [30]. Based on the reviews, they developed a set of metrics that assist guidelines for improving system usability.

For each of the above model, Table 1 summarizes its application area, proposed or applied model name, its distinguished contributions and the model references. We see that many studies have explored the usability factors for business and management applications. The researchers found some usability factors and further explained guidelines to improve the system usability based on their case studies. However, POS software is featured with multi-functions and complex e-commerce interfaces. All the above methods can only reveal partial usability view for POS systems. For example, SUMI model contains affect and control factors, which can describe system feedbacks to cashiers/customers and the pace to control a system by cashiers respectively. QUIM model includes trustfulness and universality factors. They are useful to evaluate e-commerce software with a diversity of online customers. Thereby, we need to have a more comprehensive investigation of system usability evaluation.

Table 1. Usability Models Implementation in Several Areas

Areas	Models	Contributions	Sources
Data Management and Store System	SUMI	Scale of usability aspects	Rajesh Kulkarni at al.[23]
Learning Management System	Nielsen Model	Designed a general criteria by experts	Ruth Medina-Flores *et al*.[24]
SAP ERP	System Usability Scale (SUS) and Semi-structured Interviews	Several considerations and suggestions	Wai-Peng Wong *et al*.[25]
Web Based Educational System	ISO 9126	Ability to understand and learn	Nur Razia Mohd Suradi *et al*.[26]
Business Application	Heuristic Evaluation with SUMI	Usability evaluation criteria and guidelines	Chrisna Jooste *et al*.[27]
EA Framework	QUIM	Proposed model contributes to enhanced design and prevents inconsistency and resource wasting.	Amir Bijarchian *et al*.[28]
Educational Management Software	SUMI Questionnaires	Developed methodology provides important information for the producers and designers	Tanja arh *et al*.[29]
Mobile Application	GQM	Usability metric for guidelines and measurement	Azham Hussain *et al*.[30]

3. Investigation of Usability Factors from Ten Well-known Quality Models

In software engineering, there are ten well-known quality models for system evaluation. Each of these models covers a part of usability factors. We aim to extract usability factors from each model and then aggregate them together. In such a way, more comprehensive usability factors can be obtained for analyzing POS software featured with multi-functions and complex interfaces.

[functions.

Table 2. Ten Quality Models with Usability Factors

Quality Model Index	Published Year	Quality Model Name	Usability Factors
1	1977	McCall	Operability, Training, Communicativeness
2	1978	Boehm	Reliability, Efficiency, Human Engineering
3	1991	Shackel	Effectiveness, Learnability, Flexibility, Attitude
4	1992	FURPS	Human Factors, Consistent in the Human Interface, Online and Content Sensitive Help, Training Materials, User Documentation, Aesthetics
5	1993	Nielsen	Learnability, Efficiency, Memorability, Errors, Satisfaction
6	1998	SUMI	Efficiency, Affect, Helpfulness, Control, Learnability
7	1998	ISO 9242-11 (Process)	Effectiveness, Efficiency, Satisfaction
8	2001	ISO 9126 (Product)	Understandability, Learnability, Operability, Attractiveness, Usability Compliance
9	2006	QUIM	Productivity, Efficiency, Effectiveness, Safety, Learnability, Accessibility Satisfaction, Truthfulness, Universality, Usefulness
10	2014	SEM	Understandability, Learnability, Applicability, Effectiveness / Usefulness for Future Projects, User Satisfaction

Zafar Masood *et al*. [21] proposed a model named Software Engineering Methodologies (SEM) (2014) for evaluating software usability. The model proposed five factors: understandability, learnability, applicability, effectiveness / usefulness and users' satisfaction. Understandability suggests that users can understand a task in a system. Learnability indicates users can get familiar with the functionality of a system quickly. Applicability means users can divide a task into logical concepts of the software. Effectiveness / Usefulness indicates users can complete specified functions with accuracy and completeness. User's Satisfaction helps to gauge the overall quality of a system. It also refers to users' subjective responses.

According to the above explanation, we summarized all extracted usability factors from the ten quality models in Table 2.

4. An Improved Usability Evaluation Model for POS Systems

From the analysis in section 3, we see that each of the ten well-known quality models only reveal partial views for a POS system evaluation. Thereby, we aim to integrate those usability factors from the ten models together and propose an improved usability evaluation model. Further, by following the model, we design scenarios and corresponding questionnaires for evaluation.

