Usability Metric Framework in Mobile-Based Waste Management Applications

Siti Nurhayati[1], Saudin Yuniarno[2], Dian Anandari[3]
[1,2,3]Universitas Jenderal Soedirman, Purwokerto, Indonesia
Email: siti.nurhayati@unsoed.ac.id

Abstract

Measuring usability is an essential task to ensure that an application is accurate, has adequate speed, and also to ensure compliance with user needs. The usability of software plays a primary role in the quality perceived by its users. However, various definitions and related attributes indicate that there is still no standard in this regard. The main objective of this paper is to present the results of a literature review, aiming to showcase all relevant definitions of usability and related attributes introduced to date. This comprehensive view, depicted through a knowledge map based on time, provides an understanding of the observed evolution on one hand, and also serves as a guide for usability measurement attributes on the other hand, to address some non-functional requirements.

***Keywords**: Usability, Evaluation, Mobile, Waste Management Application.*

– – – – – – – – – – ◆ – – – – – – – – – –

A. INTRODUCTION

Usability is generally understood as a broad concept that indicates the quality of use of an interactive system (ISO 9241-11, 1998) and (Bevan & MacLeod, 1994). There are many measures of usability, including task completion time, error rate, time required to enter data, as well as subjective satisfaction, such as satisfaction, ease of use, security, and so on. The word "usability" also refers to methods to increase ease of use during the initial design process (Yonglei, 2005; Miller, 2006). A focus on usability and user experience is a key element in creating successful, high-quality applications. However, the novelty of mobile applications (apps) and the unique features of mobile devices are the main challenges in usability measurement activities.

The unique characteristics of mobile devices and wireless networks pose a number of significant challenges in testing the usability of mobile applications. Some of them are mobile context, multimodality, connectivity, small screen sizes, different display resolutions, limited processing capabilities and power, as well as limited data input methods (Kondratova & Goldfarb, 2006; Nokia, 2008). These features will affect the usability of the application on the cellphone, for example slow processing time or response time. Additionally, users may be dissatisfied with the app if the display resolution is low and the screen is too small.

Many usability evaluation models have been introduced in the literature, but most of them are general in nature and may not be applicable to certain mobile applications due to their complexity and lack of appropriate descriptions of how to select usability measurements such as usability dimensions, criteria, and metrics. Models on generally introduce a set of usability dimensions for mobile application evaluation, with dimensions that include; navigation, content, information

architecture, error prevention, presentation, input levels, and menu visualization. Additionally, although on Broader evaluation studies sometimes explain how the measurements are used and how each data is related to a particular usability dimension. Measurements such as content and presentation should not be independent dimensions of usability because many studies argue that they should focus on some criteria (Seffah *et al*., 2006; Singh & Wesson, 2009).

Jooste *et al.* (2014) and Koutsabasis *et al.* (2010) stated that Coursaris and Kim introduced a usability measurement model after reviewing 100 empirical literature. The main goal of this model is to guide researchers in determining which usability dimensions should be considered when measuring the usability of mobile applications in general. The usability dimensions proposed in this model are quite comprehensive, despite the lack of a precise description of which usability dimensions should be selected for a particular mobile application. In addition, there should be supporting metrics for each defined usability dimension and a description of how each metric relates to its respective criteria. This will increase the understanding and practical applicability of the model. Therefore, this model lacks supporting metrics for each dimension and guidance for selecting appropriate dimensions for a particular mobile application. In addition, the model also needs to be tested to determine applicability and accuracy.

Measuring usability is an important task to ensure that the application is accurate, has sufficient speed, and also to ensure compliance with user needs. Software usability plays a major role in the quality perceived by its users. However, the various definitions and associated attributes show that there is still no standard in this regard. The main aim of this paper is to present the results of a literature review, which aims to present all relevant usability definitions and related attributes introduced to date. This comprehensive view, depicted by a time-based knowledge map, provides an understanding of the observed evolution on the one hand, and also serves as a guide to usability measurement attributes and on the other hand to address some non-functional requirements.

