Bulletin of Electrical Engineering and Informatics
Vol. 11, No. 6, December 2022, pp. 3433~3440
ISSN: 2302-9285, DOI: 10.11591/eei.v11i6.4277

A model for incorporating suitable methods of usability evaluation into agile software development

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Article Info

Article history:

Received Jun 10, 2022
Revised Jul 25, 2022
Accepted Aug 24, 2022

Keywords:

Agile development process
Usability
Usability evaluation
Usability management

ABSTRACT

The challenge to incorporate usability evaluation values and practices into agile development process is not only persisting but also systemic. Notable contributions of researchers have attempted to isolate and close the gaps between both fields, with the aim of developing usable software. Due to the current absence of a reference model that specifies where and how usability activities need to be considered in the agile development process. This paper proposes a model for identifying appropriate usability evaluation methods alongside the agile development process. By using this model, the development team can apply usability evaluations at the right time at the right place to get the necessary feedback from the end-user. Verification of the proposed model was conducted using the focus group method by experts from industry domain.

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1. INTRODUCTION

Usability is one of the software's quality attributes that is so widely considered in the development of successful interactive software. Usability evaluation is a key process in the usability field that checks whether a software product, especially its user interface possesses all required usability aspects as well as the extent of these [1]. It tries to find out, through massive methods and techniques, whether the product is easy to learn and use, efficient and effective in achieving users' goals, or helps the users to perform their tasks [2]. It is commonly used in development projects where usability is a primary concern [3].

Agile methodologies that emerged in the last decade provide an alternative to traditional approaches for building software, which are aimed at satisfying the customer in the software industry [4]. They seek to minimize the overall risk, enabling the project to be adapted with modifications rapidly, and maintaining the project schedule and budget [5]. They follow an iterative and incremental approach to developing software rapidly where the entire software development lifecycle is broken down into smaller iterations [6].

Up to the present, one of the main challenges in the agile software development community is how to incorporate usability evaluation work into the development process in an efficient and effective manner. Despite both fields are similar in many aspects, such as a shared focus on delivering value, being iterative in nature, and including continuous testing, they are different in how approach these aspects practically [7], [8]. Yet, many methods and techniques have been proposed for reconciling usability work with the agile development environment, but they have lacked a comprehensive strategy to persisting perform evaluations of usability alongside the development process [9]-[11]. Determining how to promote ongoing usability

evaluations in the agile development environment provides an interesting research opportunity, the results of which can be applied to improving the incorporation of usability evaluations' work.

2. INTEGRATION OF USABILITY EVALUATION INTO THE AGILE APPROACH

Explaining Integrating usability evaluation into the agile development approach has been addressed as a means by which these tensions might be resolved. For instance, Metzker and Reiterer presented the approach "evidence-based computer-aided usability engineering environment (CAUSE)" which covers the end-user aspects, where agile methods such as extreme programming (XP), feature driven development (FDD) or Scrum were originally developed to focus on satisfying development and business needs rather than end-user needs [12]. Düchting *et al.* [13] claim that existing agile approaches do not offer specific guidance on how to integrate usability practices into agile activities. Because these approaches started as methods for programming, development practitioners are often uncertain about how non-coders fit into the agile development team. They discussed the application of usability evaluation works in the agile development environment and drawn practice-oriented recommendations. Chamberlain *et al*. [14] carried out a case study to ground a broad framework about how usability and agile approaches can work together. The case study shows that this goal can be achieved through exploit typical values and practices from both approaches. Also, the study highlights the efforts that have to be made to ensure appropriate resource management, balance, and participation. Based on practical experiences, Parsons *et al*. [15] argue that because usability evaluation stems from a different area, no typical methods, techniques, or tools can be integrated directly into the agile methods, which require adapted practices for this integration. Among other integration strategies, Lievesley claims that adding an interaction designer role within the development team could contribute to observing, steering, and managing the activities of usability [16]. Sy and Miller [17] claim that despite the production of working software at a quick and constant pace providing a great setting for usability evaluations, traditional usability evaluations conducted in a laboratory are hardly fitting this kind of process. They recommended that for achieving usable software, the user interaction design must be considered an essential part of software development.

