A Systematic Literature Review About Quantitative Metrics to Evaluate Usability and Security of ATM Interfaces

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Abstract. Automatic Telle Machine or ATM remains one of the most used banking channels and have been transformed into complex machines, where multiple operations can be carried out, not just cash withdrawals as was at the beginning. In this context, the usability and security of interfaces become essential aspects for users to interact with ATM interfaces efficiently. About usability, several studies support its important on the user experience, which also applies to the ATM domain. About security, previous works manifest its importance especially in the ATM domain. In this sense, it is intended to utilize usability and security metrics that allow establishing the degree of usability or security of ATM interfaces. In order to identify whether there are already metrics that may be valid for evaluating ATM interfaces, the authors present a systematic literature review they made about metrics that assess usability and security in banking software. After executing the review, five relevant documents were obtained. Of these, the most significant contribution is that of 160 metrics divided into 13 categories of metrics to assess the security and usability of an Internet Banking. Future research will be focused on evaluating the relevance of these proposals in the ATM domain.

Keywords: Systematic literature review · Automated Teller Machine · Software metrics · Usability evaluation · Security

1 Introduction

More than 50 years ago, John Shepherd-Barron invented the first ATM (Automatic Teller Machine) in London at the request of Barclays Bank [1]. Since then, ATMs have evolved. At the beginning, it was only aimed at withdrawing cash, over time they became more complex machines and were added another financial transactions of a very varied nature, such as mobile phone, balance inquiries, data updates, among others [2].

Considering that, the most used transaction in ATM is cash dispensing, we cannot ignore that when adopting new functions, ATM should be as friendly as possible [3]. An important aspect to improve the usability, and, in general, the user experience is to consider the emotional state, feelings, and emotions that the final user experiences before, during and after interacting with the ATM [4].

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In addition, when we are talking about ATMs, security and safety aspects should be considered since ATM are targets of different criminal acts, so that financial institutions add surveillance cameras, electronic devices and others, so that users can perform their operations in a safe way in ATM [5]. Additionally, several studies mentioned that security is an important aspect in the UX [6, 7], especially for users in the ATM domain [8, 9].

In this context, the industry needs to use techniques to obtain quantitative results over the ATM interfaces, to objectively measure aspects of usability and security of ATM applications.

In this paper, the authors present a systematic literature review about metrics that are reported in the literature to assess usability and security in banking software. The objective is to identify whether there are currently specific metrics for ATM interfaces and others that evaluate bank software that can be input to build the mentioned metrics. The works that were taken into account are those published from 2014 to 2019. The final intention of this work is to carry out as a future work a proposal of consolidated metrics for the ATM domain.

2 Background

2.1 Automatic Teller Machine

Automatic Teller Machine (ATM) is a computerized telecommunications device that provides, in real time, access to the clients of a financial institution to their bank accounts in a public space without intervention of the administration of the financial institution [10].

The customer is identified by inserting the card and entering a personal identification number (PIN). This process allows customers to access their bank accounts and perform the operations available according to the bank.

2.2 Metric

It is a measurement scale and method used for the measurement of attributes that influence one or more sub-quality characteristics [11].

2.3 Usability

There are many usability concepts proposed by different authors, but Jakob Nielsen provides a more complete definition, which covers most of the characteristics mentioned by other specialists [12].

Nielsen states that usability has multiple components and is associated with the following attributes: Learning, Efficiency, Memory, Mistakes and Satisfaction [13].

2.4 Usability Metrics

They quantitatively demonstrate whether the evaluated software can be understandable, learned, operated, attractive and compatible with the standards and usability guidelines [11].

An example of usability metrics can be the time that a user takes to perform a certain task, in order to find the ease that users have to perform a task. This time being closer to 0 will show that the user has managed to perform the task quickly and efficiently [14].

2.5 Security

Security will be interpreted as the perception of security that customers have when making a transaction from the beginning to the end of it. The lack of security perception causes the client not to use a certain channel to carry out their transactions. For this reason, perceived security is the extent to which a customer believes that a channel is safe to perform their bank transaction [15].

2.6 Security Metrics

Security metrics are designed to facilitate the decision-making process and improve results. They anticipate user needs to ensure compliance the security objectives [16].

