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Appropriate Web Usability Evaluation Method during Product Development

A comparison and analysis of formative web usability evaluation methods

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ABSTRACT

Web development is different from traditional software development. Like in all software applications, usability is one of the core components of web applications. Usability engineering and web engineering are rapidly growing fields. Companies can improve their market position by making their products and services more accessible through usability engineering.

User testing is often skipped when approaching deadline. This is very much true in case of web application development. Achieving good usability is one of the main concerns of web development. Several methods have been proposed in literature for evaluating web usability. There is not yet an agreement in the software development community about which usability evaluation method is more useful than another. Doing extensive usability evaluation is usually not feasible in case of web development. On the other hand unusable website increases the total cost of ownership. Improved usability is one of the major factors in achieving satisfaction up to a sufficient level. It can be achieved by utilizing appropriate usability evaluation method, but cost-effective usability evaluation tools are still lacking.

In this thesis we study usability inspection and usability testing methods. Furthermore, an effort has been made in order to find appropriate usability evaluation method for web applications during product development and in this effort we propose appropriate web usability evaluation method which is based on observation of the common opinion of web industry.

Keywords: web usability, usability evaluation methods, usability engineering.

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I would like to heartily acknowledge my advisor Mia Persson for her excellent guidance and encouragement which has lead to completion of my master thesis with in time. To my father who is the core reason of what ever good thing I have achieved in my life.

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I want to express my profound thanks and indebtedness to my supervisor for her patient guidance, generous support and encouraging attitude during my thesis work. To my mother whose prayers are chasing in every moment of my life.

Kamran Khan Tatari

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1 INTRODUCTION

This chapter provides the background for this thesis, as well as the purpose, aims and objectives of the thesis. The reader will also find the research questions along with the research methodology.

1.1 Background

Despite of advancement in web technology, web software applications are still immature and it posses significant risk to both industry and government [11]. But at the same time it also represents an opportunity for software engineering researchers to extensively investigate in this area [11]. Web application development is maturing from the experimental practice of early years to a more professional discipline [12]. Quality is central to this maturing and it is necessary to have a full understanding of the meaning of quality in the context of the ever changing web applications [12]. The systematic and quantitative quality evaluation of web applications are frequently neglected issue [16].

In literature, most work on web applications has been done on making them more powerful but relatively little has been done to ensure their quality [13]. Important quality factors for web applications include reliability, availability, usability and security [13].

Web site usability and accessibility continue to be a pressing problem [14]. An estimated 90% of web sites provide inadequate usability [15].

An ISO/IEC 9126-1 standard mentions six principle categories of quality characteristics. They are functionality, reliability, usability, efficiency, maintainability and portability.

Usability represents one of the most important acceptance criteria for interactive software applications in general and web applications in particular [17]. It is one of the most important quality factors for web applications. Unusable web applications cause users to reject them. A good usable web application is that one from which users can achieve their goals effectively, efficiently and satisfactorily [5]. In order to design web applications two things are needed to be considered. User needs and usage contexts. User needs point towards functionally aspect of web application while usage contexts point towards usability aspect of web application.

Usable Web sites are those which help users to accomplish a goal easily, quickly, and pleasantly. Web usability is a core component of web quality. Without good usability features the web quality will always be a question mark.

There is a sort of tug of war between web application content growth and need for more usable web sites. In other words web sites are becoming more complex and at the same time higher usability is also desired. In order to keep the balance between the two, appropriate usability inspection and testing methods needs to be employed during product development of websites. Web development is different from traditional software development. The main objective of web development project is to create usable product in shortest possible time while the main objective of software project is to create a quality product at lowest possible cost [17]. Then web projects are of small duration about 3 to 6 months while average software project duration is from 12 to 18 months [17]. In this situation usability inspection and testing area are allocated with little time and this becomes one of primary reasons for the failure of many websites [17]. There is no universally accepted web usability evaluation method due to nature of World Wide Web domain. From literature [52, 54] and own observation it is found that different web development companies follow different usability evaluation methods. Many even do not follow any usability evaluation method during product development. A Research is needed to investigate which usability evaluation method can be appropriate for web industry during product development. This sort of research can help web industry in improving usability of web application during product

development. Furthermore, the research may provide an opportunity for academia to consider specific usability evaluation solutions for web industry.

1.2 Purpose

The purpose of this thesis is to investigate and propose an appropriate web usability evaluation method during product development. The proposed method will be based partly on a literature study and partly on the email survey that we will conduct in the web industry.

1.2.1 Conceptual Map of Thesis

In Figure 1, a conceptual map of the thesis is shown. Web is the main focus in the map. The conceptual map shows that Software Quality is one of the main branch of Software Engineering field. Usability is one of the core attribute of Software Quality. There are certain usability evaluation methods (UEMs for short) for evaluating usability of software. Formative usability evaluation methods are those methods which are used during product development [3]. Among the formative usability evaluation methods which method could be the appropriate choice?

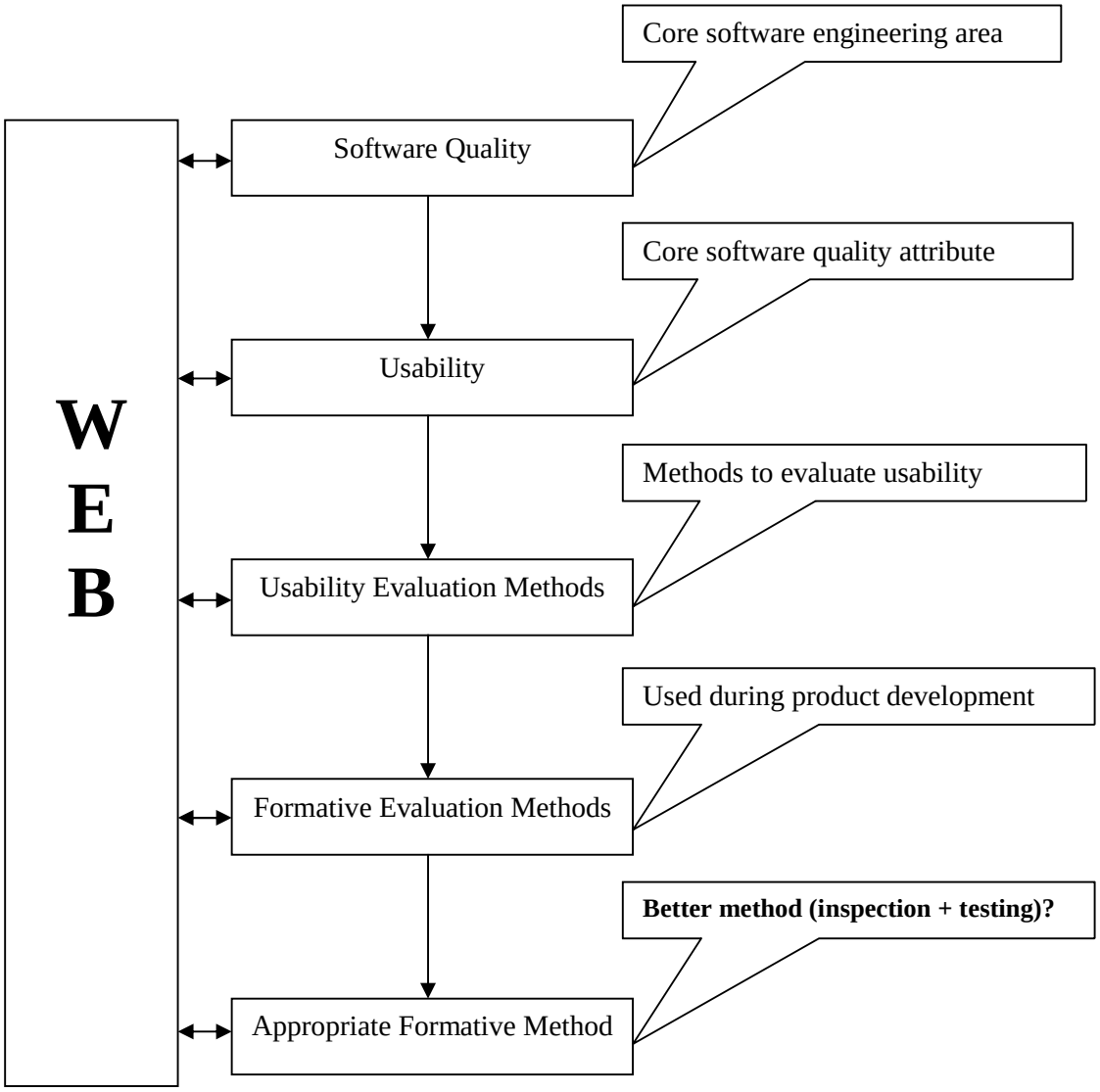


Figure 1: Thesis Conceptual Map

1.3 Aims and Objectives

The aim of this thesis is to find out the best solution for evaluating usability of websites during product development. By the best solution for evaluating web usability, we refer to a usability evaluation method which is in line with the CARE methodology (See Section 7.1), and which will be composed of one usability inspection method and one usability testing method (See Section 5 for definitions').

The objectives of the thesis are as follows.

1. Identifying and understanding of important standards related to software usability
2. Investigation into the classification of UEMs in literature.
3. Investigating current practices of usability evaluation methods (UEMs) in web industry
4. Analysis and comparison of formative web usability evaluation methods

We will achieve the aforementioned objectives stepwise. In order to compare formative usability evaluation methods for the web industry, we need the knowledge of proposed UEMs in literature. Furthermore, studying UEMs requires good understanding of the software usability concept. We also need to know which UEMs are commonly found in literature and the web industry. One will achieve a better understanding of software usability by studying its standards and models.

1.4 Research questions

Our research questions are as follows.

1. What are the important models and standards related to software usability?
2. How are usability evaluation methods categorized in literature?
3. What usability evaluation methods are practiced in web industry during product development?
4. Which web usability evaluation method can be easily and effectively deployable in industry during product development stage?

Note that the last question is the primary concern in this thesis.

1.5 Expected outcomes

Expected outcome of the research paper will be a report that will contain

- An understanding and an explanation of usability evaluation methods
- A proposed conceptual usability evaluation process model, derived from the classification of UEMs in literature
- A rating email survey results, proposing an appropriate web usability evaluation method for web industry during the product development stage

1.6 Research Methodology

Both quantitative and qualitative research methods will be used in our work. Three basic research methods would be used. They are literature study, email survey and rating email survey. A comprehensive literature study will be carried out by gathering material related to software usability in general and usability evaluation methods in particular.

Questionnaire method will be used in email survey for data collection, in order to inquire practices of usability evaluation methods in web industry during product development stage. In the end a rating email survey will be carried out on the same web industry from which data regarding usability evaluation methods will be collected. Hundred dollar test method [85] would be used in rating email survey. The result of rating email survey will provide authors' with appropriate usability evaluation method for web industry.

2 USABILITY

This chapter provides an overview of software usability. It is important to understand the concept of software usability in order to understand usability evaluation methods.

Most software developers are not well educated in usability [11]. During last few decades' usability has gained attention from wide range researchers especially from software engineering (SE) community and human computer interaction (HCI) community [37]. In particular Jackob Nielson [2,4] posed his statement that good usability can be achieved with low cost. It is similar to many other software engineering terms in a sense that it has many definitions. The term Usability was originally derived from the term "user friendly" [7]. The concept of usability is not an easy one to express [19]. It is used in many different contexts such as execution time, performance, user satisfaction and ease of learning, taken together [5, 18]. It is also used in the context of products like consumer electronics, or in the areas of communication and knowledge transfer objects (online help, book). It can also refer to the efficient design of mechanical objects such as a hammer or door lock [5, 18].

The thesis concerns with software usability (See table 1).Simply usability means that those persons who use a product, such as a software application, can learn it quickly and use it easily to accomplish the tasks they set out to do [24]. Usability enables workers to concentrate on their tasks, rather than on the tools they use to perform their tasks [24].
Usability applies to every aspect of a product with which a person interacts [24]. It includes hardware, software, menus, icons, messages, documentation, training, and on-line help etc. Every design and development decision made throughout the product cycle has an impact on that product's usability [24].

A usable product [24] is one that

- Is easy to learn
- Is efficient to use
- Provides quick recovery from errors
- Is easy to remember
- Is enjoyable to use
- Is visually pleasing

Usability has not been defined homogeneously, either by the researchers or by the standardization bodies [5]. Table 1 shows the definitions' of usability, defined differently by three distinct standards.

Table 1: Usability definitions' according to three different standards

Usability Definitions'
• "The capability of the software product to be understood learned, used and attractive to the user, when used under specified conditions." (ISO/IEC 9126-1, 2000)
• "The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use." (ISO9241-11, 1998)
• "The ease with which a user can learn to operate, prepares inputs for, and interprets outputs of a system or component." (IEEE Std.610.12-1990)

The first two definitions' in Table1 highly stresses on specified condition and context of use. It refers to the environment where a product is going to be used.