Magües *et al.* [18] proposed an approach that parallels the process between interaction design and coding. Through careful coordination, the interaction designers do an elaborated design. In light of this design, developers produce working software. Next, testers evaluate the working software using lightweight evaluation methods. Ardito *et al*. [19] argue that usability issues are important to developing an interactive software product in that agile and usability practitioners need to conform for an effective integration. They suggested recommendations aimed at understanding and learning usability methods and techniques and accepting that the concept of usability is an important quality aspect. Zorzetti *et al*. [20] performed a case study to investigate the incorporation of usability methods within an agile process using multi techniques, and they claim that a software development process model that encompasses Agile, Lean Startup, and User-Centered Design concepts can be used as a starting point for those who want to adhere to such a development approach. Gardner and Ozgur [21] propose a development framework that champions early usability integration in an Agile environment by analyzing their effect on the Scrum and Kanban development frameworks. Among the processes explored are the participatory design processes, joint-application development (JAD) sessions and design thinking activities, ethnographic studies such as contextual task analysis or inquiry, and those that modify the iterative process with the intent of prioritizing analysis and design such as the use of design sprints. Also, they evaluated the components of the proposed framework during the requirements gathering, analysis, and design phases of development by interview technique [21].

However, user interface design and evaluation are not a simple endeavor for systems that have a large UI component. Moreover, usability activities are time-consuming and may violate any of the accepted tenets of the agile development philosophy. Therefore, applying usability evaluations at the right place and at the right time is required to ensure both agility plus continuous evaluations alongside the development process.

3. THE MODEL FOR SELECTING SUITABLE METHODS OF USABILITY EVALUATION

Due to the short iteration time of agile development, the developer is more likely to sacrifice usability work to get the code implemented since functioning code is central to agile methods [22]. In practice, many agile processes have a narrow view of what competencies are needed in a project, and usability activities are routinely overlooked. Without these activities the chances of producing usable systems are slight. This is a serious weakness affecting most conventional agile methodologies. Where, if usability evaluation was considered within the development priorities, the agile values could be used to promote the idea that agile methods should be empowered, multidisciplinary, and include usability evaluation activities. To achieve this target, the authors of this paper propose a model for the selection and application of

appropriate usability evaluation methods and techniques in the right places at the right times based on certain criteria. Due to the proposed model tends to be used by the agile development team, terminologies are created familiar to the development environment, and the characterization of the methods was taken from an agile perspective. The development team should select suitable evaluations of usability to be within the development activities. For example, selecting methods that require less training for an agile team and techniques that improve the product's usability relative to the application effort. The following is a list of characteristics, metrics, and measurements for selecting suitable evaluation methods (see Figure 1).

The model acts as a flexible instrument so that the implementation of a specific procedure or process is not necessary. Since iterative refinement is a required characteristic of every user-centered development endeavor, the sole requirement for the current development process is that it be based on it.

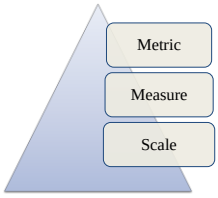

Figure 1. The general model of usability evaluation methods

4. SELECTION CRITERIA

The proposed model provides a set of attributes for selecting appropriate evaluation methods to apply during software development phases (see Figure 2). Some of these attributes were proposed by [23], the authors involve further attributes such as satisfaction, understandability, and attitude. Despite the automation attribute represented in the previous set, it is found far from affecting selection usability methods. For this, it is omitted from the proposed set. Learnability also is adapted within the set, which in this model learnability represents the ease with which the method required for achieving particular goals can be mastered, rather than how easy it is to learn the method. Table 1 shows these attributes and describes each one from the agile development perspective such as short-time iterations, high-level of collaboration with customers, focus on working artifacts, and dynamic processes.

