Journal of Theoretical and Applied Information Technology
31st January 2018. Vol.96. No 2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

A NEW FRAMEWORK FOR USABILITY EVALUATION WEB ENGINEERING METHODS

[1,2,3]KARZAN WAKIL, [1]DAYANG N. A. JAWAWI
[1]University Technology Malaysia, Malaysia
[2]University of Human Development, Iraq
[3]Sulaimani Polytechnic University, Iraq
E-mail: karzanwakil@gmail.com, dayang@utm.my

ABSTRACT

Usability is an important attribute for measuring a quality of web engineering methods. Also, many usability evaluation methods proposed. The problem is web engineering methods can not complete web development lifecycle especially evaluation phase and the developers sometimes do not meet users' expectations regarding usability. For expressing the actual feedback from developers directly, we have defined a new framework for usability evaluation of web engineering methods. The new framework consists of six phases, in these phases we defined web engineering process development, web application features, usability attributes, usability evaluation methods, and usability testing. In the usability testing, we use several ways for returning user's feedback such as usability testing by expert and group developers, open-ended and close-ended questionnaires, and interviews. This framework is too strong for measuring usability of web engineering methods because it has reach feedback from developers.

Keywords: *Usability, Usability Evaluation, Web Engineering, Evaluation Method, Framework.*

1. INTRODUCTION

The rising interest in the internet in current years has brought about the production of a high amount of Model Driven Web Engineering (MDWE) methods that provide a framework of orientation for the Web systems [1]. Conversely, there are high figures of methods with no standard agreement, [2-4] showed a lack in the employ of principles, and the shortage of both realistic experience and device support. Within the face of this state, a significant need to evaluate the excellence of accessible methodologies comes up.

Usability is considered to be one of the larger crucial quality aspects for Web applications [5]. The complex of developing more functional Web applications has supported the materialization of a huge figure of usability evaluation approaches. Nevertheless, the majority of these methods simply consider usability evaluations in the final phases of the Web development process. Efforts like that of Matera et al. and [6] and Juristo et al. [7] present that usability evaluations should as well be conducted throughout the early phases of the development procedure to enhance the consumer experience and reduce maintenance expenses [8].

To address usability evaluation issues, a process for this aim proposed that named Web Usability Evaluation Process (WUEP), which can be instantiated and integrated into different model driven Web development processes. In this type of processes, intermediate artifacts, which represent different views of a Web application, are used in all the steps of the development process, and the final source code is automatically created from these models. In this context, inspections of these models can provide early usability evaluation reports to identify usability problems that can be corrected before the generation of the source code [9].

The primary problem is that most usability evaluation methods for the Web domain have several limitations such as the concept of usability is only partially supported; usability evaluations are mainly performed when the Web application has been completed [8] on the one hand; whereas ,on the other hand, in the process development of web application by Web engineering methods, the web engineer sometimes does not meet user's expectations regarding usability. The challenge is current methods for usability evaluation return the feedback from end users and only for the user interface, this is a big challenge for measuring

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

usability by expert people and for context, moreover, the current methods have limitations because it used for usability web applications and return the feedback from web application features.

For expressing the actual feedback from web engineers or developers or expert people directly, we have defined a new framework for usability evaluation of MDWE methods. Significant of our framework is consists of six phases, in these phases we defined web engineering process development, web application features, usability attributes, usability evaluation methods, and usability testing. In the usability testing we use several ways for returning user's feedback such as usability testing by expert and group developers, open-ended and close-ended questionnaires, and interviews. By using this framework, we can get a real image for evaluation usability of web engineering methods.

This paper is organized as follows: Section 2 explains the existing works relating to usability evaluation software and web engineering. Section 3 describes the concept of usability in MDWE methods. In Section 4 we define a framework for measuring usability. In Section 5 we applied our framework for a case study. In Section 6 discusses validity and limitation of the new framework. The last section consists of the conclusion and suggestions for future work.

2. BACKGROUND

One of the important types of MDWE research is evaluation research by rating 13% as presented in [10]. Usability evaluation techniques can be largely categorized into two categories: empirical methods and inspection methods. Empirical approaches are founded on capturing and reviewing usage information from actual end-users whereas inspection approaches are conducted by specialist assessors or designers and are founded on analyzing the usability factors of Web artifacts that are normally user interfaces regarding their conformance with a collection of rules. Usability evaluation one of the important factors for completing web engineering life cycle and presenting quality of products.

Usability inspection processes have materialized as a substitute to empirical approaches as a way to recognize usability issues because they do not need end-user involvement and they can be applied in the early steps of the Web development procedure [11]. There are numerous suggestions founded on inspection approaches to handle Web usability problems, for example the Cognitive Walkthrough for the Web (CWW) [12] and the Web Design Perspectives (WDP) [13]. CWW inspects the simplicity through which a user can search a Website by employing semantic algorithms. Nevertheless, this technique simply supports simplicity of navigation. WDP expands and accepts the heuristics projected by Nielsen [14] with the intention of drawing nearer to the elements that typify a Web use: content, navigation, structure and presentation. Nevertheless, this sort of methods appears to present a substantial subjectivity level in usability assessments.