3 Systematic Literature Review

This systematic literature review was conducted as a starting point to identify the current state of research related to usability and security metrics of ATM interfaces or other banking systems. This review was carried out following the methodology established by B. A. Kitchenham and S. Charters [17].

The definition of research questions was carried out based on the PICOC method, where the following criteria are considered: Population, Intervention, Comparison, Outcomes and Context. In this work, a comparison between variables will not be made, for this reason in Table 1 this criterion does not apply.

Table 1. Definition of concepts using PICOC

Criterion	Description
Population	Banking systems
Intervention	Usability and security metrics
Comparison	Not apply
Outcomes	Study cases which report quantitative metrics can be used for a usability and security for ATM
Context	Academic context and software industry

The research questions that were established for this Review Literature Systematic are the following:

- What metrics have been reported in the literature in the last five years for the evaluation of usability and safety that can be applied to ATM?

- What metrics have been reported in the literature in the last five years for the evaluation of usability and security of banking software?

According to the research questions, the terms used to compose the search strings were defined. To perform the search, synonyms and acronyms were taken into account to structure the search strings to avoid omitting any relevant results. The established search strings are the following:

- C1: (ATM OR automatic teller machine OR automated teller machine OR banking OR bank OR financial)
- C2: (metrics OR measurement)
- C3: (Security OR secure interface)
- C4: (Usability OR UX).

The string used for the search was formed as follows:

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C1 AND C2 AND C3 AND C4
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The search was carried out in the following relevant databases in the research area of this work:

- Scopus
- IEEEXplore
- ACM Digital Library
- SpringerLink.

The search strings of primary studies that will be used for each of the specified databases are detailed below:

- Scopus: `(TITLE-ABS-KEY (metrics OR measurement) AND TITLE-ABS-KEY (ux OR usability OR “secure interface”) AND TITLE-ABS-KEY (banking OR bank OR financial OR atm)) AND PUBYEAR > 2013 AND (LIMIT-TO (SUBJAREA, “COMP”) OR LIMIT-TO (SUBJAREA, “ENGI”) OR LIMIT-TO (SUBJAREA, “BUSI”) OR LIMIT-TO (SUBJAREA, “DECI”)) AND (LIMIT-TO (LANGUAGE, “English”))`
- IEEEXplore: `(“Publication Title”:metrics OR measurement) AND (“Abstract”:usability OR “secure interface” OR UX) AND (“Abstract”:bank OR financial OR banking OR ATM)`
- ACM Digital Library: `acmdlTitle:(metrics measurement) AND content.ftsec:(+interface bank financial ATM) AND recordAbstract:(usability security UX)`
- SpringerLink: `(metrics or measurement) AND banking AND (usability OR “secure interface”) AND NOT(game AND health AND traffic)`
- Subdiscipline: User Interfaces and Human Computer Interaction
- Date published: 2014–2019.

To consider a primary study, it must have the following inclusion criteria:

- Information about usability or security metrics for ATM.
- Relevant information about usability or security metrics used in other channels and that could be used for ATM.
- Case studies on usability or security evaluations of financial channels.
- Aspects to be considered in the elaboration of usability and security metrics.

The following criteria were taken to exclude a primary study:

- Information and aspects that do not correspond to the banking or financial field.
- Information not found in the English or Spanish language.
- Articles published before 2014.

4 Search Results

After searching in the mentioned databases, 354 articles were found. In order to make the selection of the relevant articles, the title and the summary of all articles found in the search were reviewed. Table 2 shows the search results in each of the databases, duplicate articles and relevant articles.

Table 2. Number of papers founded

Data base	Results	Duplicates	Relevants
Scopus	31	0	4
ACM	101	0	0
IEEE Xplore	9	3	0
SpringerLink	203	0	1
Total	354	3	5

The relevant papers of the area of interest are the following:

- “Evaluating mobile banking application: Usability dimensions and measurements” [18].
- “Measurement on Usage of the Internet Banking in Colombia” [19].
- “Online Banking Security and Usability - Towards an Effective Evaluation Framework” [20].
- “A model for evaluating the security and usability of e-banking platforms” [21].
- “Development of Questionnaire to Measure User Acceptance Towards User Interface Design” [22].