4.1 Integration of Usability Factors

By the analysis in section 3, we totally obtained 49 factors from the ten quality models. However, some of them are duplicated and some of them have the similar meanings but with different names.

In a former expression, given the ten quality models above, the ith model M_i with p usability factors is represented by,

$$M_i = < f_{i1}, f_{i2}, \dots, f_{ip} > \quad (1)$$

Here, $1 \leq i \leq 10$.

To aggregate duplicated or similar factors from the ten models together, we need to apply the following functions,

$$UF = RS\ ((RD(M_i, M_2, \dots, M_{10}))) \quad (2)$$

Here RD (abbreviation of Remove_Duplicate) and RS (abbreviation of Remove_Similar) are two functions to remove duplicate and similar factors from all factors in the ten models respectively. UF is a resulted vector including the final factors.

Thereby, we apply the following algorithm to aggregate those factors together.

Algorithm: Aggregation of Usability Factors from Multiple Quality Models

Inputs: N quality models and Each model $M_i = < f_{i1}, f_{i2}, \dots, f_{ip} >$ including p usability factors;

Outputs: The resulted vector UF including distinctive usability factors

```
Let UF=M1;
Let i=2;
Repeat{
        For each factor fij (1 ≤ j ≤ p) in Mi, check if it has been included in
              UF with the same name, if not, then {
                  Check if UF has similar factor as fij which has the similar
                      meanings, if not, then {
                              fij is added into UF
                      }
              }
        i=i+1;
}Until( i>N)
```

Figure 1. Aggregation Algorithm

In this way, we finally have 12 categories of factors which cover all extracted usability attributes from the ten quality models. The results are shown in Table 3. Further, we analyzed how the ten models include each category of factors. If a quality model contains a category of factors, the corresponding option in the table is checked. The last column shows the number of quality models share the same category of factors. It indicates the popularity of this category of factors for usability assessment. For example, UF2, UF4 and UF12 are important factors since they all are covered by six quality models.

Table 3. Comparison between usability quality factors

UF#	Usability Factor's Name	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	No. of Models
UF1	Operability/ Accessibility	✓							✓	✓		3

UF2	Efficiency/Control/ Error		✓	✓		✓	✓	✓		✓		6
UF3	Usefulness/Effectiveness/ Applicability/ Productivity			✓				✓		✓	✓	4
UF4	Learnability			✓		✓	✓		✓	✓	✓	6
UF5	Training/ Training Materials/	✓			✓							2
UF6	Satisfaction/ User Satisfaction/ Affect					✓	✓	✓		✓	✓	5
UF7	Understandability								✓		✓	2
UF8	Helpfulness/ Online and Context Sensitive Help				✓		✓					2
UF9	Attractiveness/ Aesthetics				✓				✓			2
UF10	Reliability/ Universality/ Consistent in the Human Interface/ Safety		✓		✓					✓		3
UF11	Usability Compliance/User Documentation				✓				✓			2
UF12	Human Engineering/Human Factors/Attitude/ Memorability/ Communicativeness/ Flexibility	✓	✓	✓	✓	✓				✓		6

Note: M1 = McCall, M2 = Boehm, M3 = Shackel, M4 = FURPS, M5 = Nielsen, M6 = SUMI, M7 = ISO 9242-11, M8 = ISO 9126, M9 = QUIM, M10 = SEM.

Here UF1 (Usability Factors 1) category contains operability and accessibility. These types of usability factors are from McCall's, ISO 9126 and QUIM quality models. In these three models, operability and accessibility both indicate the ease of operation of a system.

UF2 category contains efficiency, control and error factors. These usability factors are from Boehm, Shackel, Nielsen, SUMI, ISO 9242-11 and QUIM quality models. According to these models, efficiency indicates the software providing the required performance without any errors of the software. Errors concerns errors recovery by a system itself and the system can automatically process the next steps with efficiency. Control indicates how users control the system pace / motion in an efficient way. Thereby, these factors indicate the software efficiency facility provided to users.

UF3 category contains usefulness, effectiveness, applicability and productivity. These usability factors are from Shackel, ISO 9242-11, and QUIM and SEM quality models. According to these models, UF3 indicates software functions are useful for users' tasks.

UF4 category contains the learnability factor coming from Shackel, Nielsen, SUMI, ISO 9126, QUIM and SEM quality models. It refers to how easy a system is learnt by users themselves.

UF5 category contains Training and Training Materials from McCall and FURPS quality models. They both indicate how system resources teach users to use a system.