References [11-14] defined usability inspection for web design, these works returned feedback from end users, and they used user interface for the users. Moreover they evaluated web design models and aspects. However Nielsen [14] expanded the usability technique and tried to content, navigation and structure but could not evaluate the usability of web engineering methods.

Additional works offer Web usability examination approaches that are founded on using metrics so as to reduce the subjectivity of the evaluation, for instance the WebTango approach [15] and Web Quality Evaluation Method (WebQEM) [16]. The WebTango approach permits us to get quantitative procedures that are founded on empirically authenticated metrics for consumer interfaces, to construct predictive models so as to evaluate other client interfaces. WebQEM conducts a quantitative assessment of the usability features projected in the ISO 9126-1 average [17], and these quantitative events are combined so as to offer usability pointers. The aforesaid inspection approaches are leaning towards use within the conventional Web enlargement framework; they are thus principally used in the later phases of Web development procedures. As stated above, model-driven Web development provides an appropriate milieu for early usability inspections as it permits models that are used in all the phases to be assessed. This study line has emerged lately, and just a few works deal with Web usability problems,

The authors in above References [15-17] defined a new approach and new frameworks, they improved the approaches to measuring usability evaluation, the weaknesses that the authors could not evaluate usability web engineering methods.

Atterer [18] proposed a prototype of a model-based usability validation with which to analyze models that represent enriched Web user interfaces. This approach takes advantage of models that represent the navigation (how the Website is

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

traversed), and the UI of a Web application (abstract properties of the page layout). Abrahão and Insfran in [19] proposed a usability model to evaluate software products that are obtained as a result of model-driven development processes. Although this model is based on the usability sub-characteristics proposed in the ISO 9126 standard [17], it is not specific to Web applications and does not provide specific metrics. The same model was used in [20] with the aim of providing metrics for a set of attributes which would be applicable to the conceptual models that are obtained as a result of a specific MDWD process. These works is a good step for measuring usability evaluation for MDWE methods.

Molina and Toval [14] presented an approach to extend the expressivity of models that represent the navigation of Web applications in order to incorporate usability requirements. It improves the application of metrics and indicators to these models. Nevertheless, to the best of their knowledge, there is no generic process for integrating usability evaluations into Model-Driven Web development processes.

Several frameworks proposed for usability evaluation software's, Masood et al. ,2014 proposed a usability evaluation framework is proposed which comprises usability factors and their description, criteria and their description to measure factors, importance and grading of criteria fulfillment, guidelines to apply the framework and overall evaluation process [21] as shown in Figure 1.

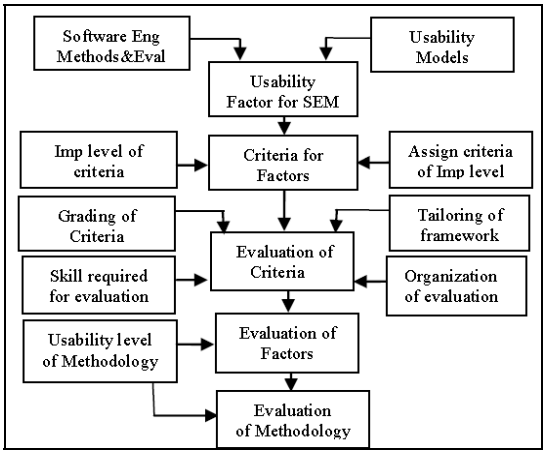

Figure 1: Usability Evaluation Frame work [21]

The framework that presented in Figure 1 one of the best frameworks because described usability factors, criteria to evaluate usability factors, the importance level of criteria fulfillment, grading of features or factors, and guidance on applying usability evaluation framework. The problem this framework cannot evaluate the web engineering methods, because these methods have a different structure and different process, also web engineering refer to web systems.

In the previous works combined web engineering methods and usability evaluations, and successfully applied usability and evaluation usability for web engineering methods, future more several frameworks proposed for usability evaluation but could not good feedback from end users also need to long time, so these frameworks need to enhance to return good feedback from expert peoples with short time.

3. USABILITY EVALUATION

In this section, we explain the concept of usability and usability evaluation. Also, we analyze the existing frameworks and their role in measuring usability evaluation of MDWE methods.

3.1 Usability Engineering

Usability Engineering (UE) is a field that is interested with the inquiry of how to devise software that is user-friendly (usable). UE is a method to the enlargement of software and systems that entails user involvement from the onset and warrants the effectiveness of the brand through the employ of a usability requirement and metrics [22]. UE offers a broad range of approaches and systematic methods for the support of improvement. These methods are known as UE models or Usability Lifecycles. Cases comprise Goal-Directed-Design [23], the UE Lifecycle [24]. Each of them has much in familiar because they portray an idealized method that guarantees the growth of utilizable software, although they vary in their specifics, within the applied approaches and the universal definition of the process, for example stages, dependencies, objectives, responsibilities, and so on [25].