2.1 Usability Background

History of usability can be traced back to the Second World War where it emerged as a result of the intensive research into and use of more advanced technology [20]. It was realized that the adaptation of machines to the human operator increased human-machine reaction, speed and performance [20]. The science soon spread into the field of telecommunications and finally computers [20]. Today usability became an integral concern of all major businesses of world.

Traditionally, usability has been considered important in the professional field due to reasons that range from safety, to annoyance, frustration, and factors of an economic nature that may involve productivity or the sale of products [21]. Today following the mass introduction of the personal computer and software into the home concepts such as "user friendly" has become part of everyday language [21].

2.1.1 Hardware and Software Usability

It is important to know the difference between hardware usability and software usability. Table 2 summarizes the difference between the hardware and software usability. The common concern of both hardware and software usability is ease of use for the users.

Table 2: Hardware usability Vs Software usability

Hardware Usability	Software Usability
The main hardware usability features are volume, weight, cost, etc [22].	The main software usability features indicate the GUI (Graphical User Interface) with its operatability and structure, etc [22].

2.1.2 Iterative Human-Centric Design

According to ISO 13407, iteration is a key principle in usability engineering for usability evaluation. The cycle of analysis, design, implementation and evaluation is continued until the iterative design has reached its usability objectives. Evaluation is an essential step in human-centered design and should take place at all stages in system life cycle. It is important to start evaluation as early as possible, because changes become more expensive to implement as design and functionality [7]. Figure 2 briefs the activities involved during iterative human centric design.

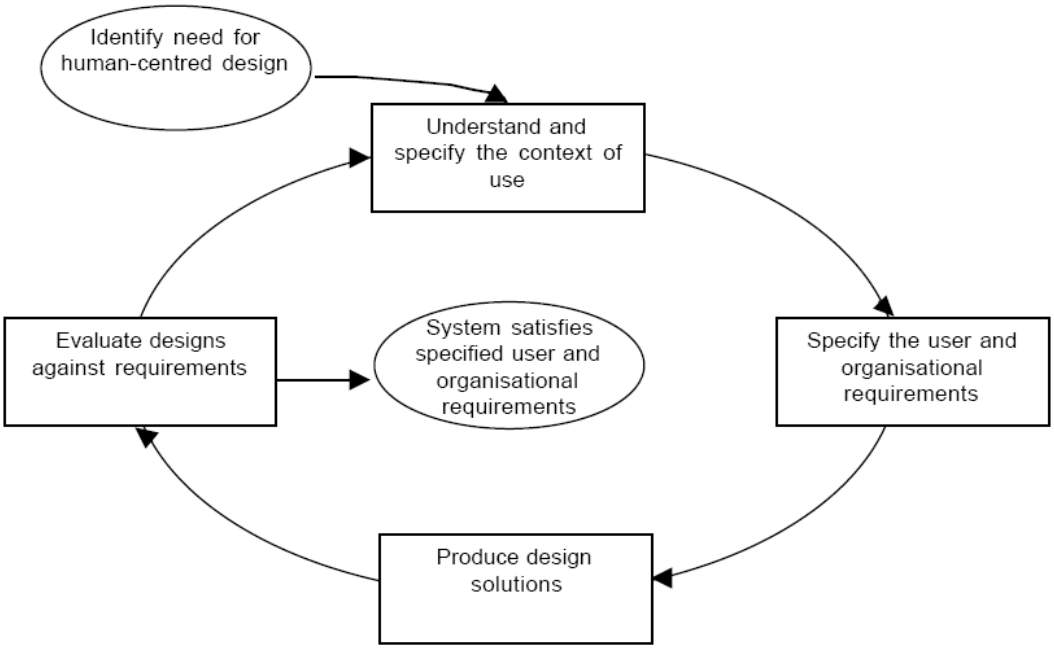


Figure 2: Iterative Human Centric Design Activities (ISO 13407)

2.2 ISO Models on Usability

According to the ISO Standard there are three basic view points regarding quality i.e. User View point, Developer View point, and Managers View point. Users always focus on the external dimension of the quality which is quality in use and consider the run time quality of a software product. On the other hand managers and developers focuses on the internal quality of the software product which includes maintainability, cost effectiveness, portability etc. for web sites. The evaluation has been done keeping the user's view point, which is external quality. Usability comes under external quality domain because it is measured according to thinking of users. It is also a non functional requirement of the software product.

Only a few software quality models have been designed to address usability aspects in a detailed and structured way [5]. The major problem with the definition of usability is that it is very difficult to specify characteristics and its attributes that should be considered particular. The nature of the characteristics and required attributes depend on the context in which the product is used [5].

The ISO has made standards related to usability but these standards do not support all aspects of usability and they are not well integrated into current software engineering practices due to lack of support [5].

The two major ISO standards related to usability are

- ISO 9126 -1
- ISO 9241-11

The definitions of both standards are written in table 1. Both standards are explained below.

2.2.1 ISO 9126-1 Quality Model

ISO 9126-1 defines a quality model that describes six categories of software quality which are relevant during product development. They are functionality, reliability, usability, efficiency, maintainability and portability (See Fig 3).

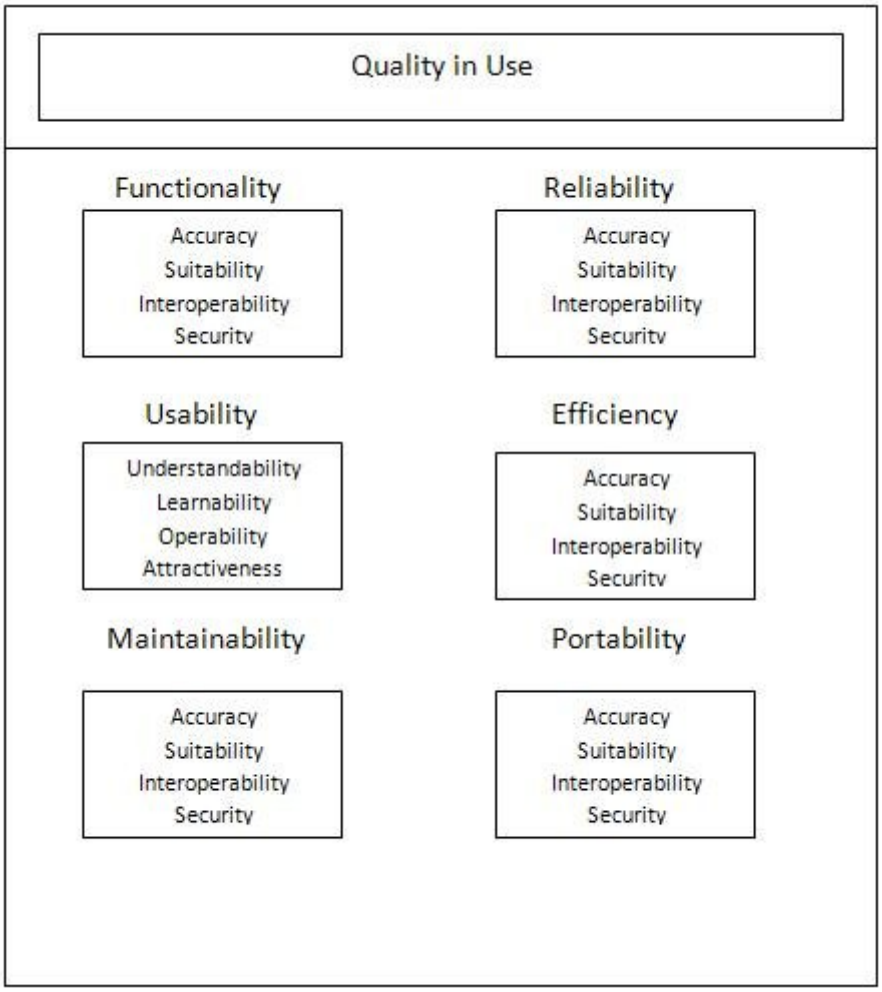


Figure 3: Software quality characteristics according to ISO 9126-1 [7].

There are four characteristics of usability according to ISO 9126-1 (See Fig 4). They are as follows.

1. Understandability
2. Operability
3. Learnability
4. Attractiveness

The characteristics are described in table 3.

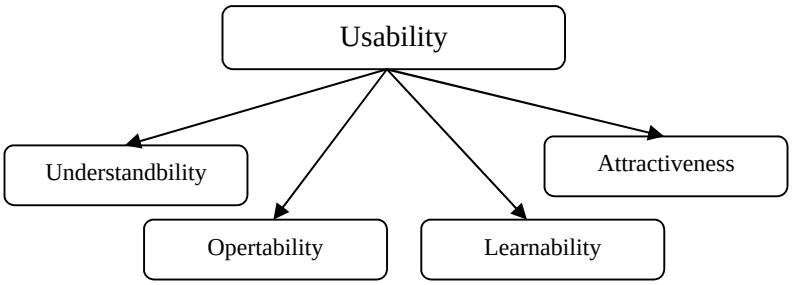


Figure 4: Usability sub-characteristics according to ISO 9126-1

Table 3: Usability characteristics according to ISO 9241-11[26].

Usability Characteristics	Description
Understandability	Does the user comprehend how to use the system easily?
Operability	Can the user learn to use the system easily?
Learnability	Can the user use the system without much effort?
Attractiveness	Does the interface look good?

2.2.2 ISO 9241-11 Guidance of Usability

ISO 9241-11 explains the benefits of measuring usability in terms of user performance and satisfaction. It emphasizes that visual display terminal usability is dependent on the context of use and that the level of usability achieved will depend on the specific circumstances in which a product is used. The context of use consists of the users, tasks and equipment [7].

1. Effectiveness
2. Efficiency
3. Satisfaction

Figure 5: Usability sub-characteristics according to ISO 9241-11 [7].

Table 4: Usability characteristics according to ISO 9241-11[25]

Usability Characteristics	Description
Effectiveness	How well do the users achieve their goals using the system?
Efficiency	What resources are consumed in order to achieve their goals?
Satisfaction	How do the users feel about their use of the system?

2.2.3 Comparison between ISO 9126-1 and ISO 9241-11

Table 5 compares ISO 9126-1 with ISO 9241-11.

Table 5: ISO 9126-1 Vs ISO 9241-11 [5]

ISO 9126-1	ISO 9241-11
Product-oriented role	Process-oriented role
Usability provides the final goal	Usability is part of a detailed software design activity
It is a component of software quality	It is a design objective
Adopted by Japan	Adopted by European Union

2.3 J.Nielsen Definition of Usability

Despite ISO standards and definitions' on usability, Jakob Nielsen's (Web Usability Guru, New York Times) definition on usability is widely accepted among usability experts [4, 32]. His definition also is very appropriate when it comes to web usability evaluation.

According to Nielson's definition, usability refers to following five components. They are as follows [6].

1. **Learnability**

The system is easy to learn. Novice users are able to complete basic tasks in a short period of time, with a minimum of training.

2. **Efficiency**

Experienced users are able to reach a steady state of productivity.

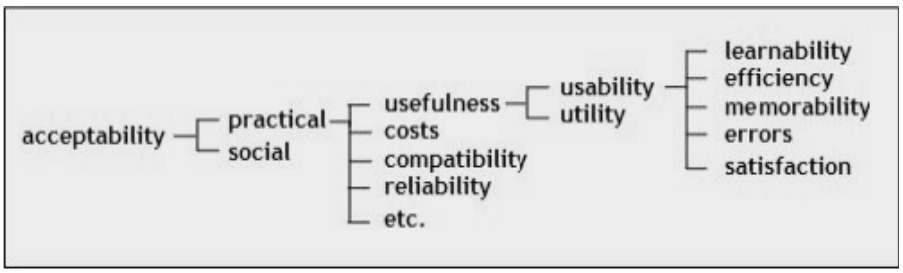


Figure 6: Jakob Nielsen's Definition of Usability [7].

3. **Memerobility**

The system is easy to remember. Users can return to it after an absence and complete tasks without retraining.

4. **Few Errors**

Users experience few errors while using the system, and recover quickly from errors.

5. **Users' Satisfaction**

The system is pleasant to use.

2.4 Benefits of Usability

Usability offers all development organizations a number of benefits. The beneficiaries of usability are not just end-users; organizations that develop software and Internet applications also benefits significantly from usability engineering.

According to Xerox company document [24] usability provides important benefits in terms of cost, product quality and customer satisfaction. Some of the major benefits of usability are following [24].