Table 3 shows a summary of the content of each of the relevant papers:

Table 3. Summary of the relevant papers

Paper	Summary
1 [9]	The authors mention how evaluation models for mobile banking applications are general, and do not represent the complexity of the area and proposes a set of dimensions and usability measures
2 [10]	Evidence the lack of studies to measure the use of Internet Banking in Colombia. It also shows the factors that influence this use such as quality, familiarity and usability
3 [11]	Compilation of usability and security metrics from the literature to evaluate online banking, indicating the lack of metrics for this area
4 [12]	It searches for the most used frameworks to evaluate usability and security and proposes 160 metrics to evaluate aspects of usability and security to evaluate internet-banking platforms
5 [13]	It develops a questionnaire to measure the acceptance of the interface of explored the expectations of ASEAN users based on constructions in the Theory of Expectation-Confirmation (ECT)

Of these five articles, the most significant contribution is that of 160 metrics divided into 13 categories of metrics to evaluate security and usability of Internet Banking. The authors indicate the points that would be evaluated in each of these categories, which are divided into 6 categories to evaluate safety (Table 4) and 7 categories to evaluate usability (Table 5).

Table 4. Security metrics

Subcategory	Metric
Category: General online security and privacy information to the Internet banking customers	
1. Account aggregation or privacy and confidentiality	1.1. Complied with the national privacy principles and privacy law
2. Losses compensation guarantee	2.1. Liability for any claim where the user identification or password used by unauthorized persons 2.2. Compensate client when bank website get hacked/unauthorized access 2.3. Compensate client when client computer get hacked/unauthorized access 2.4. Responsibility for losses or damages or expense incurred by the customer as a result of his violation of the terms and conditions 2.5. Responsibility for all telecommunications expenses (internet services)

(*continued*)

Table 4. (*continued*)

Subcategory	Metric
3. Online/Internet banking security information that the banks provide	3.1. "Customer Protection Code" document by the country's responsible authority 3.2. Threats: Hoax email, scam, phishing, spyware, virus and Trojan 3.3. Fraud Awareness 3.4. Key logger 3.5. General online security guidelines 3.6. Security alert/up-to-date issue 3.7. Provides Password security tips
Category: IT assistance, monitoring and support	
1. Hotline/helpdesk service availability	1.1. 24/7 customer contact center by phone 1.2. Messaging system (similar to an email) 1.3. FAQ/online support form
Category: Bank site authentication technology	
1. Employed encryption and digital certificate technologies	1.1. SSL encryption 1.2. Extended validation SSL certificates 1.3. Signing CA
Category: User site authentication technology	
1. Two-factor authentication for logon and/or for transaction verification available	1.1. Tokens 1.2. SMS 1.3. Site key 1.4. Not in use
2. Logon requirements	2.1. Bank credit cards number 2.2. Bank register/customer ID 2.3. Email address 2.4. Password 2.5. Other (e.g. personal code or security number) 2.6. Two-factor authentication
3. Logon failure limitation	3.1. Max. (times) 3.2. In use but does not specific maximum number of failures allowed
4. Password restriction/requirement	4.1. Enforce good Password practice 4.2. Password length restriction (characters) 4.3. Combination of numbers and letters 4.4. Combination of upper and lower cases 4.5. Special characters 4.6. Different passwords as compared to any of previously used passwords 4.7. Automatically check password strength when creating or changing password

(*continued*)

Table 4. (*continued*)