3.2 Usability and MDWE Methods

Latest studies point out that the implementation of Model-Driven Development (MDD) has augmented. Presently, there are numerous Web development methods that follow this approach, for instance OO-H, UWE, or WebML. These methods support the creation of a Web application by describing models, together with at slightest one structural prototype, a navigational archetype, and a theoretical presentation model. Several methods as well offer model alterations and automatic code creation. The Web application usability got because

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

of this alteration procedure can be evaluated at numerous phases of a MDD procedure. Fernandez, et al. suggest the employ of a Web Usability Model (WUM) that can be used within the following stages of a MDD procedure: i) Within the PIM, to evaluate diverse models that stipulate the Web application separately of platform particulars (such as navigational models, archetypes that symbolize the conceptual UI); ii) within the PSM, to evaluate the real interface models linked to a particular platform (if they subsist); and iii) in the CM, to evaluate the last UI (see Figure 2) [9].

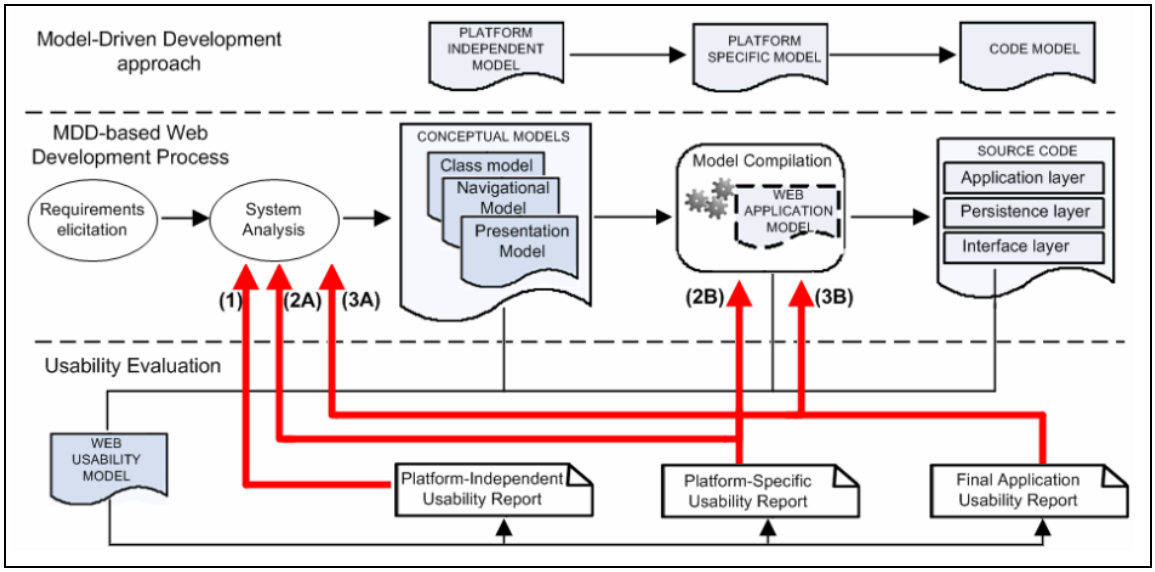

Figure 2: Integrating a Web Usability Model into the MDD process[9].

3.3 Usability Evaluation Process in Web Engineering

The ISO/IEC 25000 usability is precisely a quality aspect delineated as "the ability of any software to be comprehended, understood, and employed, while being striking to the user upon being utilized under certain conditions". This delineation could be adjusted to highly fit within MDWE domain as "the capacity of an approach aspect to be comprehended, studied, utilized and it is user-compelling when used under certain provisions, or generally as "a collection of aspects that allows impact on the effort required for use, plus the personal examination of such utility, by implied or stated collection of users".

Some quality sub-qualities are established for every quality characteristics. Excellent sub-qualities linked to each quality trait of usability are correspondingly delineated by adjusting additional delineations from ISO/IEC, IEEE, additional standards plus the already published studies. As described by Nielson, Usability entails a quality aspect that examines the accessibility of user interfaces. The phrase "usability" equally entails the techniques of enhancing accessibility during design procedure.

A total of 5 quality aspects that appear to describe usability include the following [26]:

1. Learnability: how simple is it for users to achieve some primary and important duties upon encountering the design for the very first time?
2. Efficiency: upon learning about the design, how likely are the users to perform activities?
3. Memorability: for returning users, how accessible is the design proficiency to them?
4. Errors: what is the level of erring among users, and how can they graduate from such errors?
5. Satisfaction: how efficient is it to utilize the design?

Figure 3 is illustrative of the key phases of WEUP. The three experts involved include: evaluation designer, evaluator, as well as Web developer. The task of the evaluation designer is five phases[8]:

1. Determining the evaluation needs;
2. Evaluation specification;
3. Evaluation design;
4. Evaluation implementation; and
5. Changes breakdown.