UF6 category contains satisfaction, user satisfaction and affects. They are from Nielsen, SUMI, ISO 9242-11, QUIM and SEM quality models. They refer to users' subjective responses to a system.

UF7 category contains understandability which is from ISO 9126 and SEM quality models. It shows the capability of a software product to help users understand whether the software is suitable, and how it can be used for particular tasks and conditions of use.

UF8 category contains helpfulness, online and context sensitive help factors from FURPS and SUMI quality models. They both indicate the ability to assist users in a specific context.

UF9 category contains attractiveness and aesthetics from FURPS and ISO 9126 quality models. They both suggest the software glamour and measure how users are involved in the software.

UF10 category contains reliability, truthfulness, universality and safety from Boehm, FURPS, QUIM quality models. They describe how interfaces are reliable and accommodate a diversity of users.

UF11 category contains usability compliance and user documentation from Nielsen and ISO 9126 quality models. According to these models, they refer to the capability of adhering to standards, conventions, style guides or regulations.

The last category UF12 contains human engineering, human factors, attitude, communicativeness, memorability and flexibility from McCall, Boehm, Shackel, FURPS, Nielsen and QUIM models. According to these models, these factors indicate how a system manages human users and their affairs.

4.2 An Improved Usability Evaluation Model for POS Systems

Based on the above analysis and the features of POS systems, we proposed an improved usability evaluation model with twelve usability factors for POS. The details are listed in Table 4 and each factor corresponds to a category in Table 3.

Table 4. Proposed Usability Quality Factors for POS Software

UF #	Proposed Quality Factors	Description
UF1	Operability	Operability indicates the capability of the software product to enable the user to operate and control it.
UF2	Efficiency	Efficiency indicates once users have learned the system, how quickly they can perform tasks.
UF3	Effectiveness	Effectiveness means the accuracy and completeness of a task with which users achieve specified goals.
UF4	Learnability	The capability to learn the content of software comprehensively and also can gain knowledge and skill by comfortably.
UF5	Training	Training means how system resources teach users to use a system.
UF 6	Satisfaction	Satisfaction refers to the subjective responses from users about their feelings when using the software.

UF7	Understandability	Understandability suggests that users can understand a task in the system easily.
UF8	Helpfulness	Helpfulness indicates it provide useful guidance to the user properly for a task in the system.
UF9	Attractiveness	Attractiveness means the glamour of user interface for the users who are involve in the software.
UF10	Reliability	The ability of a software to perform the tasks consistently which are required functions without any degradation or failure and also yielding similar outcomes which is dependable.
UF11	Usability Compliance	Usability compliance refers to the capability of the software product to adhere to standards, conventions, style guides or regulations relating to usability.
UF12	Human Engineering	Human Engineering indicates management of human and their affairs. It refers to making any changes based on original issue to do different things.

4.3 Scenarios Design for Usability Factors in POS Systems

Scenario is an effective means of capturing the software quality attributes. Thereby, for each of the above 12 usability factors, we design five specific scenarios to evaluate it for a POS system. For example, for UF1 about operability, one of designed scenarios is described in Table 5. Its scenario diagram is shown in Figure 2. The figure shows a concrete usability factor's scenario of operability for a POS system. In the scenario, a user (such as a cashier) scans a product barcode by using a reader and retrieves records form a database and automatically calculates the price of the product.

Table 5. Usability Scenario for Factor: Operability

Portion of Scenario	Possible Values
Source	Cashiers
Stimulus	Cashiers try to decode barcode by using barcode scanner and input the item id in the POS system.
Environment	Runtime of POS
Artifact	Transaction Interface in the POS System.
Response	Details of item is retrieved from the database depending on its quantity and price
Response Measure	Operability (What is the percentage of transactions in which information is shown in interface in 5 seconds after a scanning barcode)