- It can improve development productivity through more efficient design and fewer code revisions.
- It can help to eliminate over-design by emphasizing the functionality required to meet the needs of real users. Design problems can be detected earlier in the development process, saving both time and money.
- It can provide further cost savings through reduced support costs, reduced training requirements and greater user productivity.
- A usable product means more satisfied customers and a better reputation for the product and for the organization that developed it.

Today, many leading corporations such as American Airlines, Apple Computer, Eastman Kodak Company, Lotus Development Corporation, and Microsoft Corporation are incorporating usability engineering into their product development cycles [24].

2.5 Effects of User Characteristics on Usability

Usability is affected by users' characteristics [1]. Figure 7 shows five main characteristics which effect usability of product. Among these five characteristics experience is relatively dynamic characteristic and it enhances more with the passage of time [1].

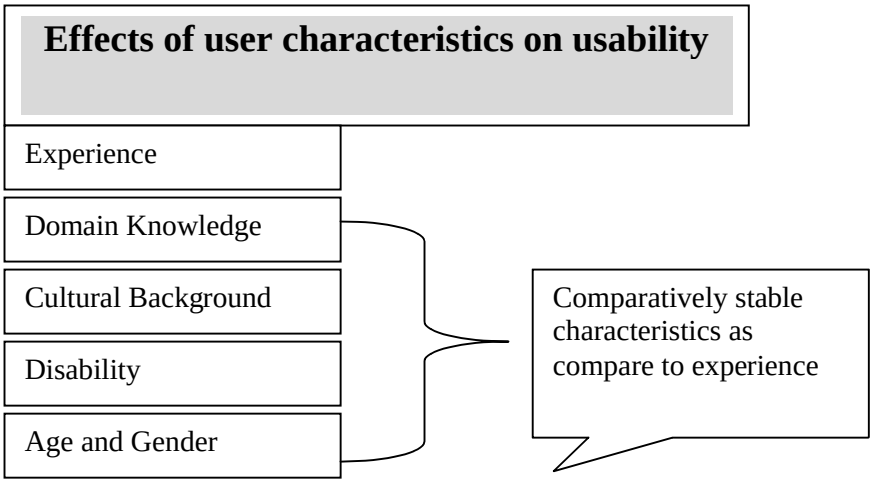


Figure 7: Effects of user characteristics on usability [1]

3 WEB USABILITY

This chapter is about web usability. The chapter describes the concept of web usability by highlighting related work done in the field.

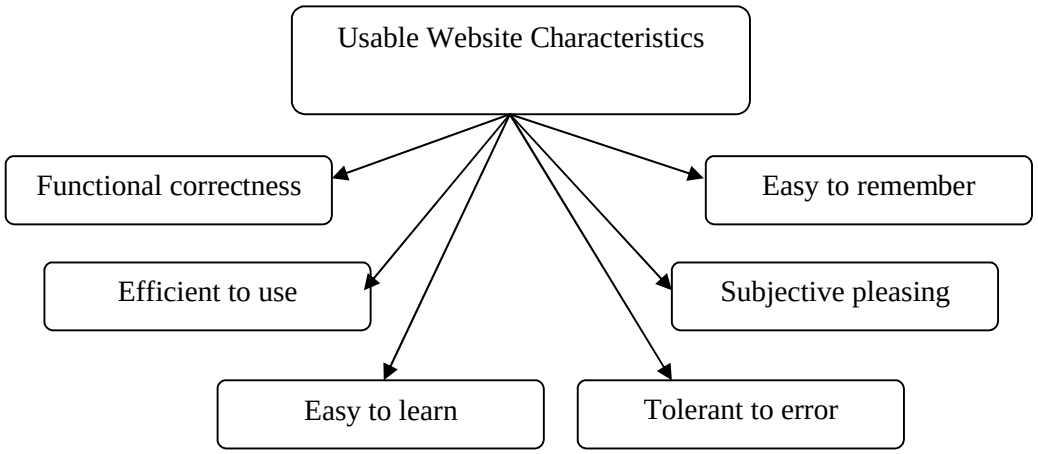
Paraphrasing the definition of usability supplied by ISO 9241, web usability is the efficient, effective and satisfying completion of a specified task by any web user [5].

3.1 Related Work

Creating a usable website is not a trivial task. T.Brinck, D. Gergle, and S. D. Wood [10], outlines the detail systematic process for creating usable websites. They present their expertise gained through years of web usability and web design projects and practices. In their book [10], they have given the concept of pervasive usability which says that usability can be factored into every stage of the web site design process. According to [10], usable website is a one that allow users to accomplish their goals quickly, efficiently, and easily. According to them [10], characteristics (See Figure 8) of a usable website include following factors.

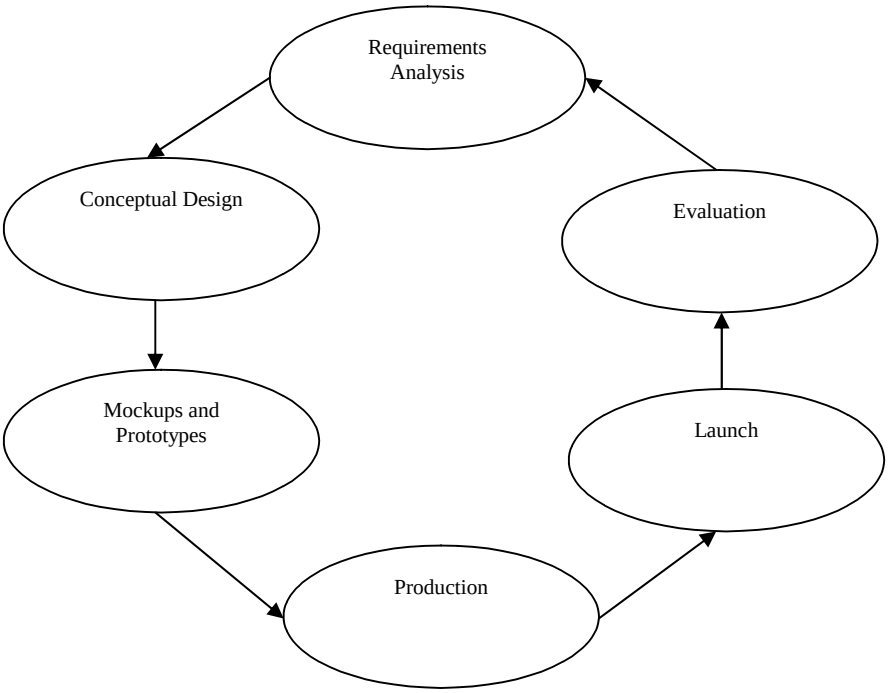
- Functional correctness
- Efficient to use
- Easy to learn
- Easy to remember
- Tolerant of error
- Subjectively pleasing

It is possible that these factors sometimes might be conflicting.
T.Brinck and his team [10] agree with K. Guenther [28] that, a website might be very functional, but it might not be aesthetically pleasing.



Figur 8: Characteristics of a Usable Website

According to [10], the iterative web site design process has six main phases. They are shown in Fig 9.



Figur 9: Web Design Process Phases

T.Brinks and his team [10] describe three types of web usability evaluation methods. They are

- Usability inspection
- Group walk through
- User testing

Usability inspection and User testing has been explained in Section 5. Group walk through is very similar to usability inspection except that the evaluation is done by a group of stakeholders [10].

K.Guenther [28] writes in his paper that "*it seems amazing how many websites score high with regard to appearance but perform poorly when it comes to usability*". The usability expert Jacob Nielsen has shown rapidly in his studies that web user skim or scan the web pages text rather than reading it [3]. Reading on web can be painful that is why Jacob Nielsen and others advocate that web does require its own style of writing, a style which facilitates scanning [28].

H. Shahizan and Li Feng [29] advocate the benchmarking approach for evaluating web usability. Benchmarking is a technique performed by an organization to compare their web site with its competitors'. According to them, usability is a broad concept covering at least seven factors. They are screen appearance, consistency, accessibility, and navigation, media use, interactivity and content. It is up to organization if it wants to benchmark all seven factors or some selected factors. Their [29] purpose of research was only to test applicability of framework. Their [29] benchmarking approach consists of eight phases. It is shown in Figure 10.

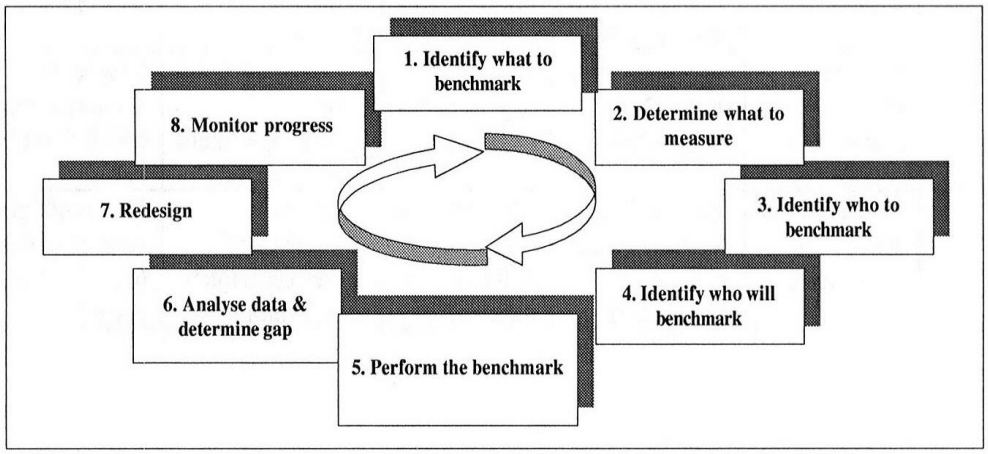


Figure 10: Eight steps to web benchmarking [29]

They [29] think that for using only one method is not adequate to access the quality of web site. Combining several approaches in web evaluation would produce better result.
Banati, Bedi and Grover [27] talk about usability pyramid. In the usability pyramid each stage should be completed before moving on to the higher stage. A website, which does not satisfy the bottom conditions, can not proceed to upper stage. According to them [27], usability cannot be achieved in a single step. It needs repeated iterations to evolve a usable website. According to them [27], human aspect needs to be stressed as user plays a central role in usability. Their point of view is that since usability is a phenomenon which is closely related to the user behavior and attitude towards a website, so it is imperative that the users' perceptions should be considered while measuring usability. They describe four-tier approach (Usability Pyramid) to improve usability from the user viewpoint. Four tier usability pyramids is shown in Fig 11. Each of the tiers considers the human dimension of the user's attitude towards the website.

Figure 11: Usability Pyramid for Websites

In [27] they, propose the following list of criteria to measure usability besides Efficiency, Effectiveness, Learnability and Memerobility

- Appearance of the site
- Work satisfaction
- Emotional satisfaction
- State of features
- Trustworthiness of the site

Marsico and Levialdi [30] mention three approaches currently used for evaluating web usability. They are questionnaire, behavior assessment techniques and automatic tools examine.
K.Guenther [31] advocates engaging users' early one. He says that although web usability has a significant priority for web development but there are very few organizations who take time to formally test usability or engage potential users early enough in development stage of project. He also writes that usability testing does not need to be sophisticated or expensive in order to be successful.
E.Folmer and J.Bosch say that most usability issues do not depend on the interface but on functionality [7].

Some Researches have proposed [73] the basic framework for cost-justifying usability engineering on Web development projects.

A group of researchers [68] have done initial investigation into the website needs of the Human Computer Interaction (HCI) community. Their research provides useful guidance for website designers and developers for creating usable websites [68].

Human Factors International, Inc. (HFI) claims to be world leader in user-centered design [90]. They offer a complete usability suit, consulting, training, and products to help customers in creating intuitive, easy-to-use Web sites and applications [90]. They have made 10 principles of web usability (See Appendix 3).

There is a Web Usability Testing Institute in University WISCONSIN-STOUT USA. They have made a good checklist for web usability evaluation (See Appendix 4).

3.2 Websites Types and Usability

On the basis to purpose and functionality websites can be categorized into three categories. They are

- Information oriented websites
- Service Oriented websites
- Business oriented websites

Each type of website has its own design rules and design needs [93]. It would have been an extensive investigation to find appropriate usability evaluation method for each type of website. Due to this reason this thesis is only focusing on web development in general.
Furthermore, we are of the opinion that it is a less professional approach to find appropriate usability evaluation method for specific type of website without finding appropriate usability evaluating method for all general websites.
We are interested in finding usability evaluation method appropriate for web applications generally during its product development stage. Finding appropriate web usability evaluation method for E commerce website or Information oriented websites can be secondary research to our thesis.