The subsequent sections offers a description of all the key phases by considering the activities decomposing into [8].

Journal of Theoretical and Applied Information Technology
31st January 2018. Vol.96. No 2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

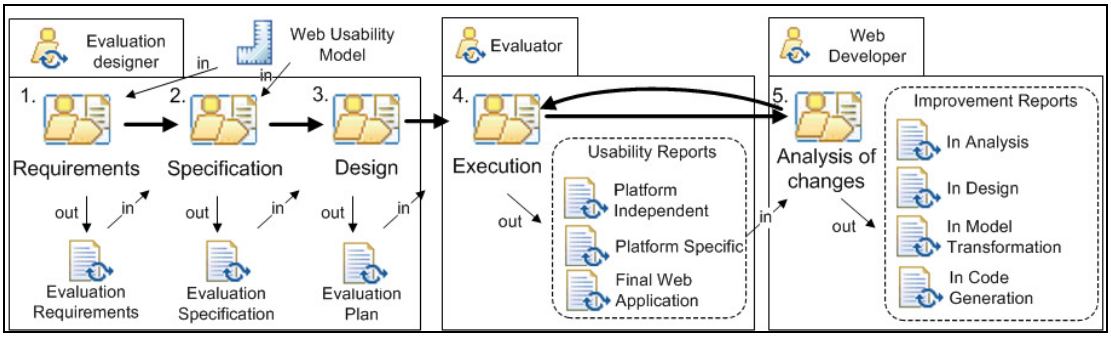

Figure 3: An overview of the Web Usability Evaluation Process [8]

Additional literature confirms the ability of usability evaluation at eventual UI to offer feedback concerning changes so as to enhance usability concerns at intermediate artifacts [26]. The Web application usability acquired as an outcome of an MDD procedure is capable of being examined at diverse conception levels (PSM, PIM and CM). The present study aims at utilizing a Web Usability Model, a collection of sub-traits broken down into quantifiable aspects, measured through metrics. The models from particular level of abstraction can be examined courtesy of the Web usability model (Figure4). Nonetheless, evaluation based on abstraction levels cannot be done on all quantifiable aspects. High abstraction levels are linked with consideration of few attributes [27].

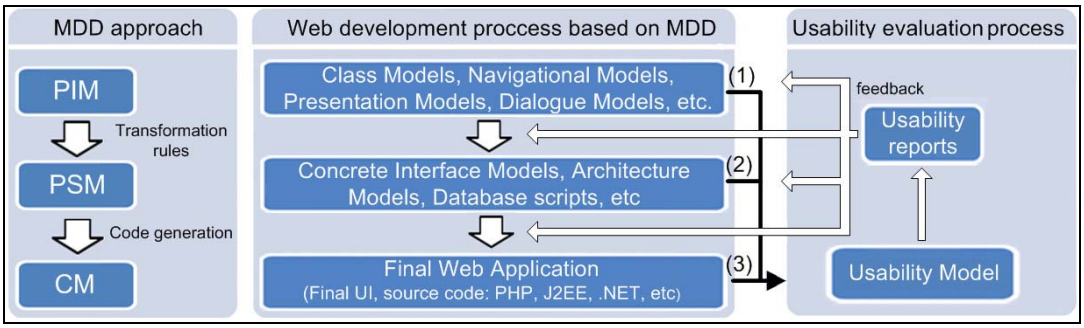

Figure 4: Integrating a Usability Evaluation Process into a Model-Driven Web development process [27]

4. A NEW FRAMEWORK FOR USABILITY EVALUATION MDWE METHODS

In previous sections, we have explained the concept of usability evaluation in software engineering and web engineering. Most evaluations have focused on the end user, while others concentrated on developers. We define a new framework for usability evaluation of MDWE methods, with the results geared towards web engineers. The term "Web engineers" refers to web developers who are working on the web engineering methods and who are generally expert designers. Since Web engineers' feedback is very useful for other designers, we have accordingly defined a new framework for measuring MDWE methods both before and after improvement of the methods, as shown in Figure 5.

Our new framework consists of six phases. We will explain the steps, together with requirements, one by one. In addition, we will demonstrate how to measure usability via the described method:

Phase 1: MDWE method, In this phase, we select a method by which we can obtain a usability evaluation from the developers. There are many web engineering methods in existence, such as: UWE, OOH, IFML, and so on. Also, some methods have been extended after combination or improvement from researchers for different aspects, such as UWE4RIA, which is a UWE method which has been improved for support of RIA. NewUWE [28] is a UWE method which has been enhanced to develop homepages, and so on. The researcher can measure usability of the standard methods or extend methods by this framework.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

This phase consists of two parts: the first selects the method that we want to evaluate; the second decides on the method we should use to highlight a particular aspect when we need to show usability. For example, should we wish to show usability metamodels, or usability object-oriented models, or new improvements, etc., the selection of aspect is very important for questionnaires and finding attributes.