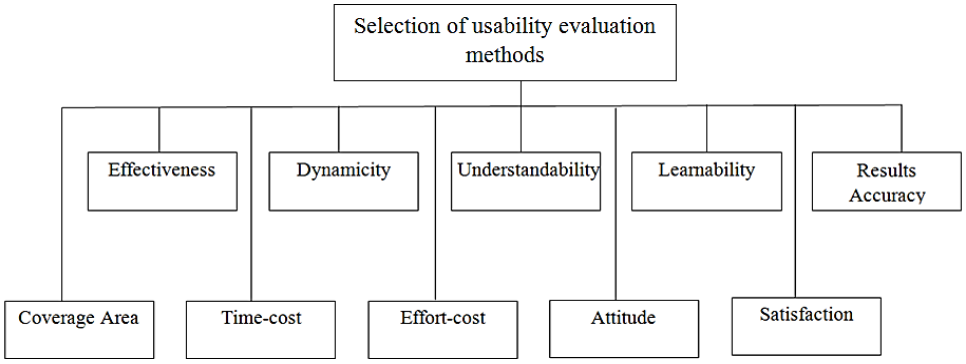

Figure 2. Usability evaluation model for selecting suitable methods

Table 1. Set of attributes for selection suitable usability evaluation methods

Attributes	Description
Effectiveness	Feedback effects on design or development
Dynamicity	The ability of the method to be changed according to the target environment
Understandability	Whether the user can understand the functions and usage of software easily (e.g., through familiar models, and metaphors).
Learnability	The ease with which the method required for achieving particular goals can be mastered. It is the capability of the software product to enable users to feel that they can productively use the software product right away and then quickly learn other new (for them) functionalities.
Results accuracy	Accuracy of results.
Coverage area	The elicitation/usability issues are covered by this method.
Time-cost	How much minimum time is needed to complete this method.
Effort-cost	How much effort is needed to perform this method (e.g., manpower, equipment, experiment place, other resources).
Attitude	The attitude of users or their subjective feelings during the use of the product.
Satisfaction	Freedom from discomfort and positive attitudes towards the use of the product. In other words, the subjective responses from users about their feelings when using the software (i.e., is the user satisfied or happy with the system?).

The effectiveness attribute is to assess the method's impact on designing and/or development. A method with high impact gets more priority than the lower one, like heuristic evaluation with usability experts on early prototypes can have more impact on design improvements compared to other evaluation methods. The agile processes can adopt the target-working environment; therefore, methods with higher degrees of dynamicity are natural alliance. The dynamicity attribute is to judge a method's ability to change its process of working according to the target environment. The time-cost attribute is to determine the time needed to perform a particular usability evaluation method. This has a direct relation with the time frame of agile iteration. Therefore, we suggest choosing those methods that can fit properly in the time frame of the targeted iteration.

The understandability attribute talks about the understandability of usability evaluation methods by the responsible persons within the development team. A method with higher ease of understandability takes less time while performing it, hence compliment to agile short nature of iterations. The satisfaction attribute talks about freedom from discomfort and satisfaction towards the use of the method in term of effectiveness, correctness, and verifiability. The attitude talks about subjective feelings of the responsible persons during the use of the method. As such, a method with higher positive attitudes takes less time while performing it, hence complementing agile's short nature of iterations. Also, a method's results act as feedback for the improvements in the design and development of the developed product.

The effort-cost talks about other resources (manpower, equipment, money, and experiment place) that are needed to perform the selected method. This also has a direct relation with the targeted agile iteration. For example, normally agile teams are made up with a small set of people and a particular method may not be well suited if it requires more man power than the team's capability. The learnability attribute talks about a usability evaluation method's learnability. A method with greater ease of learnability takes less time while performing it, which makes it easy to obtain information about improving product usability.

The accuracy feedback of a particular method can play a critical role in the successful outcomes of agile development iteration. Each usability evaluation method covers only parts of the problem. The coverage area describes the perspective of highlighting eliciting issues or usability issues by a particular method. Hence, it is better to select those two methods that highlight issues from different perspectives rather than those two from the same perspective.

A central aim of this model is to apply evaluations of usability smoothly during the agile process. Using the selection attributes of the model would enable agile practitioners to specify which usability evaluation methods are suitable and possible to apply in the right places at the right times. The contexts in which these methods are appropriate, the reasons why they should be employed, the data they yield, in what type of organization or for what purpose they would be most valuable, value each offers, and the downsides of each. However, with using this model the authors recommend that for early design activities, an emphasis on paper-based or simple UI prototype-based evaluation methods to improve design early. In later iteration activities, using formal evaluation methods, such as task model-based usability evaluation method, to get formal results. Also, the authors recommend using a mixture of evaluation methods, preferably supported by end users and UX experts for maximum results.

5. METRICS

The usability literature has offered a rather large number of testing metrics. These metrics fall into two categories: (i) preference metrics, which quantify subjective evaluations, and (ii) performance metrics, which evaluate the actual performance of the users when completing a task in a certain scenario (e.g. success rate, error rate, time completion time).