B. METHODS

Systematic Literature Review was carried out in three stages: planning, implementing and reporting the literature review (Wahono, 2015). The first step in the planning stage is to identify the need to conduct a systematic literature review. Next is to develop the review protocol that will be used. The SLR protocol was designed to guide review planning and reduce the possibility of researcher bias. The next step is to evaluate the review protocol used. Finally, in the implementation phase, research questions, search strategies, selection of inclusion and exclusion criteria, quality assessment, data collection, and data analysis are carried out. The review protocol is presented in the sections *research question, search strategy, inclusion and exclusion criteria, quality assessment, data collection,* and *data analysis*. The review protocol was developed, evaluated, and refined iteratively during the implementation and reporting phases of the review. In the reporting step, data

analysis is discussed in detail and presented in tables and graphs. Research questions (RQ) were determined to maintain the focus of the review. The RQ was designed with the help of Population, Intervention, Comparison, Outcomes, and Context criteria (PICOC) (Kitchenham & Charters, 2007). Table 1 shows the PICOC structure of the research questions.

Table 1. Structure of PICOC Questions Study

Structure	Description
Population	Application management rubbish mobile based
Intervention	Usability metrics framework
comparison	n/a
outcomes	Understand indicators used _ For measurement device mobile based
	Understand method What just use it for usability measurements
Context	Sectors used _ on studies this is web and android

Question research (*research question*) used on review literature This stated in Table 2.

Table 2. Questions Study (Research Question) on SLR

Question	Information
Q1. What the indicators used for measuring device usability-based car	Identification the most frequent indicators used for measuring device usability-based car
Q2. method What just use it for usability measurements?	Identification frequent methods used for measurement usability

Strategy search (*search strategy*) is used for get source relevant power for answer question research (RQ) and reference related. Search process done with use machine Mozilla Firefox search with the source address of the site used become reference is https://scholar.google.co.id/ and http://semanticscholar.org. Developing plans for writing Boolean algorithms for keywords in search engines , namely (usability) AND (metric* OR means*) AND (framework) AND (solid waste management) AND (mobile OR android) .

Stage criteria inclusion and exclusion (*inclusion and exclusion criteria*) Stage This used for determine what is the data (article journal) found suitable for used in SLR research or No. Article appropriate journal condition entered in Criteria Inclusion, while not suitable chosen in criteria exclusion. Criteria This can seen in Table 3.

Table 3. Criteria Inclusion and Exclusion Study

Criteria	Description
Inclusion	1. Article journal during ten year latest (2014 to 2023),
	2. Data obtained via the sites https://scholar.google.co.id/ and http://semanticscholar.org
	3. Article journal or conference proceedings
	4. Open access

	5. Full text language English or Indonesian
	6. the data describe about usability metrics framework on application management rubbish mobile based
Exclusion	1. Data about usability is not it on application management rubbish. 2. Textbook, results thesis, thesis and dissertation.

Stage evaluation quality (*quality assessment*). In SLR research, data found evaluated based on question criteria evaluation quality following:

1. is article open access journals/conference proceedings and full text? (QA1)
2. Whether data is obtained via the sites https://scholar.google.co.id/ and http://semanticscholar.org? (QA2)
3. is article journal published on 2014-2023? (QA3)
4. is article journal mention methods For measure usability? (QA4)
5. is article journal covers usability metric framework indicators on application management rubbish mobile based (QA5)

Data collection is the stage where the research data collected. Deep data collection study This through a number of stages, including:

1. Look for article journals at https://scholar.google.co.id/ and http://semanticscholar.org
2. Validate is journals the open access and full text in English or Indonesian? If not open access, full text in English or Indonesian, articles journal the No will used in study This.
3. Keep article journal that has been collected in application Mendeley.

On stage this data analysis, article journal that has been collected will analyzed for get answer from question research (Research Question/RQ). Article journal that will analyzed includes:

1. Indicators used for usability measurements on application management rubbish mobile- based (RQ1)
2. The methods used for usability measurements on application management rubbish mobile-based (RQ2).

Results Finally is table summary research consisting from review narrative to study latest and map framed knowledge time.

C. RESULTS AND DISCUSSION

Results of the search process, data is grouped by year articles, dimensions/indicators, methods, technologies, to see trends Related research. Most journal articles were found in 2023, 2022, 2021, 2019 and 2015 each with 2 articles and the minimum number of journal articles there is in 2017 and 2020 consists just one article. Based on the search *strategy* used Boolean algorithm (usability) AND (metric* OR means*) AND (framework) AND (solid waste management) AND (mobile OR android). 17,300 articles were obtained from Google Scholar and 6 from semanticsholar.org. Then articles the selected more carry on based on title, abstract, inclusion and exclusion criteria. Quality assessment results, inclusion and exclusion

criteria, resulting in 30 3 journal articles successfully selected. Selection next about relevance content articles, and generated 12 articles. These results can be seen in Chart Prism. The resulting article must meet five quality assessment requirements from QA1 to QA5. If the article does not meet any of the conditions, the journal article is not used. A diagram of the number of journal articles at each stage can be seen in Figure 1.