Phase 2: In this phase, it must be remembered that the evaluator needs to assess which step in the web engineering lifecycle can provide the best usability to cover all phases of the web engineering lifecycle. The lifecycle, as defined by MDA or Agile methods and general Web engineering Lifecycle in particular, consists of: planning, analyzing; design, implementation and testing.

Phase 3: Web application Features: web application features based on web engineering methods in [29] explain the attributes that are supported by MDWE methods. These include, for example: Rich User Interface; Adaptivity; design ontology; web mining; etc.

Phase 4: Usability Attributes: Usability is defined by five (5) quality components as follows [26]:

1. Learnability: How easy is it for users to accomplish basic tasks the first time they encounter the design?
2. Efficiency: Once users have learned the design, how quickly can they perform tasks?
3. Memorability: When users return to the design after a period of not using it, how easily can they re-establish proficiency?
4. Errors: How many errors do users make, how severe are these errors, and how easily can they recover from the errors?
5. Satisfaction: How pleasant is it to use the design?

Phase 5: Usability evaluation methods, There are many usability evaluation methods used in the evaluation of usability of software products. Among these, the more frequently-used methods are : (1) Questionnaire; (2) User Testing; and (3) Heuristic Evaluation[30]. Evaluators can use one of more methods as well as mixed method when combining two or more methods.

Phase 6: Process of usability evaluation: This important phase determines show to perform the usability evaluation. We adopted the process usability evaluation from [31] after the enhancement we carried out for our framework, as shown in Figure5. This phase consists of five steps, explained as follows:

Step 1: Usability Testing: this step consists of four parts, as described below:

A: Task definition: in this part, we determine the requirements of the task and ask the developers to design the task by the web engineering method selected in phase 1.

B: Pre-test: this stage involves implementation of the task by developers. The task can be implemented by way of two methods:

Individual task: the task should be implemented by two (2) developers and two (2) expert developers respectively.

Group task: the task should be implemented by three (3) groups each of which has three (3) members. These members should be developers or students in the software engineering department.

C: Post-test: in this stage, the above developers should redesign the task after improvements to the method have been carried out.

D: In this part, we will determine the extent of the usability problem by use of the following equation:

Problems-found (i) = N (1 - (1 - l)i)

i = number of test users
N = number of existing problems
l = probability of finding a single problem with a single user

Step 2: this step also consists of four parts, described as follows:

A: Questionnaire Guideline: although a number of guidelines have been proposed for a list of usability evaluation criteria for questionnaires, the implementation from developers in step 1 is the best guideline for proposing a list of questionnaires.

B: The design process of the questionnaire starts after the analysis of usability test which gives authors a better understanding about the system and how users interact with it. Here we prepare a list of questions with 5 options ranging from: 1-very poor;2-poor; 3- moderate; 4-good; 5-Excellent. We need the input of a number of developers, experts, researchers and students in software engineering departments.

C: Open-ended questions: this is a type of question where respondents are free to respond in their own way. These questions are also known as subjective questions. Here we need to propose some open-ended questions based on our attributes and our task.

Journal of Theoretical and Applied Information Technology
31st January 2018. Vol.96. No 2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

D: Feed Back: after the process has been carried out by the questioners, we collect the result from users. Analysis can then be performed by one of the usability methods (such as heuristic evaluation).

Step 3: Interview: For validation of results, an informal interview will be conducted with four students or developers which will provide confirmation of the said conclusion. During these interviews, the authors asked open-ended questions with interviewees relating to their interaction with improvements in the web engineering methods. The questions were designed to be in keeping with the view of the results of the usability test and statically-obtained data from questionnaires.

Step 4: Result: finally, after the completed interviews, the results will emerge from the usability testing, questionnaires, and interviews. We will then demonstrate these by means of table, bar chart, and graph. The table consists of attributes and developer answers which we convert for the purposes of the chart and graph.

Step 5: We conclude the results and demonstrate how usability has been increased. Further, we indicate the strengths and weaknesses of our improvement.