We have discovered a total of 18 metrics for usability evaluation attributes based on research of existing usability measurement standards and frameworks (see Table 2). These metrics are derived from the agile software development perspective, which categorizes usability evaluation methodologies according to their agility. Some metrics are essentially formula-defined functions, whereas others consist of simply countable data. Raw data acquired from a variety of sources, including log files, interviews, and surveys, may be utilized to derive countable metrics. Countable metrics include the proportion of a task that has been accomplished, the ratio of task successes to failures, and the frequency with which technique aids are utilized. Calculable metrics are the outcomes of mathematical computations or heuristics utilizing raw observational data or countable metrics as inputs. Where Quantity is the proportion of the work done and Quality represents the proportion of the objective attained.

Table 2. Usability evaluation metric

Attribute	Metric
Effectiveness	Feedback effect
	Quality
Dynamicity	Environmental software adaptability
	Environmental hardware adaptability
	Adaptability
Time-cost	Short turnaround time
	High throughput
Effort-cost	Ease of method effort
	Human effort
	Resources effort
Learnability	Ease of method learning
Understandability	Ease of method understanding
Results accuracy	Incomplete result
	Incorrect result
	Unexpected results issued
Coverage area	Coverage
Attitude	Acceptance of method
Satisfaction	Satisfaction with method

6. VIEWS OF THE MODEL

View of usability evaluation: This view is grouped by the selected method's name. It is advantageous when developers are familiar with a certain usability evaluation approach (they have heard of it) or have been convinced of its usability benefits. This perspective of the model provides the opportunity to learn the characteristics of a certain usability evaluation approach.View of development activities: During the development process, while developers are trying to find acceptable usability evaluation techniques, they utilize this view of the model. To utilize the model for this purpose, developers have to map the model's procedures to the exact names of activities regarded by their organization. Then, among the offered ways for each type of activity, individuals can choose the ones that best suit their unique goals.

The offered views in the model are not exclusive. The modeled perspectives are not exclusive. They may be used independently, but the model is anticipated to be utilized through a multi-view information search. For the purpose of introducing usability evaluation procedures into the development process, developers are able to move between views to access the kind of data. For such an activity, the developer will select one or more ways based on both the characterisation of the criteria and the information regarding the optimal time for method application. The developer may switch to the view by usability evaluation techniques in order to review the training standards of the approach and determine if certain members of the development team need to attend a lengthy usability training session. We believe that these various perspectives of the model provide a varied resource for improving the usability integration attempt. In order to give software developers with more guidance, the model is not intended as a tool for the automatic development of a custom process add-in, but rather it assists them in the complex work of incorporation.

Knowing where to inject usability evaluation techniques and activities into the existing process does not automatically enable software developers to implement usability practices in their daily work. We include a basic reference for each usability evaluation technique in the model, to which developers can consult for further information on the method's use.

7. VERIFICATION OF THE MODEL THROUGH FOCUS GROUP

The model is verified through focus group technique, which was attended by the domain experts from both agile and usability backgrounds. The following sub-sections discuss the implementation of the focus group technique, which constitutes the planning, executing, along with analyzing the date and reporting the result [24].

7.1. Plan of the focus group

Thorough planning is needed to effectively implement the focus group technique. In that, five main activities were proposed within the plan of the implementation: i) defining the objectives, ii) identifying the participants, iii) scheduling the meeting, vi) preparing the materials for the focus group and v) sending reminders to the participants. These activities are further elaborated on in the following sub-sections.

7.2. Define the main objective of the focus group

Basically, the objective of the focus group is to verify attributes, metrics, measures and scales of the proposed model based on certain criteria. These criteria involve comprehensiveness, accuracy, understandability and sufficient (see Table 3), which are adapted from previous studies [25]-[27].

Table 3. Descriptions of verification criteria

Criteria	Descriptions
Comprehensiveness	This criterion shows that the attributes, metrics, measures and scales are included in the model.
Understandability	The criterion suggests that the attributes, metrics, measures and scales are decomposed clearly and unambiguously.
Sufficient	The criterion indicates that the attributes, metrics, measures and scales are decomposed to achieve sufficient classification.
Accurateness	The criterion indicates that the attributes, metrics, measures and scales are adequately decomposed to achieve accurate classification.