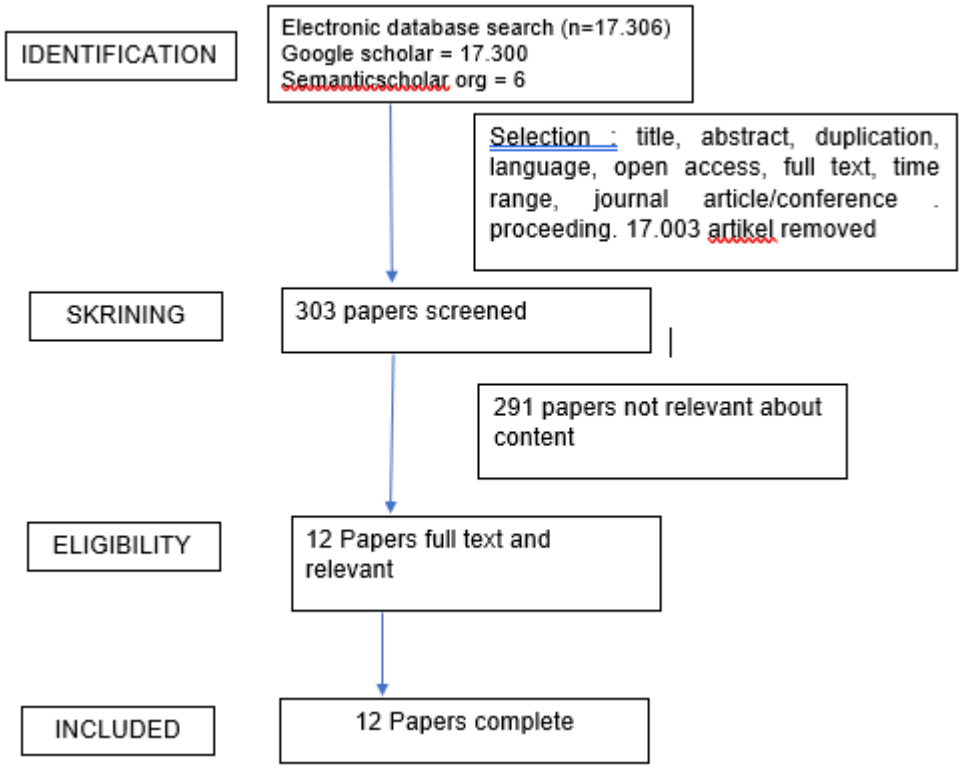

Figure 1. Prism Chart

Results end selection in form narrative analysis stated in Table 4. At Table 5, listed percentage usability dimensions obtained. Results data analysis stage This will answer question research (RQ).

Table 4. Narrative Analysis

No	Title / Journal / Year	Usability Dimension	Method	Technology
1	Usability Evaluation on Application Pick up Village Online Trash Rejosari Use System Usability Scale Method (Journal Explore Informatics, September 2023)	Frequency usage, complexity, level convenience, need help in usage, features operate with good, consistent, easy understood, level complexity, efficacy self, time spent _ For learn	System Usability Scale	web
2	Planning Rework UI/UX Website	Match between system and the real world,	Design Thinking (Emphatize,	web