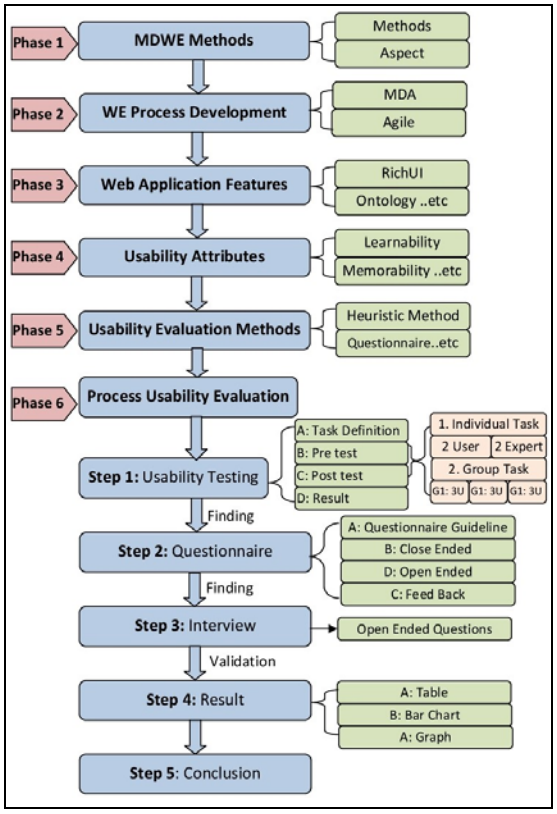

Figure 5: A New Framework for Usability Evaluation Web Engineering Methods

5. CASE STUDY

In this section, we apply our framework for usability evaluation of the UWE method, during which we extended the development of homepages [28]. Based on our framework, we measure usability extension of UWE metamodels by developers. In [28], we enhanced the UWE navigation model by defining six elements with the use of an extension mechanism to fully support homepage modules. The new UWE is a current UWE with the addition of new elements to support the homepage's content. We can also use this for web applications, if need be. The new elements in UWE can solve most weaknesses in a homepage's content, such as: Main Menu; Flash News; Multi Data; Marquee; Frame; Application. We cannot apply the full framework because this would require a number of developers and expert developers; however, we can explain the steps that do not need the input of developers.

Figure 6: UTM homepage [28]

Phase 1: In this phase, we select the method needed to evaluate aspects of change or improvement.

- Our method is the UWE method.
- Aspect is Extension UWE Navigation model for developing homepages.

Phase 2: In this phase, the appropriate stage of process development and web engineering process development should be selected. This consists of five stages, namely: requirements; analysis/design; implementation; testing and evaluation.

Journal of Theoretical and Applied Information Technology
31st January 2018. Vol.96. No 2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

- Our phase is Analysis/Design.

Phase 3: Web application features. The features will be changed based on the improvement of methods. In this case, our features are new modules on homepages on the UTM homepage.

- Features in the UTM homepage include: Main Menu; Flash News; Multi Data; Marquee ; Frame; Applications.

Phase 4: Usability attributes: there are several usability attributes which can be defined such as learnability, efficiency, memorability, etc.

- We measure the efficiency design of New UWE.

Phase 5: There are a number of methods used to evaluation usability; in this study, we use heuristic evaluation, questionnaires and interviews respectively.

Phase 6: this stage consists of five (5) steps as described below:

Step 1: Usability testing: this step consists of four parts as follows:

A: Task definition: in this part, we determine the task to be undertaken. We asked the developers to design a UWE navigation model for the UTM homepage.

B: Pre-test: In this stage, we asked the developers to design a UWE navigation model for the UTM homepage before enhancement of the UWE Navigation model. It was required that the task be implemented by two types of developers, as described below.

Individual task: The UTM homepage should be designed by two (2) users and two (2) expert developers respectively.

Group task: The UTM homepage should be designed by three groups each of which has three (3) members. It is recommended that the members should be developers or students in a software engineering department. Figure 6 shows the UWE navigation model for the UTM homepage using ArgoUWE tool before enhancement by [28].

C: Post-test: in this stage, the above developers should be able to redesign the UTM homepage by using the UWE navigation model after enhancement of the method.

D: In this part, we will

- determine a usability problem by the following equation:

Problems-found (i) = $N (1 - (1 - l)^i)$

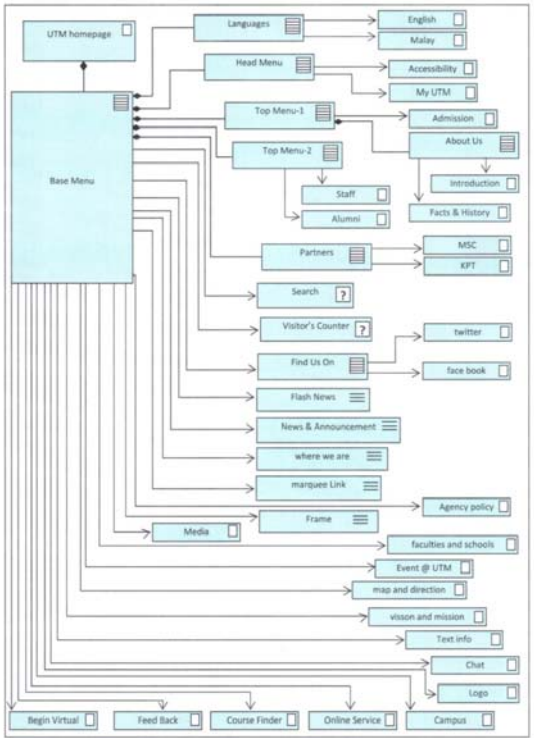

Figure 7: UWE Navigation Model for UTM homepage before enhancement [28]