4 USABILITY EVALUATION METHODS AND CLASSIFICATION

4.1 History

The usability evaluation methods are as old as the term usability is. Before 1989 usability evaluation process is thought to be an expensive process. In 1989 Jacob Nielson presented his revolutionary research paper 'Discount Usability Methods', which latter known as 'Guerilla HCI' [88]. In his paper Nielson argued that good usability can be achieved with little recourses. He has developed many usability methods specially usability inspection methods during nineties.
Many of usability evaluation methods have their roots in psychology [1]. Examples are experiments, questioners, interviews and incident diaries etc. Some methods have been adapted for marketing. Examples are focus group and workshops etc. Some methods are specifically developed for usability evaluation. Examples are co-discovery method, cognitive walkthroughs and logging.

4.2 Interface Design and Usability Evaluation Methods

The interface design and evaluation have the same relationship what body has with head. Without evaluation it is not possible to produce a professional interface design. The relationship between usable design, usability evaluation and usability evaluation methods is shown in Figure 12. The diagram shows that for making a good usable interface design, evaluation is needed and evaluation process is guided by UEMs. The better the usability evaluation method selected, better will be the software design and overall project.

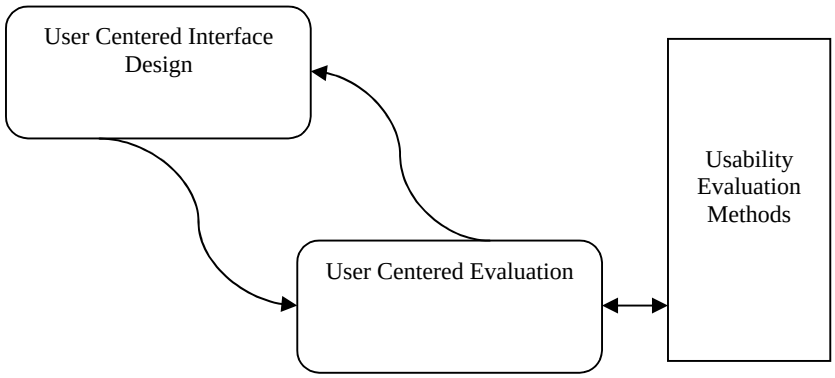


Figure 12: Relationship between interface design, evaluation and UEMs

There are various usability evaluation methods. Each has its own pros and cons. The selection of methods depends on number of factors. *"The selection of usability evaluation methods (UEMs) to determine usability problems is influenced by time, cost, efficiency, effectiveness, and ease of application [92]".* The whole design and evaluation can not be relied on single evaluation method. The combination of method is beneficial [38]. Christine E. Wania [38] says that every situation must be assessed individually in order to determine which UEM method to apply.

4.2.1 Interface Design Types

In order to know software evaluation concept, it is very important to know the interface design types. Design types have evolved over the past few decades. They can be categorized into three generations. First generation design methods which are also known as product oriented design methods focused on systems theory and software engineering [39]. Second generation design methods which are also know as process oriented design methods developed in 1970's, focused on user participation, communication and democracy in the design process [39]. Third generation methods which are also known as use oriented design methods focus on the actual use situation and assess the quality in use of the designed system [39]. The concept of participation and evaluation finds its self an integral part of software design industry.
Popular software design methods among the HCI and Software Engineering (SE) community are participatory design, user-centered design, and interaction design.

4.2.2 Participatory design

There are many views' about participatory design method (PD), but the common focus of each approach is on user's active participation and cooperation with designers in the design process [38]. According to Kyng [40] participatory design (PD) method is a way for users and designers to apply their knowledge and experience in designing computer systems. Europe started using participatory design (PD) method in early 1970's [41]. North America started using PD in late 1980's [42]. The Scandinavian approach to participatory design stresses on the importance of active, creative, participation of potential end-users in the design process [43].

4.2.3 User-Centered Design

Donald Norman states in his book *The Design of Everyday Things* [44] that "user-centered design (UCD) is a philosophy based on the needs and interests of the user, with an emphasis on making products usable and understandable". According to Preece, Rogers and Sharp [45] UCD is an approach that focuses on users and their goals, not just technology. The users and their goals are the driving forces behind the development of a product [45]. Christine E. Wania [38] states that PD and UCD are two similar approaches to design that are often confused but Carroll [46] point out that in many UCD approaches users are involved but not as full participants.

4.2.4 Interaction Design

According to Preece, Rogers, and Sharp [45] Interaction design is a method for designing interactive products to support people in their everyday and working lives. There are three key characteristics of interaction design [38]. They are

- Focus on users
- Iteration
- Identification and documentation of specific usability and user experience goals

The usability evaluation methods are more concern with user centric design and interaction design.

4.3 Classification of Usability Evaluation Methods

There is no universally accepted classification of Usability evaluation methods (UEMs). Different usability experts have classified usability differently. Following sections describes some of the classification done by researchers and practitioners.

4.3.1 Nielsen and Molich Classification

In 1990, Nielsen and Molich [8] divided usability evaluation into four categories:

- Formal
- Automatic
- Empirical
- Inspections

Formal methods are not much used in real software development projects because the methods are tedious to apply [8]. Automatic evaluations, on the other hand are feasible only to very primitive checks [8]. Therefore, empirical testing and usability inspection forms the basis of usability evaluation in product development [8].

4.3.2 Andy Whitefield's Classification

In 1991 Andy Whitefield [4] presented a model which divides usability evaluation methods into four classes. They are Analytical Methods, User Report, Specialist Report and Observational Methods.

Analytical Methods are also known as formal methods. They are used for usability estimation purpose. These methods are used in scenarios when both user and system are not real. User report methods are also known as usability inquiry methods. They are used for feedback purpose. Specialist Methods are also known as usability inspection methods. They are used in a scenario when system is real and users are absent. Observational Methods are also known as usability testing methods. They are used in a scenario when real users and real system are present. These methods are though to most effective and indispensable [1, 2].

Figure 13 shows a derived form of A. Whitefield classification of UEM according to thesis design. Block a represents the original model and block b is derived version.

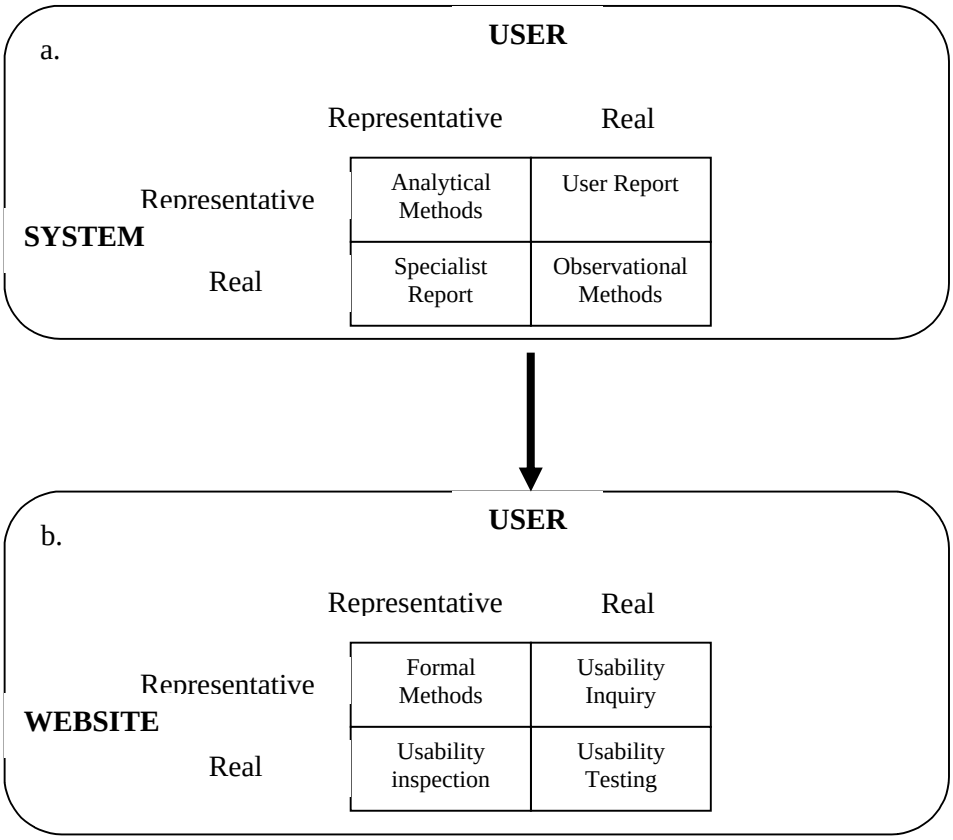


Figure 13: Derived A. Whitefield Model showing Classes of UEMs [4].

4.3.3 Adelman and Riedel Classification

Adelman and Riedel [33] identified three types of usability evaluation methods:

- Heuristic
- Subjective
- Empirical

Figure 14 shows the diagram of Adelam and Riedel classification of usability methods.

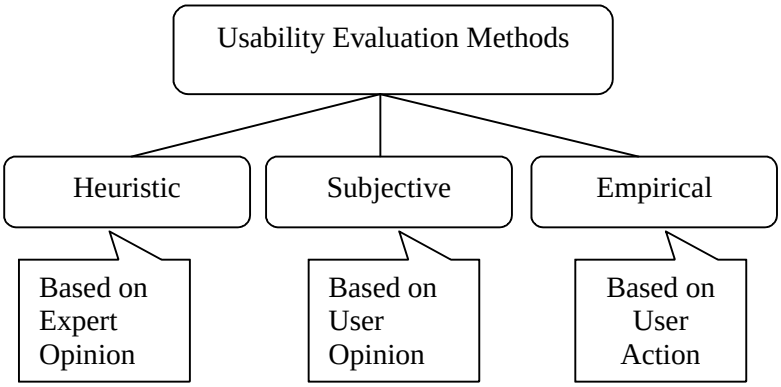


Figure 14: UEMs classification according to Adelman and Riedel [33].

4.3.4 Wixon and Wilson Classification

Wixon and Wilson studied usability methods in general. They name five dimensions that characterize the methods: They are summarized below [8]:

- **Formative vs. summative methods:** Formative methods are used to generate new ideas, whereas summative methods are used to evaluate existing systems.
- **Discovery methods vs. decision methods:** Discovery methods are sometimes also called qualitative methods. They are used to discover how users work, behave or think and what problems they have. Decision methods are used in selecting a design among several alternatives or in picking elements of interface designs. These methods are sometimes called quantitative methods.
- **Formalized methods vs. informal method:** Many methods have been described formally, but in practice, the evaluators adapt the methods to their needs, i.e., use them informally.
- **Users are involved vs. users are not involved:** Usability methods differ in the extent to which users are involved in evaluation, analysis and design.
- **Complete methods vs. component methods:** Some methods cover all the steps needed to complete the usability design effort. Usability engineering as a whole is a complete method. Most methods are component methods, so they represent only a part of a complete usability process.

S. Riihiaho [8] has mapped (Table 6) some of usability evaluation methods according to Wixon and Wilson Classification.

Table 6: Mapped methods according to Wixon and Wilson Classification [8].

Method	Formative / summative	Discovery/ decision	Formal/ informal	Users involved/ not	Complete/ component
Thinking aloud	formative	discovery	quite informal	involved	component
Heuristic evaluation and guideline reviews	summative	discovery (decision if problems ranked)	quite formal	not	complete
Pluralistic usability walkthrough	mainly summative	discovery (decision if empirical ratings added)	quite formal	involved	complete
Consistency and standards inspection	summative	discovery	formal (also some informal)	not	complete
Cognitive walkthrough	formative	discovery	very formal	not	complete
Formal usability inspection	summative	discovery	formal	not	complete
Feature inspection	formative	discovery	formal	involved	complete

4.3.5 Y. Ivory and M. A. Hearst Classification

Y. Ivory and M. A. Hearst [71], researchers from University of California divided usability evaluation methods in much detail manner. (See Fig 15)

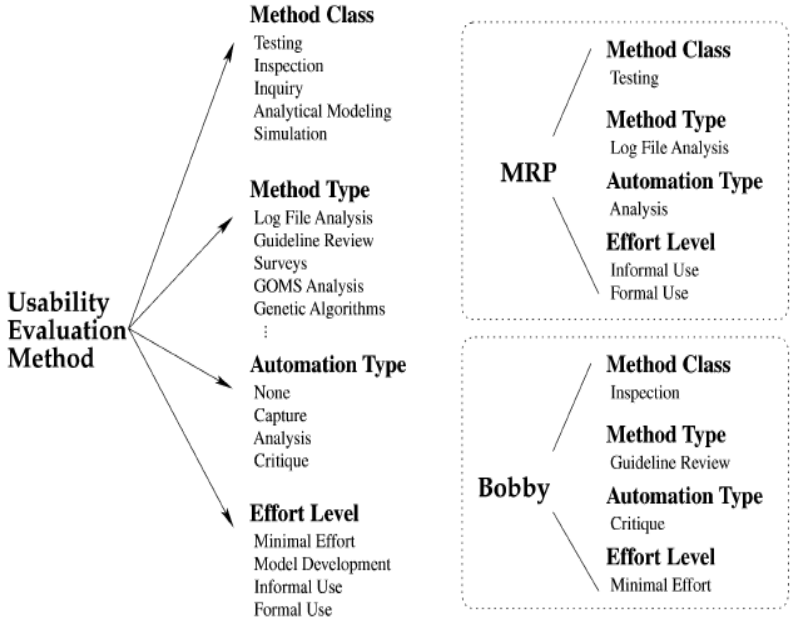


Figure 15: UEMs classification according to Y. Ivory and M. A. Hearst [71].