Subcategory	Metric
5.5. Password recovery method (Using ATM card number and PIN/username)	5.1. User ID, Card Number and PIN Number 5.2. Users can reset password online 5.3. Restore via ATM 5.4. SMS code 5.5. Answer Security Question 5.6. Restore via Email 5.7. Call customer service to complete this action
6. Transaction verification	6.1. All transactions required token/SMS 6.2. All external transactions required token/SMS 6.3. Other method e.g. password
Category: Internet banking application security features	
1. Automatic timeout feature for inactivity	1.1. Expiration time limit (maximum minutes) 1.2. In use but does not specific maximum number of failures allowed
2. Session management	2.1. Session tokens 2.2. Page tokens 2.3. Clear session Cookie information after logoff or shut down the Internet browser
3. Limited default daily transfer amount to third party account/BPAY/international transactions	3.1. Less or up to 5,000 USD 3.2. More than 5,000 USD 3.3. The default maximum daily limit transfer is vary depending on the type of the Internet banking customer 3.4. The maximum daily limit transfer may be increased with the approval by the banks 3.5. International transfer limit is different from the national transfer limit
Category: Software and system requirements and settings information	
1. Compatibility best with the popular Internet browsers (based on the banks information provided)	1.1. Chrome 1.2. Firefox 1.3. Internet Explorer 1.4. Netscape 1.5. Opera 1.6. Safari
2. Internet banking user device system and browser setting requirement	2.1. Operating System 2.2. Type of browser 2.3. Browser setting 2.4. Screen resolution
3. Free/paid security software/tool available to the Internet banking customers	3.1. Antivirus/anti-spyware 3.2. Internet security suite 3.3. Browser setting 3.4. Provides Internet links to security software vendor(s)

Table 5. Usability metrics

Subcategory	Metric
Category: Interface	
1. Design principles	1.1. Home page is concise and clear 1.2. Effective use of white space 1.3. Effective and consistent use of color, color combination and backgrounds 1.4. Effective graphics 1.5. Aesthetics and minimalist design - apply appropriate visual representation of security elements and not provide irrelevant security information
2. Graphics and multimedia	2.1. Site is visually attractive 2.2. Graphics and multimedia help the navigation 2.3. Icons are easy to understand 2.4. Not excessively used 2.5. No negative impact on loading times
3. Style and text	3.1. Consistent use of pages style and format 3.2. Consistent use and easy to read fonts 3.3. Correct spelling and grammar 3.4. Text is concise and relevant 3.5. Purpose of site is made clear on home page 3.6. User language - the use of plain language that users can understand with regard to security
4. Flexibility and compatibility	4.1. Pages sized to fit in browser window 4.2. Printable versions of pages are available 4.3. Text-only version is available 4.4. Options of many available languages 4.5. Accommodation made for users with special needs 4.6. User suitability - provide options for users with diverse levels of skill and experience in security
Category: Navigation	
1. Logical structure	1.1. Intuitively progressing (proceeding) 1.2. Rational design of the content 1.3. Menus are understandable and straightforward 1.4. Sitemap is available 1.5. Consistent navigation throughout the site 1.6. Navigation bar is available

(*continued*)

Table 5. (*continued*)

Subcategory	Metric
2. Ease use of the site	2.1. Easy to find the site 2.2. Easy to learn and navigate the site 2.3. Easy to use the navigation bar 2.4. Easy to return to main page 2.5. Easy to modify users settings
3. Ease use of the online banking pages	3.1. Easy to access complete online banking range 3.2. Separation of online banking pages from the rest pages 3.3. Separation between individual and business customers, as well among various channels
4. Search feature	4.1. Easy to use search engine 4.2. Search engine provides accurate and useful results 4.3. Good description of search engine findings 4.4. No search engine errors
5. Navigational necessities	5.1. No broken links 5.2. No under-construction pages 5.3. Links are clearly discernible, well labeled and defined 5.4. Clear label of current position on the site 5.5. Effective use of frames, non-frames version is available
Category: Content	
1. Online banking information	1.1. Full information about the purpose of each service 1.2. Full information about the charges 1.3. Terms and conditions are easily accessed 1.4. Full information about Technical Requirements 1.5. Familiarity programs and demo are available
2. Bank information and communications	2.1. Full bank information is available 2.2. Different ways for communication with the banks employees are available 2.3. Telephone and fax numbers are available 2.4. Postal and physical addresses are available
3. Advertisement	3.1. Adequate advertisement of banks services 3.2. Controlled amount of advertisements by other companies 3.3. Careful advertisement use 3.4. Effective use of advertisement techniques

(*continued*)

Table 5. (*continued*)