	Processing Rubbish Use Design Thinking Method (Startup XYZ) (Journal Technique Informatics and System Information Vol. 10, no. 1, March 2023)	Consistency and standards, Flexibility and efficiency of use, help users recognize, diagnose, and recover from errors, User control and freedom, Visibility of system status, Aesthetic and minimalist design	Define, Ideate, Prototype and Testing.)	
3	Evaluation of Effectiveness and Satisfaction Quality in Use Model in Waste Bank Application Service Environment Life and Cleanliness (DLHK) Pekanbaru City (Journal Computer Applied Vol. 8, no. 1, May 2022)	effectiveness, efficiency, satisfaction (usefulness, trust, pleasure, comfort), freedom from risk and context coverage	ISO/IEC 25010 discusses about Quality in Use and Product Quality Model.	Web and mobile/android
4	A Framework for Designing Usability: Usability Redesign of a Mobile Government Application (Information, 13(10), 470, 2022)	Simplicity, Accuracy, Time taken, Features, Safety, Attractiveness, Effectiveness, Efficiency, Satisfaction, Learnability, Memorability, Errors, and Cognitive load	ISO 9241-11. Mobile Goal Question Metric (mGQM) and People at the Center of Mobile Application Development (PACMAD).	Mobile/Android
5	Usability Aspects in Pervasive Computing: Needs and Challenges (International Journal of Computer Applications, October 2021	User satisfaction, learnability, effectiveness, efficiency, memorability, correctness, standardization, simplicity,	ISO 9126	Mobile/Android

		intuitiveness, usefulness, security		
6	Mobile application model for solid waste collection management (Proceedings of the Federated Conference on Computer Science and Information Systems. 2021. pp. 1005–1008 DOI: 10.15439/2018F137 ISSN)	User satisfaction, Effectiveness, Efficiency, Useful, Less time consuming, Performance, Intuitive, Correct, Simplicity, Comprehensive, Memo-ability, Learn-ability.	ISO 9241-11:1998 ISO 25062: 2006	Mobile/Android
7	Application Usability Evaluation Processing Rubbish with Website Using Importance Performance Analysis Method (Journal System Information Business 01(2020))	Learnability Security navigation Website Content Performance/ Accessibility Web Design Interactivity	Importance-Performance Analysis Matrix	Web
8	Evaluation Usability aspects _ Application Simalu Use Usability Testing Method (Journal Pigeons, Vol. 7, NO. August 2, 2019)	effectiveness, efficiency, and satisfaction user	ISO 9241-11 standard with Usability Testing. The technique are Retrospective Think Aloud (RTA) and Performance Measurement. Retrospective Think Aloud is used Because can measure Satisfaction user moment use something system, Performance	Mobile/Android

			Measurement is used Because can measure effectiveness and efficiency	
9	Designing a Mobile Application Framework as an Innovative IT Solution for Waste Recycling (Proceedings International Conference on Information Technology and Digital Applications, 2019)	Understandability, learnability, operability	ISO 9241-11: 1998 ISO 25062: 2006	Mobile/Android
10	Usability attributes revisited: a time-framed knowledge map. (AIP Conference Proceedings, 2017)	Effectiveness, Learnability, Flexibility, Attitude, Aesthetics, Consistency, Documentation, Human factors, Understandability, Operability, Affect, Efficiency, Helpfulness, Control, Memorability, Errors, satisfaction, Reliability in Use, Attractiveness, Compliance, Security, Productivity, Safety, Trustworthiness, Accessibility, Universality, Usefulness	ISO/IEC 9126-1 ISO 9241-210:2010, ISO 25010:2011, ISO 9241-11:2018	Mobile/Android

11	Extension of pacmad model for usability evaluation metrics using goal question metrics (GQM) approach (Journal of Theoretical and Applied Information Technology 10th September, Vol.79. No.1 2015)	Effectiveness, efficiency, satisfaction, learnability, memorability, errors, cognitive load	goal question metrics (GQM) approach	Mobile/Android
12	Urban waste management and the mobile challenge (Waste Management & Research, 2015)	User satisfaction, Effectiveness, Efficiency, Performance, Correct, Simplicity, Comprehensive, Memorability, Learnability. Understandability, operability, attractiveness, security.	ISO 9241, ISO 13407 and Schaffer Methods	Mobile/Android

Table 5. Percentage Usability Dimension

No	Usability Dimension	Amount	Percentage
1	Helpfulness	3	3,226
2	Consistency and standards	3	3,226
3	Time taken	3	3,226
4	Flexibility	2	2,151
5	Efficiency of use	9	9,677
6	Aesthetic and minimalist design	2	2,151
7	Effectiveness	7	7,527
8	Satisfaction	7	7,527
9	Usefulness	5	5,376
10	Simplicity	4	4,301
11	Safety,	2	2,151
12	Learnability,	8	8,602
13	Memorability	6	6,452
14	Errors	3	3,226
15	Cognitive load	2	2,151
16	Intuitive	2	2,151
17	Security	4	4,301