4.3.6 On the basis of product development

There are three stages of product development.

- Product before development
- Product during development
- Product after development

On the basis of purpose and product development usability evaluation methods can be categorized into two main types [3, 47]. They are

- Summative evaluation methods
- Formative evaluation methods

Summative usability evaluation methods (SEMs) are used before and after product development. These methods are used to assess overall quality of a finished interface. Comparison of alternative designs and testing of definite performance requirements are the main focus of SEMs. Formative evaluation methods (FEMs) are used during product development. These methods help in improving interface design. Qualitative observations of what happened and why something went wrong is the main focus of FEMs. In other words formative UEMs are associated with qualitative usability data for example usability problem identification [76]. The qualitative usability data is very vital for usability engineers, managers and marketing people in order to identify convergence of a design to an acceptable level of usability and to decide when to stop iterating the development process [76]. Some researchers and practitioners [76] have gone so far in favor of FEMs that they consider UEMs only about qualitative usability data. The focus of this thesis is formative usability evaluation methods. The role of usability evaluator is very important during usability evaluation process. Authors' have mapped the role of evaluators with the classification of usability evaluation methods in fig 16.

In figure 16, three product development process stages are shown. Before and after the product development summative usability evaluation methods are used and usability inquiry is the main method for evaluating usability in this stage. Before product development requirement engineers gather requirements for the product and they interact with users for this purpose. They normally use inquiry methods such as field observation, focus group, pro active field study, interviews and questionnaire etc. After the product is developed and released in market the user becomes the primary actor for evaluation the usability of a product. Mostly questionnaire method is used for giving feedback regarding usability of system. Web-based user interface evaluation with Questionnaires is popular means of evaluating usability of a product's next release. N. Claridge and J.Kirakowski [35] have made a questionnaire tool called WAMMI (Website Analysis and Measurement Inventory) for evaluating websites from users' feedback. SUMI (Software Usability Measurement Inventory) another web based questionnaire method [36] has been used for measuring software quality from the end user's point of view. During product development usability experts should evaluates the usability of a product. They use usability inspection and usability testing methods. The usability experts also work with summative usability evaluations but there they work as secondary actors.

We have drawn a model for classification of UEMs and named it as Conceptual Visualization of Usability Evaluation Process (See Fig 16). In it, three primary actors are mapped with three stages of product development (keeping web as a product in mind). They are Usability Evaluators, Requirement Engineers and Users. Primary actor in usability evaluation is a person who directly observes and reports usability problems. A person who uses UEM's to evaluate the usability of interaction design is known as usability evaluator [76]. The model has been drawn in order to assist author's research. The classification in the model best suits the research of this thesis.

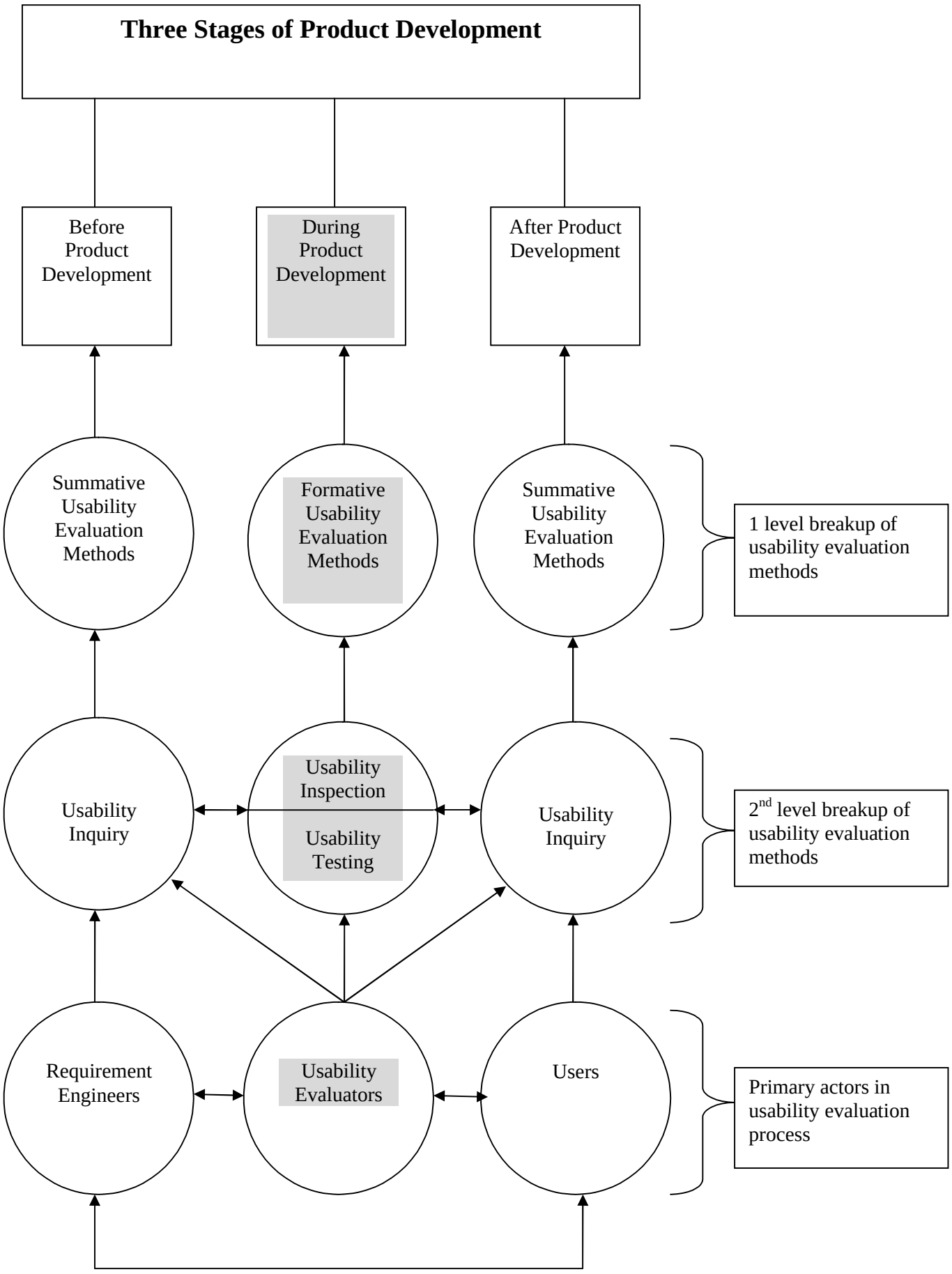


Figure 16: Conceptual Visualization of Usability Evaluation Process

Since the model (Figure 16) is a conceptual one and is only drawn to provide authors with clear direction of moving forward with their research there is neither a need nor desire to validate this model. Furthermore, we are of the opinion that validation of this model will not contribute anything related to aim and objectives of our thesis. It can be a secondary research to validate this model in web industry, e.g. if web development companies start taking interest in the drawn model.

5 USABILITY INSPECTION AND USABILITY TESTING

This chapter is about usability inspection and usability testing methods. The UEMs which were found common in literature and web industry are briefed.

5.1 Usability Inspection Methods

Usability inspection is the generic name for a set of evaluation methods in which skilled evaluators examine a user interface for finding usability problems [48]. It is a way of evaluating user interface designs cheaper because testing with users is costly in terms of time and resources [48].

5.1.1 Related Work

T.Hollingsed and D.Novick [9] throws light on the experience and practices of four important usability inspection methods. According to them [9], Heuristic evaluation and the cognitive walkthrough appear to be the most actively used and researched techniques. The pluralistic walkthrough remains a recognized technique but it is not the subject of significant further study. Formal usability inspections appear to have been incorporated into other techniques or largely abandoned in practice.

According to J. McKirdy [50], one of the main problems in software development practice is that both the development and evaluation of user interfaces (UI) are most often done by developers, who are in general not dedicated usability experts. M. Schmettow [51] thinks that Pattern Based Usability Inspection Method is appropriate for developers.

Z. Zhang, V. Basili, and B.Shneiderman [52] considers current usability inspection techniques rather ineffective. They challenged Heuristic evaluation method (HE) which is considered by many researchers and practitioners' most effective usability evaluation method. They compared Perspective-based Usability Inspection method (PUIM) with HE and concluded PUIM better one.

Karat [2] has done a general comparison of usability testing and usability inspection method. He mentions trade offs regarding inspection methods. According to him usability inspection methods may be compared according to the following set of possible differences [2].

- Method employs individuals or teams
- Evaluator expertise
- Prescribed tasks versus self guided exploration
- Utility of guidelines
- Data collection and analysis
- Generation of recommendations
- Role of debriefing session

A group of researchers [53] have developed MiLE (Milano-Lugano Evaluation method) for web usability evaluation. It is the blend of Heuristic Evaluation (HE) and task-driven techniques.
Another group of researchers [54] challenged the Heuristic Evaluation method. They valued SUE (Systematic Usability Evaluation) a novel usability inspection technique in comparison with HE [54].

Roger A. Grice [75] had done a comparison of usability inspection methods and concluded that the combination of UEMs results in greater impact on assessing and improving the usability of a product.

Table 7: Checklist by Brinck [10]

Web Usability Inspection Checklist	
1	Page layouts are consistent throughout the site.
2	Page titles are consistent with link names.
3	All headers have consistent syntax, capitalization, and punctuation.
4	Bullets are the same style throughout the site.
5	Images receive the same stylistic treatment throughout the site.
6	Logos all conform to strict corporate standards without variation.
7	Link colors do not vary from page to page.
8	Link colors are consistent with web conventions.

Brinck [10] advocates a checklist shown in table 7 as a part of web usability inspection.

We have identified following seven usability inspection methods in literature study [72, 79].

- Heuristic evaluation
- Cognitive Walkthroughs
- Formal Usability Inspections
- Pluralistic Walkthroughs
- Feature Inspection
- Consistency Inspection
- Standards Inspection

From the author's questionnaire report (See Section 6), it was found that web industry has the practical experience with following four usability inspection methods.

- Heuristic Evaluation (HE)
- Cognitive Walkthrough (CW)
- Pluralistic Usability Walkthrough
- Feature Inspection

5.1.2 Heuristic Evaluation

In Heuristic Evaluation (HE) the evaluators judge whether each dialogue element conforms to the heuristics or not in other word a small group of usability experts evaluate a user interface using usability principles called the heuristics [2]. It is the most commonly used usability inspection method in industry [4, 8, and 58]. It is based on experiences of Nielsen, Molich and several usability guidelines [4]. It was proposed as a substitute for empirical user testing.

After the introduction of this method, researchers began to compare the results of heuristic evaluation to the results of other methods [9]. Many researchers and practitioners consider that HE as one of the most popular inspection methods, due to its easiness, cheapness and no need for advance planning [8, 9]. One study [55] compared the four best-known usability evaluation methods empirical usability testing, heuristic evaluation, the cognitive walkthrough, and software guidelines. The study [55] found that heuristic evaluation reports more problems than any other evaluation method. The study [55, 57] also

concluded that usability testing revealed more severe problems, more recurring problems and more global problems than heuristic evaluation. Another group of researchers [56] compared HE with Cognitive Walkthrough (next section) with the condition of availability of usability experts. They found out that heuristic evaluation found more problems than a cognitive walkthrough.

Nielsen conducted number of experiments and concluded usability experts are more effective in finding usability problems than the designers. He studied in dept the role of expertise as a factor in the effectiveness of heuristic evaluation [58]. He compared evaluation results from three distinct groups of usability experts: Novice evaluators, Regular experts and Double experts. All had expertise both in usability and in the particular type of interface being evaluated. The novice evaluators have little knowledge of usability evaluation procedures, regular evaluators have sufficient knowledge of usability practices and doubles experts have good knowledge of both usability evaluation practices and domain. Nielsen [59] concluded that individual evaluators were mostly bad at doing heuristic evaluations and that they can only found between 20% and 51% of the usability problems in the interfaces they evaluated. He suggests two to three evaluators if double usability experts are employed [4]. He recommends three to five usability experts if regular usability experts are used and group of fourteen evaluators if novice experts are used [8].