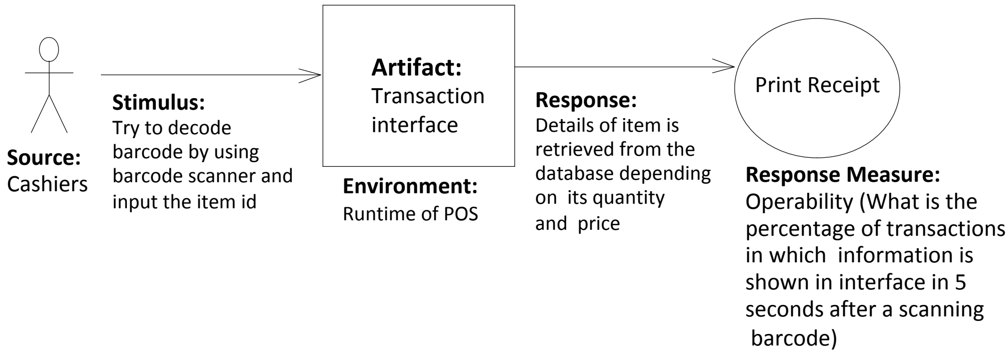


Figure 2. Usability Scenario for Factor Operability

4.4. Questionnaire Design for Usability Factors in POS Systems

Based on scenarios, we designed survey questionnaires for evaluating usability factors from software customers. Each scenario maps to one question and it expects to get the measured response from a customer. Every survey question has five satisfaction level choices and a customer can select one from them. For example, for usability factor UF1 as operability, the five survey questions for POS are listed in Table 6 as below. Among them, question 3 maps to the scenarios described in Table 5.

Each question has five desired answers as named satisfaction level and it corresponding value is shown in Table 7, such as 5 for very satisfied level. By the numbers, we can have statistical analysis based on the survey from a group of customers.

Table 6. Survey questions for UF1 - operability

Question Index	Questions
1	Can you access the functions of Input item of a sale?
2	Did you get sufficient information before using the entering of the sales item?
3	Did you get response from barcode scanner in 5 seconds when you attempt for sale of a product?
4	Does the system calculate the amount of sales item after entering product ID?
5	Did the system convert the fractional values of amount automatically?

Table 7. Satisfaction level and value

Satisfaction Level	Level's Value
Very Satisfied	5
Somewhat Satisfied	4
Neither Satisfied Nor Dissatisfied	3
Somewhat Dissatisfied	2
Very Dissatisfied	1

5. Demonstration with a Case Study of Evaluating a POS System

We conducted a survey for a SMART POS system that was used in a developing county, Bangladesh. We collected data from seven POS customers. These customers operate SMART POS for managing business in different types of markets. For example, North Super Market is a fresh vegetables market located in Mirpur 2 – Dhaka, Bangladesh that sells fresh vegetables, fish and meat. For selling their vegetables in a convenient and fast way, they used SMART POS systems by twelve cashers. This software is used for inventory managements, purchase order management and supply chain management. It is also used for store operations. They generate daily report for store management and financial analysis. As another example, Rafiqul Supershop is a big market located in Shukrabad - Dhaka, Bangladesh. The supermarket sells the largest selection of stationary products. For conducting sale smoothly, they operated SMART POS system by their four cashiers. They used the software for inventory management, purchase order management, store operations and supply chain management. They also generate various type of reports for analyzing the financial planning and cost benefits.

For system evaluation, these seven customers are asked to answer 60 questions related to the total twelve categories of usability factors in Table 4. In total, we obtained 420 answers. The statistic of survey results is shown in Table 8. For all the 60 questions, seven customers selected "very satisfied level" as answers for 166 times, that is 33%. They selected "Somewhat Satisfied" as answers for 144 times, that is 27%. Around 40% percentage of answers related to the usability of the POS system is not satisfied.

Table 8. Satisfaction Level Percentage of Answers

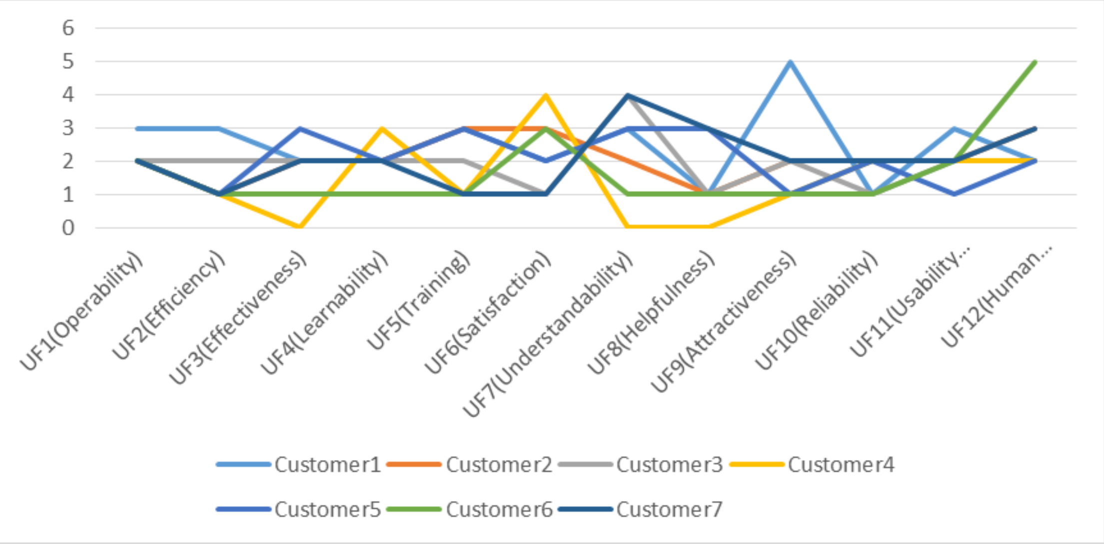
Satisfaction Level	Satisfaction (%)
Very Satisfied	33%
Somewhat Satisfied	27%
Neither Satisfied Nor Dissatisfied	20%
Somewhat Dissatisfied	13%
Very Dissatisfied	7%