Subcategory	Metric
4. Website users support	4.1. Feedback forms are available 4.2. Telephone and email numbers for providing help 4.3. Round the clock support 4.4. Free or toll free telephone assistance 4.5. Security help are relevant and apparent to users
5. Competency of the provided assistance	5.1. Detailed information about every step 5.2. Easily understandable assistance for amateur users 5.3. Assistance regarding settings is provided 5.4. Transaction guide is provided
Category: Services offered	
1. General services	1.1. Information about banks announcements 1.2. Profile/username/password management 1.3. Ease use of services 1.4. Revocability - allow users to revoke security actions where appropriate 1.5. Tools such as organizer and calculator are available 1.6. Extra services such as ticket booking, shop online, charity
2. Financial services	2.1. Account and loan information 2.2. Credit card and check information 2.3. Loan request
3. Provided transactions	3.1. Bill payments 3.2. Mobile phone bill or card recharge
Category: Reliability	
1. Registration	1.1. Easy to register 1.2. Easy to log on to the site 1.3. Adjustable customer profile is stored 1.4. Email request for receiving offers or information 1.5. Easy modification of users profile
2. Transaction procedure	2.1. Foreign language support is available 2.2. Disconnection management 2.3. Actions history is available
Category: Technical aspects	

(*continued*)

Table 5. (*continued*)

Subcategory	Metric
1. Loading speed	1.1. Fast loading speed of the home page as well the rest pages 1.2. Consideration of non-broadband users
Category: Multi-factor authentication methods	
1. Tokens	1.1. Hardware tokens 1.2. Software tokens 1.3. Easy to get the code from the device 1.4. Security and stability 1.5. User adoption 1.6. Total Cost of Ownership (TCO) 1.7. Replacement of the token in the event of defects
2. SMS	2.1. Multiple mobile numbers allowed (maximum)
3. Tokens	3.1. Effective use of site key

5 Discussion

After the Systematic Literature Review carried out, we were able to answer the two research questions mentioned at the beginning.

- What metrics have been reported in the literature in the last five years for the evaluation of usability and safety that can be applied to ATM?

No documents were found with could be answered the first question, this evidences the absence of specific metrics to evaluate the usability of ATM interfaces or to evaluate the security of the interfaces from this same channel.

- What metrics have been reported in the literature in the last five years for the evaluation of usability and security of banking software?

It is observed that by extending the scope of search to other financial systems, contributions are found since the issue has been addressed and deepened in the case of Internet Banking and mobile banking. The most important contribution was the list of metrics found for Internet Banking to assess usability and security.

6 Conclusions and Future Work

In the papers founded, it is expressed the importance of the evaluation of two aspects: Usability and Security, and the close relationship between them. It should be noted that several of the points evaluated for security are not related to the interface but to the communication issue of the banking channel and the banking entity, an aspect that is not relevant for the purposes of this investigation.

According to the above, we can conclude that there is an absence of specific metrics to evaluate the usability and security of ATM interfaces.

As future work, we will adapt the usability and interface security metrics obtained for other banking systems in the systematic literature review to identify a proposal that is valid and that applies to the ATM domain. To validate this proposal of metrics, the opinion of industry experts will be considered, who should be interviewed and conducted surveys in order to define the points that can be replicated in ATM and those that cannot.