According to Nielsen [2, 59] HE is composed of following five steps

- Pre-evaluation training session
- Individual evaluations
- A debriefing session if needed
- Combination of the problems into one list
- Estimation of the severity of the problems

Table 8: Advantages and Disadvantages of Heuristic Evaluation [65, 10]

Advantages	Disadvantages
Cheap	Several Evaluator experts are needed
No requirement for advanced planning	Evaluator must be experts
Can be used early in the development process	Most of issues identified by HE are minor
	Difficult to summarize the findings from multiple evaluators as different evaluators report problems differently and at different levels

5.1.3 Cognitive Walkthrough

Cognitive walkthrough (CW) is a usability inspection method that focuses on ease of learning. This method is based on theory of learning by explorations [8]. The idea behind this method is practical nature of human being. User wants to use the new system without reading manual or formal instructions. Learning by exploration is easily acceptable phenomena to most of human minds.

Wharton [60] originated this method in early nineties. The method came up several versions [8]. A group of researchers showed the need for changes in the cognitive walkthrough method because of difficulty in learning cognitive psychology terminologies by untrained analysts [61]. In [61], they revised the cognitive walkthrough method to better suite their needs and time schedule in projects. They called the revised version as cognitive jogthrough [61]. The present version of this method [60] concentrates on user's motivation to select and execute the correct sequence of actions. The versions of the cognitive walkthrough continue to be developed [62]. Marilyn H. Blackmon and his team proposed Cognitive Walkthrough for the Web (CWW) which they claim is superior for evaluating websites, support users' navigation and information search tasks.

While other usability inspection method evaluates the characteristics of the interface, cognitive walkthrough method guides the analysts to consider users' mental processes in detail [8]. The method can be used very early in design to evaluate designers' preliminary design ideas and it is not necessary to have a running version of the system or detailed layouts of displays [8].
According to Wharton [63] the process of cognitive walkthrough can be divided into following five steps.

1. Define inputs to the walkthrough.
2. Find a group of analysts.
3. Walk through the tasks.
4. Record critical information.
5. Think of ways to fix the problems.

Table 9: Advantages and Disadvantages of Cognitive Walkthrough [65]

Advantages	Disadvantages
Does not require functioning model of the product	Does not provide guidelines about what makes an action clearly available to a user
Rests on an acceptable cognitive model of user activity during the phase of exploratory learning	Does not tell what types of actions are considered by a broad range of users

5.1.4 Pluralistic Usability Walkthrough

Pluralistic Usability Walkthrough is a version of cognitive walkthrough [21]. This method involves three participants' users, developers and human factor engineers. They are asked to write their separate reports putting themselves in the place of user, using their own experience and perspective [2].

Table 10: Advantages and Disadvantages of Pluralistic Walkthrough [2, 21, 48].

Advantages	Disadvantages
Faster resolving of the usability issues	Scheduling of group can be a problem
Greater number of usability problems are identified at one time	The group can move only as quick as its slowest member
More significant in identifying problem areas of websites	If paper mock up is use to conduct pluralistic walkthrough the functionality of interface can not be completely communicated
Gives information when no prototype or previous versions of interface exist	Hard copies can prevent the user from exploring the flow of interface by browsing through it

5.1.5 Feature inspection

Feature inspection is a usability inspection method which emphasizes on the importance of functionality for achieving usability [67]. This method identifies the tasks that a user would perform with an application and the features of the application that would be used to perform those tasks [67]. After the identification of all appropriate features, each feature is evaluated for whether it is understandable, useful, and actually available to the user when needed [67].

Table 11: Advantages and Disadvantages of Feature Inspection [1].

Advantages	Disadvantages
Performs product inspection and usability inspection at a time	Can not measure usability directly
More significant in identifying problem areas of websites	Can not provide rich data about user's experience of data
Gives information when no prototype or previous versions of interface exist	Judgment and interpretation about the feature's ease of use is an extra burden for the evaluator
	Provide only broad overview of product usage

5.2 Usability Testing Methods

Unlike usability inspection methods, there is relatively little research done on usability testing methods. It seems that usability testing methods are not recognized as compare to usability inspection methods.
In usability testing users are systematically observed as they perform tasks [48]. There is no alternative of observing users directly and making notes while they perform their tasks.
Various methods of usability testing have been proposed in literature.

- Coaching Method
- Co-discovery Learning
- Performance Measurement
- Question-asking Protocol
- Remote Testing
- Retrospective Testing
- Shadowing Method
- Teaching Method
- Thinking Aloud Protocol

From the author's questionnaire report (See Section 6) it was found that web industry has the practical experience with following five usability testing methods.

- Remote Usability Testing
- Coaching Method
- Co-discovery Learning
- Performance Measurement
- Think Aloud Protocol

5.2.1 Remote Usability Testing

The idea of conducting remote usability tests emerged ten years ago [69]. It is a relatively distinct method with in other usability testing methods because user is not physically present during testing. This method becomes an ultimate choice when users and usability experts are sitting far away from each other.
Recently a group of researchers [69] have compared remote usability with conventional usability testing. They [69] concluded that remote usability testing has the potential to cross organizational and geographical boundaries and support new approaches to software development such as outsourcing, global and open source software development.

Table 12: Advantages and Disadvantages of Remote Usability Testing [70]

Advantages	Disadvantages
Comparatively cheaper	Can bring security and performance issues
Comparatively wider reach	Has limited visual feedback
	Makes more difficult to build relation and trust
	Can be difficult to use for the participant

5.2.2 Coaching Method

In Coaching Method usability expert works as a coach. Unlike other usability methods which disallow questioning, users are encouraged to ask questions from usability expert in coaching method [67]. The usability expert responds with appropriate instruction. By hearing typical user questions, problems are identified and help documentation can be designed [67].

Table 13: Advantages and Disadvantages of Coaching Method [67]

Advantages	Disadvantages
Builds the user's involvement in the evaluation	Relatively time consuming
Users learn more quickly	The coach has to do dual job i.e. coaching and evaluations

5.2.3 Co discovery method

This method involves two participants that working together and verbalize their thoughts while exploring a product's interface [1]. This method also discovers how particular tasks are done [1]. Pair of users helps each other through difficulties.

Table 14: Advantages and Disadvantages of Co Discovery Method [1]

Advantages	Disadvantages
More structured and explorative technique	Careful candidate screening is required
Good for learning aspect of usability	Verbalization can distract exploration

5.2.4 Performance Measurement

In this method the quantitative data are obtained about the test participant's performance while performing task Quantitative data is very useful in doing comparative testing, or testing against predefined benchmarks [72].

Table 15: Advantages and Disadvantages of Coaching Method [1]

Advantages	Disadvantages
Provides quantitative data	Users are needed to act naturally in unnatural environment.
Due to quantitative data the prediction is comparatively easy as compare to other UEM's	Requires rigorous test designs and extensive resource to conduct usability evaluation.
	Interaction between user and tester is prohibited

5.2.5 Think Aloud Protocol

In Think Aloud Protocol method, users are asked to speak their thoughts as they perform a task [67]. By thinking aloud while attempting to complete the task, users can explain their method of attempting to complete the task. This will clarify any difficulties they encounter in the process.

Table 16: Advantages and Disadvantages of Think Aloud Protocol Method [1]

Advantages	Disadvantages
Leads to direct design solutions	Participant has to perform two tasks. i.e. doing test and verbalizing what they are doing
Verbalization gives the answer of both what and why problem arises with interfaces	Verbalization can interrupt the task that is being performed by users

6 USABILITY EVALUATION PRACTICES IN WEB INDUSTRY

We have conducted an email survey in order to investigate which usability evaluation methods are currently being practiced by web industry during product development. Questionnaire and interviews are two primary ways of conducting a survey [77].
Questionnaire method has been used in our research for data collection. The reason for using questionnaire method is that it is considered as a well established way of conducting this kind of research [87, 88, and 91].

6.1 Questionnaire Design

The authors' designed a seven question questionnaire in Microsoft word document (See Appendix 1). The questionnaire was structured in such a way that it provided all possible answers to the evaluators. This was done in order to get quantitative data which is not possible to obtain if questions are asked without possible answer parameters. The evaluators just had to highlight the appropriate answers.

The design of questionnaire was made simple because it is said that the quality of giving answers deteriorates with the passage of certain time [89, 91]. The designed questionnaire seems to be answerable with in 20 minutes.

It is hard to motivate people to answer survey questions [91]. In [91], it is suggested that the researcher will be able to increase the motivation by clearly state that the research that is conducted will be relevant to them and furthermore, that their confidentiality will be preserved.

The interest of web industry was motivated by persuading them that the research should be relevant to them and their confidentiality will be preserved. This was done by sending them brief emails which gave them the idea of research and its purpose. By web industry we refer to selected sample of web development companies (See Section 6.2) for this research. The questionnaire technique proved to be very simple and effective. From the feedback, most of the respondents appreciated the easiness of questionnaire design.

In line with the results from [91], we have made an effort to develop neutral questions. Neutral questions help in minimizing researcher's bias [91], although researcher's biasness is one of main disadvantages of conducting survey [77].

Question one was a general one. It was designed to know whether web industry thinks that usability evaluation is important or not for web development. Question two was specific to usage of usability evaluation method. It was designed to know whether web industry is following any usability evolution method during web development. Question three and four are very specific to the needs of this thesis. Question three was designed to know familiarity of industry with usability evaluation methods. Question four was designed to figure out names of usability evaluation methods which web industry had applied or applying in their projects. Question five was designed to know, in which phases of web development companies deploy usability evaluation methods. Question six was designed to know about the primary actor who normally evaluates the usability of web application. Primary actor is a person who observes, and reports the usability problem during product development. Question seven was designed to know the major constraints in a way of usability evaluation methods becoming integral part of web development.

6.2 Demographics and Questionnaire Process

The questionnaire was send remotely to project managers of sixteen reputable web development companies through email. The companies are situated in Pakistan and Gulf region. Out of sixteen companies ten companies responded positively. From telephone interviews it was made sure that those who will actually answer the questions would be persons having at least 2 years of working experience with web design and its evaluation.
Three actors were involved in the process (See Figure 17). They are Authors', Project mangers and Web Usability Evaluators. The Questionnaire was send to Project manager who gave it to Web Usability Evaluators. Web usability evaluators were the people who had been involved in evaluating usability of web application in previous projects. At the end authors' were able to get the answers from companies prospective.

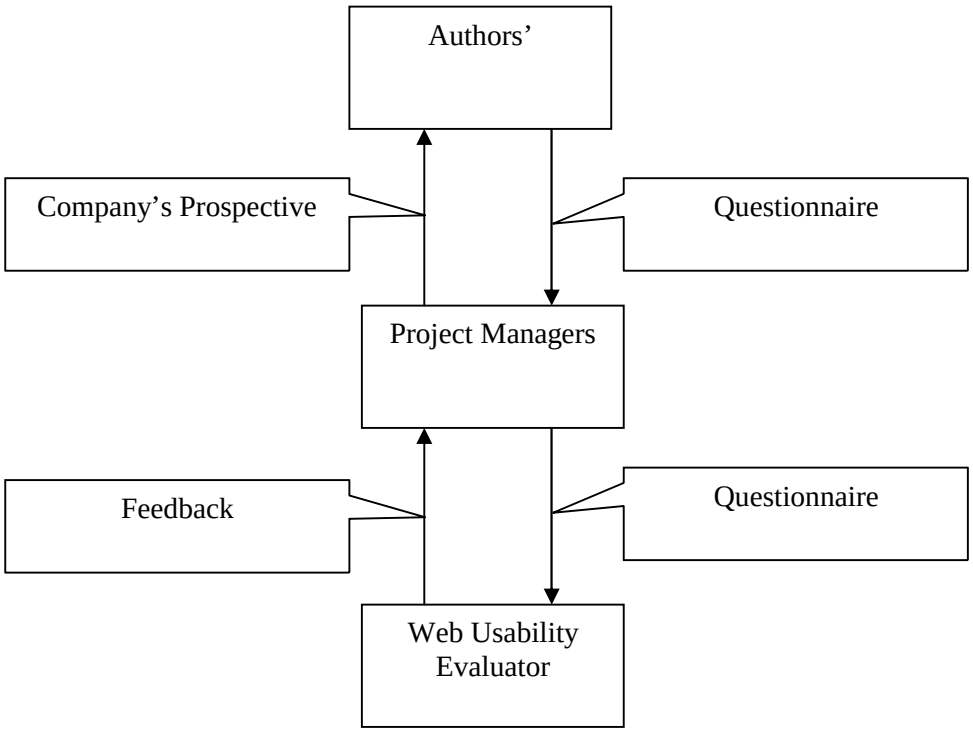


Figure 17: Questionnaire Process

6.3 Questionnaire Results

Authors' have divided the questionnaire results into three parts. They are described in tabular form in table 17, 18 and 19 respectively.
In Table 17, the questionnaire data is summarized into four factors. The seven questions questionnaire is divided into four factors. The four factors can be seen in table 17. The answers given by ten web development companies are merged into percentage conclusions. First two factors clearly shows that web industry agrees with the fact that usability is essential for web application but only 20 % of industry are using usability evaluation methods as a part of every web development project. This concludes that usability is not a common practice. If we compare factor three and factor four we will come to know that 70% of web industry are familiar with usability evaluation methods but only 40% of them have practically used any of usability evaluation method in their projects. This means that 30% of industrial personal have never used usability evaluation methods despite of its knowledge.