Table 9. Satisfaction (%) for all Categories of Usability Factors for POS Software

Satisfaction Level	Satisfaction (%) of all Usability Factor (UF)											
	UF1	UF2	UF3	UF4	UF5	UF6	UF7	UF8	UF9	UF10	UF11	UF12
Very Satisfied	43%	29%	34%	40%	40%	46%	49%	29%	40%	31%	40%	54%
Somewhat Satisfied	26%	48%	37%	26%	31%	40%	31%	48%	34%	46%	23%	20%
Neither Satisfied Nor Dissatisfied	25%	20%	17%	26%	26%	11%	14%	17%	23%	17%	31%	23%
Somewhat Dissatisfied	3%	3%	9%	3%	3%	3%	6%	6%	3%	6%	6%	0%
Very Dissatisfied	3%	0%	3%	6%	0%	0%	0%	0%	0%	0%	0%	3%

Table 9 shows that the detailed survey results for the twelve categories of usability factors. For UF4 (Learnability), there are 6% answers are very dissatisfied. For UF3 (Effectiveness), there are 12% answers are either somewhat dissatisfied or very dissatisfied. These two factors are the most visible usability shortcomings from the view of customers. On the other hand, UF12 (Human Engineering) wins most customers' satisfaction feedbacks. By the analysis based on Table 9, we see clearly how a POS system performs from the twelve usability factors view. By following the view, developers can improve the system usability accordingly.

Going further, Figure 3 illustrates the satisfaction level for each usability factor from every customer. For example, from the point view of customer 6, the factor UF12 (Human Engineering) is very satisfied with the POS software. However, from the view of customer 4, the factor UF3 (Effectiveness) is very dissatisfied. With the customer



information together, we can see clearly the different demands for different types of customers based on the above analysis.

Figure 3. Tracking Usability Factors for each Customer of POS Software

6. Conclusions

As increasing demands of POS systems in developing countries recently, their usability evaluation has been under focused of research. POS systems are featured with multifunctional features and complex interfaces. The popular quality evaluation models just cover partial view of usability factors. In this study, we have analyzed ten well-known quality models and extracted their usability factors. By removing duplicate and similar factors, we proposed an improved model with twelve factors for evaluating the usability of POS systems. We proved its effectiveness in a case study. It demonstrates our model can comprehensively evaluate the usability of a POS system. In addition, it can highlight different software usability demands for different types of customers.

In our next step, we will explore quantitative measurement of software usability. Also, we would like to apply the similar methodology to build enhanced models for evaluating other software quality attributes.

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Authors

Md Alamgir Kabir . Md Alamgir Kabir obtained his B.S. degrin Software Engineering from Daffodil International University, Bangladesh, in 2014. He is currently a graduate student at the International School of Software in Wuhan University, Wuhan, China. His major research interests focus on usability testing, software engineering measurement, data mining and big data.

Bo Han. Bo Han received the B.S. degree in computer science and its applications from Wuhan University of Technology, Wuhan, China in 1993, and the M.S. degree in computer science from Wuhan University, Wuhan, China in 1996, and the Ph.D. degree in computer and information science from Temple University, Philadelphia, USA in 2007. He is currently an Associate Professor with the International School of Software in Wuhan University, Wuhan, China. His research interests are in spatiotemporal data mining, text mining and machine learning.