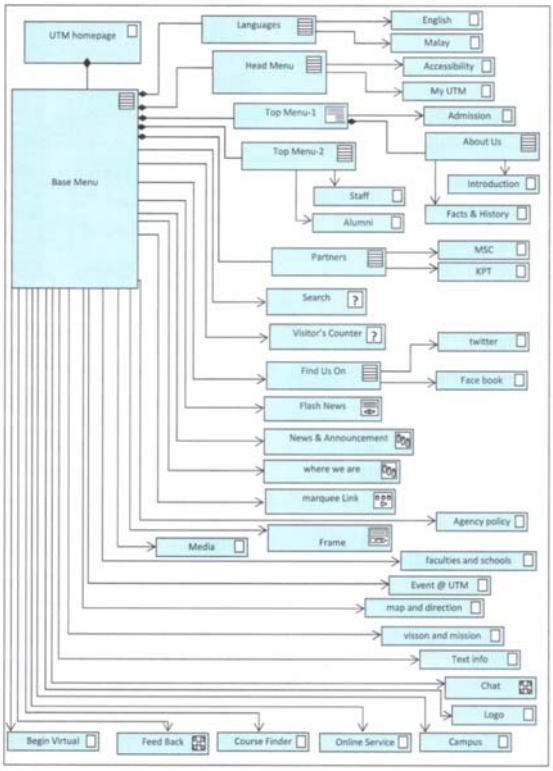

Figure 8: UWE Navigation Model for UTM homepage after enhancement [28]

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Step 2: This step consists of four parts as follows.

A: we propose some questions for users based on development of the UTM homepage.

B: We prepare six (6) close-ended questions and answers which are to be graded from 1-5 being (1-very poor, 2-poor, 3- moderate, 4-good, 5-Excellent). Table 1 shows the list of questions.

Table 1: List of close ended questions

No.	List of Questions	Answers									
1	New UWE can support Main Menu in UTM homepage.	1		2		3		4		5	
2	New UWE can support Flash News in UTM homepage.	1		2		3		4		5	
3	New UWE can support Multi Data in UTM homepage.	1		2		3		4		5	
4	New UWE can support Marquee in UTM homepage.	1		2		3		4		5	
5	New UWE can support Frame in UTM homepage.	1		2		3		4		5	
6	New UWE can support Application in UTM homepage.	1		2		3		4		5	

C: Open-ended questions: in this section, we ask the developers for their opinion regarding enhancement of the UWE navigation model. Our questions are as follows.

- Question 1: What is your impression about the enhancement of UWE?
- Question 2: What are the weaknesses you found during the design process for the UTM homepage?
- Question 3: What is the efficiency of the new UWE for design of the Navigation Model?
- Question 4: What are the advantages and disadvantages of the enhancement?

D: Feed Back: after the process of questioners, we collected the results from users. We then conducted an analysis of one of the usability methods, namely, heuristic evaluation.

Step 3: Interview: for validation of results, informal interviews were conducted with developers which will provide confirmation of the said conclusion. During interviews, the authors asked the interviewees open-ended questions regarding their interaction with the UWE navigation model.

Step 4: Result: in this instance, we cannot create tables, bar charts and graphs for our result because only one developer designed the UWE navigation model for the UTM homepage. If the number of evaluations increased, we would then be able to show the result by means of matrixes.

Step 5: We conclude the result and demonstrate how usability has increased. Further, we show the strengths and weaknesses of the enhancement of UWE, as well as the rate of usability.

However we could not present the result of our case study with quantity, but we showed how to apply our framework for evaluating web engineering methods especially after enhancement the methods, the challenge of full present is the number of expert and developers. Our case study becomes a guide to researchers for evaluating the methods.

6. VALIDITY AND LIMITATIONS

The new framework can evaluate usability methods with thorough result. Difference between the framework with others are used a number direction to evaluate the methods that are; group and individual, expert developers and student. There are finding different point in the usability. Then our framework used a number type of evaluation such as questioners close and open questions, interview, and implement by expert developers.

We have some limitations, the expert people and web designers not available in any place, and most designers worked on a specific method, this is a reason to evaluators not used our framework.

7. CONCLUSION AND FUTURE WORK

In this paper, we have defined a new framework for usability evaluation of MDWE methods. Our framework consists of six phases, in the phases we explained all requirements by detail. In this framework we combined the phases of several of frameworks. This framework is too strong for measuring the usability of web engineering methods from web engineers or developers, because when the feedback returned from expert people and questioners form we should make an interview for verifying our framework. Furthermore we applied to a case study successfully. However we have some limitation especially no more expert people in any place for returning feed back or interview, that is the reason not easy to use the new framework. In the future, we plan to adopt a process by which to implement usability evaluation. We recommend that developers use this framework and improve upon it after real implementation.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

REFERENCES

[1] M. J. Escalona and N. Koch, "Requirements engineering for web applications-a comparative study," *J. Web Eng.*, vol. 2, pp. 193-212, 2004.

[2] M. Escalona, *et al.*, "The treatment of navigation in web engineering," *Advances in Engineering Software,* vol. 38, pp. 267-282, 2007.