The results in Table 17 are concern with our general objective and that is to highlight that web industry is facing the problem of adapting usability evaluation method.

Table 17: Interpretation from questionnaire results

Factors	Yes	No
Usability Evaluation is important for web design	100%	0%
Usage of usability evaluation methods is always a part of web development project	20%	80%
Familiarity with usability evaluation methods	70%	30%
Practically worked with usability evaluation methods	40%	60%

The results of Table 18 are concern with the primary objective of this thesis. It provides the filtered list of usability evaluation methods. We have identified sixteen usability evaluation methods in literature [72, 79]. The questionnaire result ended up with nine usability evaluation methods which were found common in literature and web industry.

Table 18: UEMs practiced in web industry

Usability Inspection Methods Practiced in industry
• Heuristic Evaluation (HE) • Cognitive Walkthrough (CW) • Pluralistic Usability Walkthrough • Feature Inspection
Usability Testing Methods Practiced in industry
• Remote Usability Testing • Coaching Method • Co-discovery Learning • Performance Measurement • Think Aloud Protocol

Table 19 shows percentage of UEMs overall utilization in different phases of web development process. Most of companies use usability evaluation methods during design and testing phases. This result also provides an opportunity for future researchers' to develop new usability evaluation methods specific for analysis phase. It would be interesting research to develop some automatic mechanism for usability evaluation specifically for coding phase.

Table 19: UEMs usage in web development phases

Web development phases	UEMs usage in percentage form
Analysis	20%
Design	80%
Coding	0%
Testing	70%

There were also two secondary objectives of questionnaire (See Appendix 1). They were

- To find primary actor (See Section 4.3.6 and Appendix 1), who is responsible for usability evaluation of web applications.
- To find two major constraints (See Appendix 1) that are liable for usability evaluation method not becoming as an integral part of web development process.

From the questionnaire results, it was found that most of the web development companies are not employing any usability specialist for evaluating usability of websites. It was also found that the two major constraints in making usability evaluation method becoming an integral part of web development process are lack of usability expert and fewer resources.

6.4 Results Validation

C. Wohlin [77] has proposed four types of validations for experiments in software engineering. According to B. Kitchenham and S. Pfieeger [78], software engineering surveys are weak in the area of validity and reliability [91]. A survey is reliable if we administer it many times and get roughly the same distribution of results each time [78].

In order to check the validity of answers provided by the web development companies, the questionnaire was resend to same web development companies. Authors' changed the design of questionnaire and reshuffled some questions. This was done to make sure that companies will not be attempting the one hundred percent same questionnaire which they have attempted before. The second time reshuffled questionnaire was resend to web development companies after the gap of one week, they responded the first questionnaire. The results of first questionnaire and second questionnaire were same. There was the probability that companies might have changed their opinion but in this case it was not so.

6.4.1 Validity Threats

Some validity threats can be assessed by general assumptions. Since data was collected from remote web development companies its impossible to physically watch the conditions in the web development companies under consideration. Obviously, not all the web development companies could have the same sort of conditions and furthermore, we have no complete knowledge of the actual conditions of web development companies. The inner and outer conditions of organization can be major validity threat to our research. At the same time, the sincerity of persons involved in answering the questions is accordingly not physically observable due to the conditions of our study. Personal biasness of answering people to questionnaire can be another validity threat to our research.

7 COMPARISON OF WEB USABILITY EVALUATION METHODS WITH CARE METHODOLOGY

To best of our knowledge there is no standard criterion for comparison of UEM's. The authors' observation has been weighted by group of usability researchers and practitioners from Virginia Tech University [76], who highlighted the reasons for why it is so hard to make criteria for comparison of UEM's. According to them [76], UEM's can not be evaluated and compared reliably because of lack of standard criteria for comparisons. Their [76] observation is that it's almost impossible to do an appropriate Meta comparison of usability studies. They [76] believe that there are two reasons which contribute to the challenge of comparing UEM's. The first reason is that the field of UEMs is young as compared to social science discipline in which baseline studies are frequently performed. The baseline comparative studies are almost non existence due to youth of UEMs. The second reason is that UEMs themselves are not stable. The fact is that they continue to change because of human computer systems, their interaction components and their evaluation needs change rapidly. This change results in requirement for new kinds of UEMs and need for constant improvement and modification to existing UEMs.
According to [76], researchers' are finding it difficult to reliably compare UEMs due to lack of

- Standard definitions', measures' and metrics on which to base the criteria
- Stable, standard process for UEM evaluation and comparison

Since usability evaluation methods (UEM's) proposed in literature were analyzed with web development companies so author's now have come with total nine usability evaluation methods. Due to this reason authors' considered these nine methods as web usability evaluation methods.
The authors' strategy was to filter out two usability inspection methods and two usability testing methods. For this purpose CARE methodology has been used (See Section 7.2).

7.1 Care Methodology

CARE Methodology has been proposed by group of students from North Dakota University [74]. The methodology has been made by combination of several past usability testing methods. CARE stands for cheap, accurate, reliable and efficient method.
Authors have considered two parameters of CARE methodology in order to filter out two usability inspection methods and two usability testing methods. The two parameters are cheapness and efficiency. The reason of considering these two parameters is that, previous research [72, 73] has been done for finding out relative cheapness and relative efficiency among several UEM's. Furthermore the web projects are limited in terms of time and budget [94] so cheapness parameter seems to valid criteria. Similarly the efficient usability evaluation method will save the time. It was also one of the findings of our questionnaire report that one of major constraint in making usability evaluation method becoming an integral part of web development process is fewer resources. To best of our knowledge no research has been done to find out relative reliability and relative accuracy among UEM's. Ideally we would like to consider all four parameters of CARE methodology but it is beyond the scope of our thesis.

7.1.1 Reasons for selecting CARE

CARE methodology [74], has been selected for comparison because of following reasons.

- Relatively new research
- Specific to web usability
- IEEE publication

7.2 Comparison of UEM's on the basis of CARE

Two comparisons were done. One was among the four usability inspection methods and the other was among five usability testing methods.

7.2.1 Comparison of web usability inspection methods

The comparison of derived four web usability inspection methods in the light of previous research [72, 73] has been summarized in table 20. From the table 20 it can be seen that Heuristic Evaluation (HE) and Feature inspection are the two methods which qualifies for rating survey. The efficiency parameter has been compared earlier in previous research [72]. HE and Feature inspection are cheaper method then cognitive walkthroughs and pluralistic usability walkthrough (PUW) [9, 72]. It is because in CW and PUW, usability expert also need to have good knowledge of human psychology. Developers and novice level usability professional can adapt HE. Feature inspection work like a dual bladed sword from which usability is indirectly checked by inspecting all the features of website.

Table 20: Usability Inspection Methods Comparison

Sr.	Web Usability Inspection Methods	Relative Efficiency	Relative Cheapness
1	Heuristic Evaluation (HE)	✓	✓
2	Cognitive Walkthrough (CW)	x	x
3	Pluralistic Usability Walkthrough	x	x
4	Feature Inspection	x	✓

7.2.2 Comparison between web usability testing methods

The comparison of derived four web usability testing methods in the light of previous research [72, 73] has been summarized in table 21. The efficiency factor between these five web usability testing methods has been compared in previous research [72]. Remote usability testing is cheaper then the remaining four web usability testing methods because customer physical presence is not needed and no special lab are required. From the table 21, it can be seen that Remote usability testing and Performance measurement are two web usability testing methods which qualifies for next round of rating survey.

Table 21: Usability Testing Methods Comparison

Sr.	Web Usability Testing Methods	Relative Efficiency	Relative Cheapness
1	Remote Usability Testing	✓	✓
2	Coaching Method	x	x
3	Co-discovery Learning	x	x
4	Performance Measurement	✓	x
5	Think Aloud Protocol	x	x

7.3 Filtered list of UEM's

After the comparison (See Section 7.2), the two filtered web usability inspection methods and two web usability testing methods are following.

- Heuristic Evaluation
- Feature Inspection
- Remote Usability Testing
- Performance Measurement

7.3.1 Combination of Web UEMs

In line with the authors' strategy (See Section 7) following four UEMs have been made. Each method is composed of one usability inspection method and one usability testing method.

1. Heuristic Evaluation + Remote Usability Testing
2. Heuristic Evaluation + Performance Measurement
3. Feature Inspection + Remote Usability Testing
4. Feature Inspection + Performance Measurement

8 RATING E-MAIL SURVEY

According to a group of researchers [80], "*survey is useful when control of the independent and dependent variables is not possible or not desirable"*. They [80] further describe in their research that, in software engineering field survey usually means to poll a set of data from an event that has accorded to determine how the population will react to a particular method.
Since the field of web usability evaluation is relatively new so our research has been more exploratory rather then confirmatory. The survey was conducted because the control of the independent and dependent variable were not desirable. E-Mail survey was conducted because it was more feasible for the research as compare to interview survey.
The survey was performed in a typical way of software engineering field i.e. opinion polls of the industrial practitioners (See Section 8.1) who have the experiences with usability evaluation of web applications.
The strategy used in email survey was to combine one usability inspection method with one usability testing method (See Section 7.3.1) and use 100 Dollar test (See Section 8.2). The rating survey was conducted on the combination of web usability evaluation methods (See Section 7.3.1).

8.1 Demographics

One of the findings of questionnaire report (Section 6) was that there were seven web development companies who had the familiarity with UEMs. We decided to collect more information regarding these seven development companies in order to conduct rating email survey with more visibility. We come to know that those who have evaluated our questionnaire were all at least graduates in computer science or software engineering. Four of the company's evaluators were master degree holders while other three company's evaluators had bachelor degrees. Two of the companies evaluators had more then 5 years of experience, while remaining five companies' evaluators had experience between one to three years in web designing and evaluation.
In short average qualification of evaluators was bachelors' degree, average experience was 3 years and average age was 28 years. These seven web development companies were re-approached for rating email survey. Five companies were Pakistan based and two were from Gulf region.

8.2 Survey Method, the 100 Dollar Test

The 100 dollar [81] test method has been used in rating email survey (See Appendix 2). The 100 dollar test is commonly known as Cumulative Voting (CV). This method has been used widely in political elections [82]. Analytical Hierarchy Process (AHP) and CV are widely used techniques in software engineering for ratio scale requirement prioritization. The Hundred Dollar has not been reported as popular as Analytical Hierarchy Process (AHP), but its usage has been increased during last few years especially in the area of software requirement prioritization [83] and prioritization of process improvement [84].
By ratio scale prioritization, appropriate UEM can be proposed. The 100 Dollar Test and AHP are the two main choices for ratio scale prioritization. The 100 dollar Test has been used in research because it seemed more feasible then AHP. The comparison between AHP and CV on the basis of results has shown [85] that CV is much easier to apply, faster, providing more accurate results, more scalable and considered overall better then AHP. Another reason for using it was that the research was intended to figure out the opinion of the small sample of web industry (Section 8.1) regarding most appropriate combination of

usability evolution method during product development. For small sample, The Hundred Dollar test is a better choice.
In 100 dollar test, users are asked to distribute 100 points among the various choices. From the combined opinion, ratio scale result is obtained. In our case it was four combinations of usability evaluation methods. The web usability evaluators were asked to distribute 100 points among four UEMs (Section 7.3.1).
Figure 18 shows diagram of overall research. UEMs were identified from literature and compared its practice in web industry. Filtration among selected web UEMs was done on the basis of CARE methodology (See Section 7.2). The filtered web UEMs formed the basis of a good rating email survey. Rating email survey provided our research with appropriate web UEM according to opinion of web industry. Note that the double arrow between the UEMs and Web Industrial Practices represents the comparison of UEMs in literature with Web Industry.