References

1. Redacción, E.C.: El cajero automático cumple 50 años: ¿Cuándo llegó y cuántos hay en el Perú? Obtained from (2017). https://elcomercio.pe/economia/cajero-automatico-cumple-50-anos-llego-hay-peru-437983
2. Kamfiroozie, A., Ahmadzadeh, M.: Personalized ATMs: improve ATMs usability. In: Stephanidis, C. (ed.) HCI 2011. CCIS, vol. 173, pp. 161–166. Springer, Heidelberg (2011). https://doi.org/10.1007/978-3-642-22098-2_33
3. Hellmann, R.: In a mobile banking era, the ATM is more important than ever. Obtained from (2018). https://www.atmmarketplace.com/blogs/in-a-mobile-banking-era-the-atm-is-more-important-than-ever/
4. Van der Geest, T., Ramey, J., Rosenbaum, S., Van Velsen, L.: Introduction to the special section: designing a better user experience for self-service systems. IEEE Trans. Prof. Commun. **56**(2), 92–96 (2013). https://doi.org/10.1109/tpc.2013.2258731
5. McGlasson, L.: ATM Security: Customers And Machines Are At Risk. Obtained from (2008). https://www.bankinfosecurity.com/atm-security-customers-machines-are-at-risk-a-686
6. Weir, C.S., Douglas, G., Richardson, T., Jack, M.: Usable security: user preferences for authentication methods in eBanking and the effects of experience. Interact. Comput. **22**(3), 153–164 (2010). https://doi.org/10.1016/j.intcom.2009.10.001
7. Gutmann, P., Grigg, I.: Security usability. IEEE Secur. Priv. Mag. **3**(4), 56–58 (2005). https://doi.org/10.1109/msp.2005.104
8. Chanco, C., Moquillaza, A., Paz, F.: Development and validation of usability heuristics for evaluation of interfaces in ATMs. In: Marcus, A., Wang, W. (eds.) HCII 2019. LNCS, vol. 11586, pp. 3–18. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-23535-2_1
9. Aguirre, J., Moquillaza, A., Paz, F.: Methodologies for the design of ATM interfaces: a systematic review. In: Ahram, T., Karwowski, W., Taiar, R. (eds.) IHSED 2018. AISC, vol. 876, pp. 256–262. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-02053-8_39
10. Khalifa, S.S.M., Saadan, K.: The formal design model of an Automatic Teller Machine (ATM). Lect. Notes Inf. Theory **1**(1), 56–59 (2013). https://doi.org/10.12720/lnit.1.1.56-59
11. ISO: IEC 9126: Software Engineering-Product Quality. Geneva, Switzerland (2000)
12. Paz, F.: Método para la evaluación de usabilidad de sitios web transaccionales basado en el proceso de inspección heurística (Doctoral Thesis). Universidad Católica del Perú, Perú (2017)
13. Nielsen, J.: Usability Engineering, 1st edn. Academic Press, San Diego (1993)
14. Diaz, E., Arenas, J.J., Moquillaza, A., Paz, F.: A systematic literature review about quantitative metrics to evaluate the usability of e-commerce web sites. In: Karwowski, W., Ahram, T. (eds.) IHSI 2019. AISC, vol. 903, pp. 332–338. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-11051-2_51

15. Chang, H.H., Chen, S.W.: Consumer perception of interface quality, security, and loyalty in electronic commerce. Inf. Manag. **46**(7), 411–417 (2009). https://doi.org/10.1016/j.im.2009.08.002
16. González, W., Almeida, G., Díaz, D.: Especificación de métricas para la evaluación de la seguridad en productos software. Iberoam. J. Proj. Manag. **5**(1), 35–45 (2014). https://doi.org/10.1016/j.im.2009.08.002
17. Kitchenham, B., Charters, S.: Guidelines for performing systematic literature reviews in software engineering version 2.3. Engineering **45**(4), 1051 (2007). https://doi.org/10.1145/1134285.1134500
18. Hussain, A., Abubakar, H.I., Hashim, N.B.: Evaluating mobile banking application: usability dimensions and measurements. In: Proceedings of the 6th International Conference on Information Technology and Multimedia (2014). https://doi.org/10.1109/icimu.2014.7066618
19. Torres, J.M.S., Fredy, E.: Measurement on usage of the Internet banking in Colombia. J. Internet Bank. Commer. **20**(2) (2015). https://doi.org/10.4172/1204-5357.1000105
20. Alsaleh, M., Alarifi, A., Alshaikh, Z., Zarour, M.: Online banking security and usability - towards an effective evaluation framework. In: Proceedings of the 11th International Conference on Web Information Systems and Technologies (2015). https://doi.org/10.5220/0005493901410149
21. Alarifi, A., Alsaleh, M., Alomar, N.: A model for evaluating the security and usability of e-banking platforms. Computing **99**(5), 519–535 (2017). https://doi.org/10.1007/s00607-017-0546-9
22. Baharum, A., Amirul, S.M., Yusop, N.M.M., Halamy, S., Fabeil, N.F., Ramli, R.Z.: Development of questionnaire to measure user acceptance towards user interface design. In: Advances in Visual Informatics, pp 531–543. Springer, Berlin (2017). https://doi.org/10.1007/978-3-319-70010-6_49