[3] C. Kroiss and N. Koch, "UWE metamodel and profile: user guide and reference," Technical Report 0802, Ludwig-Maximilians-Universität München2008.

[4] W. Schwinger, *et al.*, "A survey on web modeling approaches for ubiquitous web applications," *International Journal of Web Information Systems,* vol. 4, pp. 234-305, 2008.

[5] J. Offutt, "Quality attributes of web software applications," *IEEE software,* vol. 19, p. 25, 2002.

[6] M. Matera, *et al.*, "SUE inspection: an effective method for systematic usability evaluation of hypermedia," *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans,* vol. 32, pp. 93-103, 2002.

[7] N. Juristo, *et al.*, "Guidelines for eliciting usability functionalities," *IEEE Transactions on Software Engineering,* vol. 33, pp. 744-758, 2007.

[8] A. Fernandez, *et al.*, "A web usability evaluation process for model-driven web development," in *International Conference on Advanced Information Systems Engineering*, 2011, pp. 108-122.

[9] A. Fernandez, *et al.*, "Integrating a usability model into model-driven web development processes," in *International Conference on Web Information Systems Engineering*, 2009, pp. 497-510.

[10] K. Wakil and D. N. Jawawi, "Model driven web engineering: A systematic mapping study," *e-Informatica Software Engineering Journal,* vol. 9, pp. 107--142, 2015.

[11] G. Cockton, *et al.*, "Inspection based evaluations," 2008.

[12] M. H. Blackmon, *et al.*, "Cognitive walkthrough for the web," in *Proceedings of the SIGCHI conference on human factors in computing systems*, 2002, pp. 463-470.

[13] T. Conte, *et al.*, "Usability evaluation based on Web design perspectives," in *First International Symposium on Empirical Software Engineering and Measurement (ESEM 2007)*, 2007, pp. 146-155.

[14] F. Molina and A. Toval, "Integrating usability requirements that can be evaluated in design time into Model Driven Engineering of Web Information Systems," *Advances in Engineering Software,* vol. 40, pp. 1306-1317, 2009.

[15] M. Y. Ivory, "An empirical foundation for automated web interface evaluation," UNIVERSITY of CALIFORNIA at BERKELEY, 2001.

[16] L. Olsina and G. Rossi, "Measuring Web application quality with WebQEM," *Ieee Multimedia,* vol. 9, pp. 20-29, 2002.

[17] F. Coallier, "Software engineering–Product quality–Part 1: Quality model," *International Organization for Standardization: Geneva, Switzerland,* 2001.

[18] R. Atterer and A. Schmidt, "Adding usability to web engineering models and tools," in *International Conference on Web Engineering*, 2005, pp. 36-41.

[19] S. Abrahao and E. Insfran, "Early usability evaluation in model driven architecture environments," in *2006 Sixth International Conference on Quality Software (QSIC'06)*, 2006, pp. 287-294.

[20] J. I. Panach, *et al.*, "Understandability measurement in an early usability evaluation for model-driven development: an empirical study," in *Proceedings of the Second ACM-IEEE international symposium on Empirical software engineering and measurement*, 2008, pp. 354-356.

[21] Z. Masood, *et al.*, "Usability Evaluation Framework for Software Engineering Methodologies," *Lecture Notes on Software Engineering,* vol. 2, p. 225, 2014.

[22] J. Nielsen, *Usability engineering*: Elsevier, 1994.

[23] A. Cooper and R. Reimann, "About Face 2.0," *The Essentials of Interaction Design,* 2003.

[24] D. J. Mayhew, "The usability engineering lifecycle," in *CHI'99 Extended Abstracts on Human Factors in Computing Systems*, 1999, pp. 147-148.

[25] N. Woletz, "Evaluation eines User-centred-Design-Prozessassessments: empirische Untersuchung der Qualität und Gebrauchstauglichkeit im praktischen Einsatz," 2006.

[26] J. Nielson. (2012, *Introduction to Usability*. Available:

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

http://www.nngroup.com/articles/usability-101-introduction-to-usability/

[27] A. Fernandez, *et al.*, "Towards a Usability Evaluation Process for Model-Driven Web Development," *I-USED,* vol. 9, pp. 1-6, 2009.

[28] K. Wakil, *et al.*, "Enhancement of UWE navigation model: Homepage development case study," *International Journal of Software Engineering & Its Applications,* vol. 8, 2014.

[29] K. Wakil, *et al.*, "Analyzing Modern Web Applications to Recognize Features-based Web Engineering Methods," presented at the KSII The 7th International Conference on Internet (ICONI) 2015 Symposium, 2015.

[30] F. Paz, "Usability Evaluation Methods for Software Development: A Systematic Mapping Review," in *2015 8th International Conference on Advanced Software Engineering & Its Applications (ASEA)*, 2015, pp. 1-4.

[31] K. Qureshi and M. Irfan, "Usability evaluation of e-learning applications, A case study of It's Learning from a student's perspective," Master Thesis, Blekinge Institute of Technology, 2009.