7.3. Participants identification and recruitment

The participants were selected by using purposive sampling [28]. They were chosen based on several common characteristics such as: i) developing software, ii) working in Kuala Lumpur or nearby areas, iii) Working with the agile methods, and iv) concerning with usability issues.

7.4. Meeting schedule

The suitable meeting places were identified based on the guidelines provided by [29]. The places were chosen to be near and suitable for the experts, which include facilities such as a meeting room, discussion table, laptops, LCD projector, and other documents. Also, they were provided a pleasant and comfortable environment for the experts. Additionally, all appointments were scheduled on Saturday and Sunday, which were convenient for the experts.

7.5. Preparation of the focus group interviews

Prior to conducting the interview with the experts, the principles of preparing the interview guides were adept, whereby the discussion was planned to be started with a general topic, which is the introduction of the study. Then, the verification process of the proposed model was continued. Additionally, the materials that were used during the interviews were prepared, such as the presentation slides, the proposed model materials, and documents for the experts.

7.6. Remind the experts

One day before an interview, the expert is reminded about the interview to confirm with them. This procedure was conducted to ensure that the experts would not miss the interviews as well as to make them feel their importance in attending the interviews.

7.6. Conducting process of the focus group

The focus group was conducted on the scheduled day and time. However, two of the participants who agreed to come could not attend the session. Thus, only six of the participants turned up to attend the session, which is considered a sufficient number of participants for a focus group, the guideline provided by [29], [30] were followed.

Upon arrival at the meeting room, the participants were greeted and friendly contact was established in order to create rapport. This was done by having an informal conversation among the participants and moderators before the formal discussion begins. They were also served with refreshments. This was intended to make the participants feel comfortable and relaxed. On top of that, this enabled the moderators and participants to get to know each other. In the formal session, the participants were seated at a U-Shaped discussion table to facilitate interactions. They were provided with the materials that were needed for the session. They were encouraged to express their experience and points of view freely and spontaneously.

8. RESULTS FOR THE ATTRIBUTES, METRICS, MEASURES AND SCALES

In a nutshell, all of the experts agreed that the attributes, metrics, measures and scales are comprehensive, understandable, sufficient and accurate (see Table 4). However, they had some comments on the understandability, sufficient and accurate of the attributes, metrics, measures and scales. For example, Expert A suggested that the metrics of the attributes such as effectiveness are required further clarification, while Expert D and G claim that some measures of the metrics are not much enough clear that require more description. Meanwhile, Expert B concluded that the measures relevant effort-cost are not enough to measure this attribute and he suggested proposing extra effort-cost measures. Lastly, Expert C and D suggested that the selection criteria should be organized based on three scales rather than five. However, all suggestions of the expert were taken into consideration. Hence, the attributes, metrics, measures and scales were updated accordingly as suggested.

Table 4. Recapitulates the comments from the knowledge experts

Expert	Comprehensiveness	Understandability	Sufficient	Accurate
A	Agreed	-Suggested that the metrics of the attributes such as effectiveness are required further clarification	Agreed	Agreed
B		Agreed	-Claimed that the measures relevant effort-cost are not enough to measure this attribute -Suggested to propose extra effort-cost measures	Agreed
C	Agreed	Agreed	Agreed	-Suggested that the selection criteria should be organized based on three scales rather than five
D	Agreed	-Some measures of the metrics are not enough clear that require more description	Agreed	-Suggested that the selection criteria should be organized based on three scales rather five
E	Agreed	Agreed	Agreed	Agreed
G	Agreed	-Some measures of the metrics are not enough clear	Agreed	Agreed

9. CONCLUSION

This paper presents a model for increasing representation of usability evaluation activities within the agile development process by supporting the timely and relevant selection and application of usability evaluation methods. The model characterizes each method of usability evaluation according to ten attributes that may be of interest to the practitioners in the usability integration endeavor. Further, the model was verified in a focus group technique, in which the verification process involved experts from both usability and agile backgrounds. Future work can focus on implementing the model in the development environment based on practitioner case studies.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the Malaysia Minister of Education and Research Management Center at Universiti Malaysia Terengganu (UMT) for funding the grant with the reference code FRGS 59561 to pursue research in this field.

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