18	Performance (Productivity)	4	4,301
19	Correct	3	3,226
20	Comprehensive	2	2,151
21	Navigation controls	2	2,151
22	Accessibility	2	2,151
23	Understandability	3	3,226
24	Operability	3	3,226
25	Attractiveness	2	2,151

Digital evolution and mobile developments are shaping a new era that influences human behavior and global governance. Interconnection and the flow of information through various types of modern means create new opportunities for cooperation and ways of working. Waste management cannot be separated from the impact of this change. New potential is emerging for the sector, offering new areas of innovation, changing the way waste management practices are implemented. In this framework, mobile products and applications can be devices It is important for authorities, companies, civilians, and other stakeholders, to integrate this technology in efforts for environmental protection, recycling, etc. This mobile application presents an opportunity to assist sustainable waste management with an emphasis on recycling and waste transportation performance. Next, this article reviews the most important relevant literature and summarizes the usability of mobile applications for management rubbish. Useful conclusions are drawn regarding both the content and format of mobile applications required for recycling and waste management. Finally, this article presents the most typical mobile applications that already exist in the waste management sector.

This study investigates two aspects of mobile reusability; usability evaluation; and usability metrics. Usability is the quality of a product or system. It refers to the degree to which a product enables people to achieve their tasks and goals easily and quickly. This applies to every part, aspect, and feature of the product that users interact with (for example, software, hardware, icons, and menus). It is assessed through a set of objective, specific, and predefined usability dimensions often referred to as usability metrics.

Based on Table 5. known that majority dimensions reusability is efficiency of use (9.677%); learnability (8.602%); effectiveness (7.527%); satisfaction (7.527%); memorability (6.452%); usefulness (5.376%); security (4.301%); performance/ productivity (4.301%). According to Hussain & Kutar (2015) as well Kronbauer *et al.* (2012) stated part big study using effectiveness, efficiency, and satisfaction as usability characteristics. Results study Weichbrothmost (2018) show that majority frequent attributes appear on usability are efficiency, satisfaction, learnability and effectiveness. Harrison *et al.* (2013); Mendes & Dias-Neto (2016); Saleh *et al.* (2015) found seven attributes, which together reflects a usability application namely effectiveness, efficiency, satisfaction, learnability, memorability, errors, and cognitive load.

Efficiency on generally became a major tribute Usability measurement, is the user's ability to complete tasks quickly and accurately. Efficiency is measured in various ways, such as the duration spent on each screen, the duration to complete a specific task (a set of tasks), and the user error rate. Satisfaction is the level of comfort and satisfaction felt by users, or the level of fulfillment of user expectations and needs. Satisfaction is measured using only surveys, with predetermined statements with a Likert scale rating system, which is generally used to capture users' abstract attitudes towards an application. Effectiveness is the user's ability to complete a task in a particular context. This is measured by the number of successfully completed tasks, the number of steps required to complete the task, the number of double taps unrelated to app operation, and the number of times the back button was used by the mobile device (not the app). Learnability is defined as the level of ease in which one learns users can interact with newly encountered systems without assistance or referring to documentation. It is measured by the number of attempts to complete the task, the amount of help while performing the task, and the number of errors made by the user. Including learnability is a user's capacity to achieve expertise with an application. Typically, a user's performance during a series of tasks is observed to measure how long it takes the user to reach a predetermined level of expertise. Memorability is the level of ease in which a person is present users can remember how to use the application effectively. This is measured by asking users to perform a series of tasks after becoming skilled in using the application, and then asking them to perform similar tasks after a period of inactivity. To determine how memorable the application is, a comparison can be made between the two sets of results. In this case, the eye-tracking technique is also used as a method to collect gaze data which is then used to evaluate usability. Cognitive load refers to the amount of mental activity imposed on a user's working memory while operating an application. Cognitive load theory differentiates cognitive load into three types: extrinsic, intrinsic, and germane. First, extrinsic cognitive load refers to the instructional scheme and presentation, which is caused by mental activity and elements that do not directly support the use of the application. Second, intrinsic cognitive load refers to task complexity, which is caused by the number of elements in a task and the degree to which these elements are related to each other. Third, cognitive load germane refers to the amount of mental effort used to form schemas and actively integrate new information with previous knowledge during application use. In the practice of measuring cognitive load, instruments such as subjective rating scales, open-talk dual task protocols, or eye tracking are commonly used.

D. CONCLUSION

Based on 12 selected articles published from 2014 to 2023. There are 25 usability indicator attributes the majority stated efficiency of use (9.677%); learnability (8.602%); effectiveness (7.527%); satisfaction (7.527%); memorability (6.452%); usefulness (5.376%); security (4.301%); performance/productivity (4.301%).

ACKNOWLEDGEMENT

The author would like to thank the Institute Study and Devotion Public University General Soedirman, for funding this research through a Research Grant.

REFERENCES

1. Bevan, N., & MacLeod, M. (1994). Usability measurement in context. *Behaviour & Information Technology, 13*, 132-145.
2. do Nascimento Mendes, I., & Dias-Neto, A. C. (2016). A process-based approach to test usability of multi-platform mobile applications. In *Design, User Experience, and Usability: Design Thinking and Methods: 5th International Conference, DUXU 2016, Held as Part of HCI International 2016, Toronto, Canada, July 17–22, 2016, Proceedings, Part I 5* (pp. 456-468). Springer International Publishing.
3. Fabil, N. B., Saleh, A., & Isamil, R. B. (2015). Extension of pacmad model for usability evaluation metrics using goal question metrics (GQM) approach. *Journal of Theoretical and Applied Information Technology*, *79*(1), 90-100.
4. Harrison, R., Flood, D., & Duce, D. (2013). Usability of mobile applications: literature review and rationale for a new usability model. *Journal of Interaction Science*, *1*, 1-16.
5. Hecker., B., & Berger, M. (2011). *Presented at the International Conference of Design, User Experience, and Usability*.
6. Hussain, A., & Kutar, M. (2015). *Usability Metric Framework for Mobile Phone Application*. Retrieved from: https://www.researchgate.net/publication/267368031
7. ISO. (1998). *International Standard: ISO 9241-11 (Guidance on usability)*. Geneva.
8. Jooste, C., Van Biljon, J., & Mentz, J. (2014). Usability evaluation for Business Intelligence applications: A user support perspective. *South African Computer Journal*, *53*(si-1), 32-44.
9. Kitchenham, B., & Charters, S. (2007). Guidelines for performing systematic literature reviews in software engineering version 2.3. *Engineering*, *45*(4ve), 1051.
10. Kondratova, I., & Goldfarb, I. (2006, April). M-learning: Overcoming the usability challenges of mobile devices. In *International Conference on Networking, International Conference on Systems and International Conference on Mobile Communications and Learning Technologies (ICNICONSMCL'06)* (pp. 223-223). IEEE.
11. Koutsabasis, P., Vlachogiannis, E., & Darzentas, J. S. (2010). Beyond specifications: Towards a practical methodology for evaluating web accessibility. *Journal of Usability Studies*, *5*(4), 157-171.
12. Kronbauer, A. H., Santos, C. A., & Vieira, V. (2012). Smartphone applications usability evaluation: a hybrid model and its implementation. In *Human-Centered Software Engineering: 4th International Conference, HCSE 2012, Toulouse, France, October 29-31, 2012. Proceedings 4* (pp. 146-163). Springer Berlin Heidelberg.
13. Miller, J. (2006). Usability testing: A journey, not a destination. *IEEE Internet Computing*, *10*(6), 80-83.
14. Nokia. (2008). *Getting Started with Mobile Design*. Nokia Corporation.
15. Seffah, A., Donyaee, M., Kline, R. B., & Padda, H. K. (2006). Usability measurement

and metrics: A consolidated model. *Software quality journal*, *14*, 159-178.
16. Singh, A., & Wesson, J. (2009, October). Evaluation criteria for assessing the usability of ERP systems. In *Proceedings of the 2009 annual research conference of the South African Institute of Computer Scientists and Information Technologists* (pp. 87-95).
17. Tao, Y. (2005, October). Work in progress-introducing usability concepts in early phases of software development. In *Proceedings Frontiers in Education 35th Annual Conference* (pp. T4C-7). IEEE.
18. Weichbroth, P. (2018, September). Usability attributes revisited: a time-framed knowledge map. In *2018 Federated Conference on Computer Science and Information Systems (FedCSIS)* (pp. 1005-1008). IEEE.
19. Wahono, R. S. (2015). A systematic literature review of software defect prediction. *Journal of software engineering*, *1*(1), 1-16.