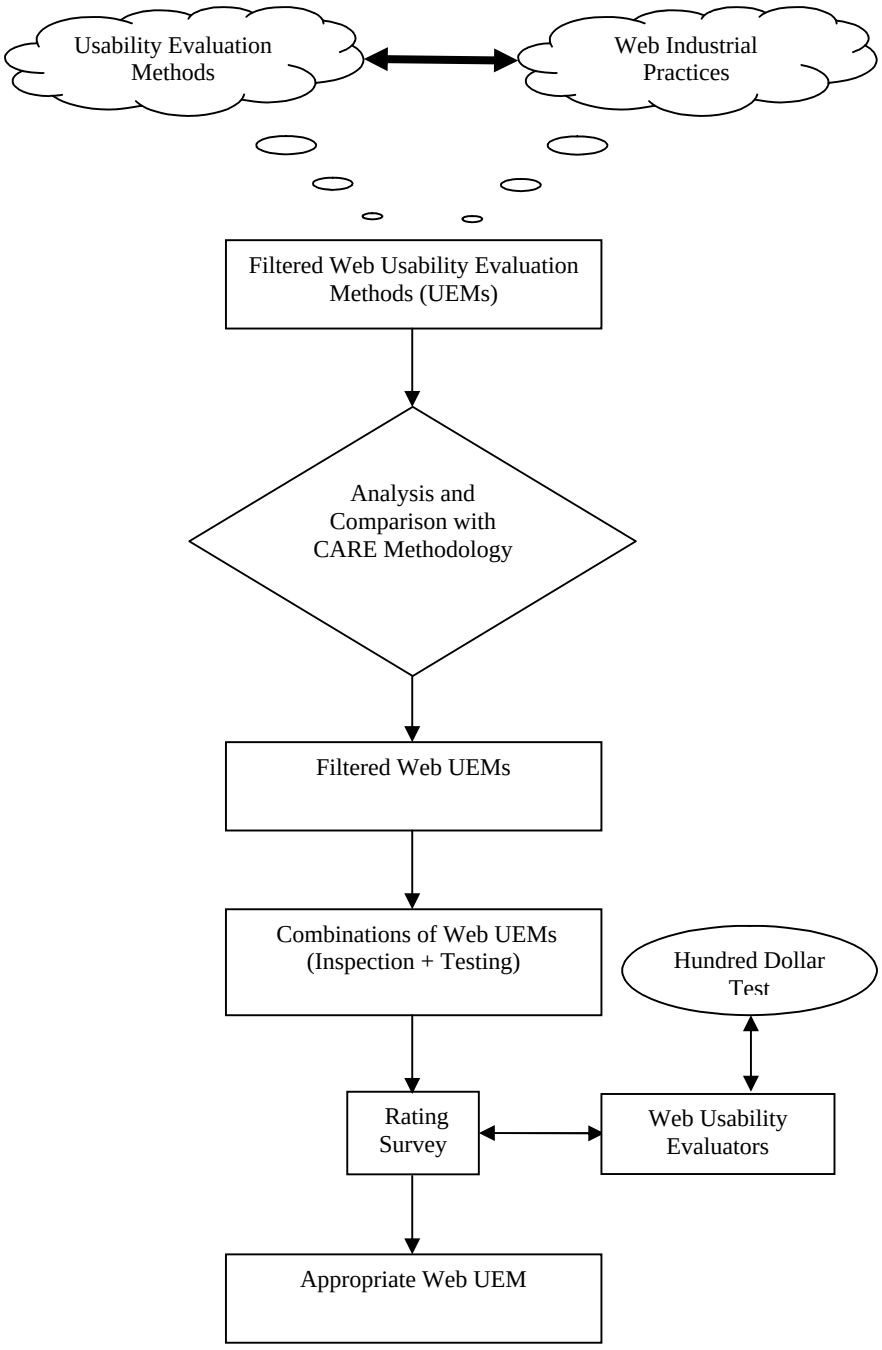


Figure 18: Thesis Actual Map

8.3 Results

The whole rating survey process took two weeks. We got response from all the seven companies. Each of company had 100 points to distribute. So the seven companies had 700 total points to distribute. The results of rating survey are combined into a single table. It is summarized in Table 22. The table total points are the points given by seven companies among each of the four combinations of web usability evaluation methods (See Section 7.3.1).

Table 22: Summary of Rating E- Mail Survey in Tabular form

Sr.	*Combinational UEMs*	*Total Points*
1	Heuristic Evaluation + Remote Usability Testing	**170**
2	Heuristic Evaluation + Performance Measurement	**240**
3	Feature Inspection + Remote Usability Testing	**160**
4	Feature Inspection + Performance Measurement	**130**

According to survey the most appropriate web usability evaluation method is the combination of Heuristic Evaluation and Performance Measurement. The following ratio scale results were concluded from the mail survey.

1. Heuristic Evaluation + Performance Measurement
2. Heuristic Evaluation + Remote Usability Testing
3. Feature Inspection + Remote Usability Testing
4. Feature Inspection + Performance Measurement

The summary can also be seen in graphical form in Figure 17.

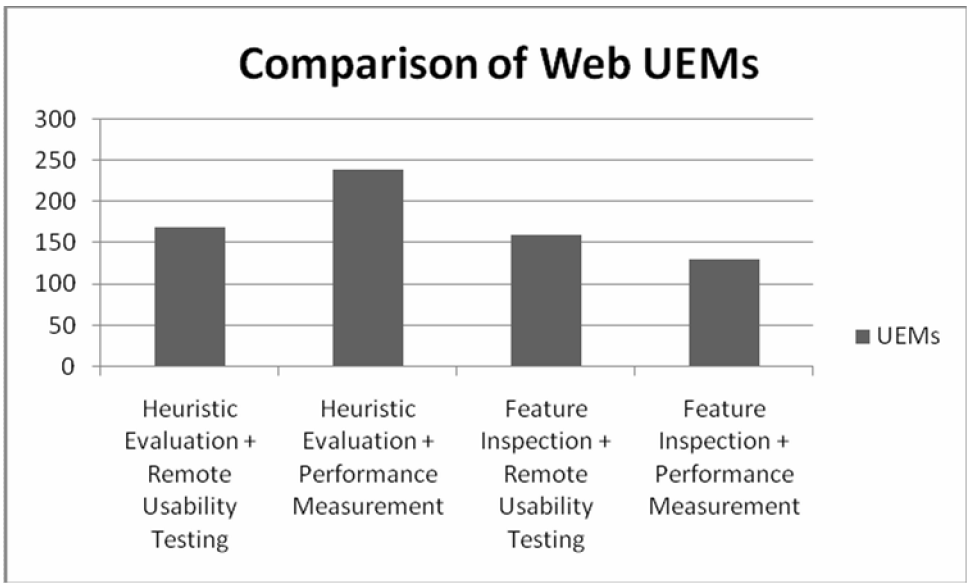


Figure 19: Summary of Rating Mail Survey in Graphical Form

8.4 Analytical Review

The participants of the rating email survey have considered the combination of Heuristic Evaluation (HE) and Performance Measurement (PM) method most appropriate for web development. It is prevalent from the results that HE has been considered as a clear choice in comparison to feature inspection.

We think it is probably because web industry wants to deploy easiest method early in web development stage and at latter stages it wants to work with quantifiable data

The quantifiable data collection process takes more time. So people involved in web development project wants to make sure that they should do all other tasks before working with quantifiable data which is specific to usability. The quantifiable data is useful for making future decisions but it seems that PM takes more time then Remote Usability Testing (RUT). It looks that participants seems to consider that initially a cheaper and easiest method to work so that they can start work. In the testing stage when there is some ready module for example when a web page or prototype is available then they should work with quantifiable data collection technique such as PM.

The two combinations with feature inspection have been rated low by the participants, probably because feature inspection indirectly serves usability problems. Feature inspection method can not be deployed until features are ready. Although web industry could have considered that feature inspection distinct ability to serve two main objectives of product at a time. They are functionality and usability. It can be concluded from result that web industry seems to feel more comfortable with specialized usability evaluation methods, means those methods which directly find usability problems like HE.

9 CONCLUSION AND FUTURE WORK

This chapter consists of conclusion and identification of areas where future research could be valuable for web industry.

9.1 Conclusion

The importance of usability evaluation has dramatically increased due to extremely fast growth in Internet technology. The website design is directly related to the purpose of the website. Website with poor usability can easily destroy the purpose of website. Various usability evaluation methods have been proposed in literature to identify usability problems. There is no standard on classification of usability evaluation methods. The contribution of this thesis is the development of a conceptual process model (See Figure 16) on classification of usability evaluation methods. The model has been made in order to assist author's research work. We generally studied the literature and drawn the conceptual process model.

There is no standard framework or mechanism of selecting usability evaluation method for software development. In the context of web development projects where time and budget are more limited than traditional software development projects, it becomes even harder to select appropriate usability evaluation method. Certainly it is not feasible for any web development project to utilize multiple usability inspection method and multiple usability testing methods during product development. The good choice can be the combinational method composed of one usability inspection method and one usability testing method. The thesis has contributed by identifying those usability evaluation methods which are common in literature and current web industry.

Despite of recognizing the value of usability evaluation methods for web application development, the usability evaluation methods are not consider as an integral part of web development projects. The thesis has contributed in filling some part of the gap between companies thinking and their actual practices by proposing appropriate combination of usability inspection and usability testing method. This can be seen as a step towards finding the best solution for web usability evaluation.

Different strategies have been adopted in the research focusing on filtration and combination of web usability evaluation methods. In the process of finding an appropriate web usability evaluation method, some filtration has been done on the basis of two parameters which are method cheapness and method efficiency. These two parameters are in line with CARE methodology. The purpose of filtration was to conduct a better and more effective rating email survey which was the basic technique for finding the appropriate web usability evaluation method.

Although this thesis has proposed an appropriate usability evaluation method for web development companies, but the degree of subjectivity and expert judgment still plays an important role in overall effectiveness of utilizing usability evaluation methods.

9.2 Future Work

During the research some interesting areas were found for future reaseach. They are as follows.

9.2.1 Development of standard framework UEMs selection

There is no standard framework for UEM selection and utilization in a software development project. Standard selection framework of UEMs can benefit software industry in developing good usable software.

9.2.2 Development of Specific UEMs for Web application

Web development is different from traditional software development. The birth of Web Engineering as an independent field from Software Engineering field is a clear cut example. There are no specific UEMs for Web domain. The traditional software UEMs are used for analyzing web usability. A research is needed to develop new UEMs specific to web domain because web interfaces are more dynamic and they need constant change as compare to traditional software interfaces.

9.2.3 Finding Relative Reliability among UEMs

To best of our knowledge there is no research done on finding out relative reliability among UEMs. Such research will help in development of standard model for selection of UEMs during product development.

9.2.4 Finding Relative Accuracy among UEMs

Like finding of relative reliability among UEMs, the finding of relative accuracy among UEMs will also help in development of a standard model for selection of UEMs during product development.

9.2.5 Standard for transforming usability data into usability information

The purpose of using usability evauation methods is to idenfity usability problems which is usability data. Converting usability data into usability information is an area where lot of reseach is needed [86]. The usability data is useless if not converted in to usability information. There has been some reaseach done [86] on this area, but still it needs more attention from reserachers to develop some stardard framwork or process models of transforming usability data into usability information.

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APPENDIX 1: QUESTIONNAIRE

<u>Instructions:</u> The purpose of questionnaire is to assist authors' research work. The questionnaire is meant for elicitation of the basic information about web usability evaluation practices in industry during product development. Highlight (In Yellow Colour) the answers which are applicable. The information will be kept confidential.

Name	
Organization Name	
Designation	
Contact	

Q 1: Is usability evaluation important for web design?

- Yes
- No
- Can't say

Q 2: Do you use usability evaluation methods (UEMs) during development of every web project?

- Yes
- No
- Can't say

Q 3: How many UEMs you are familiar with from the following list? Highlight (In Yellow Colour) all which are applicable.

<u>Usability Testing</u>

- Coaching Method
- Co-discovery Learning
- Performance Measurement
- Question-asking Protocol
- Remote Testing
- Retrospective Testing
- Shadowing Method
- Teaching Method
- Thinking Aloud Protocol

<u>Usability Inspection</u>

- Heuristic evaluation
- Cognitive Walkthroughs
- Formal Usability Inspections
- Pluralistic Walkthroughs
- Feature Inspection
- Consistency Inspection
- Standards Inspection

Q 4: Which of the following usability evaluation methods you have used practically in your projects? Highlight (In Yellow Color) all which are applicable

Usability Testing

- Coaching Method
- Co-discovery Learning
- Performance Measurement
- Question-asking Protocol
- Remote Testing
- Retrospective Testing
- Shadowing Method
- Teaching Method
- Thinking Aloud Protocol

Usability Inspection

- Heuristic evaluation
- Cognitive Walkthroughs
- Formal Usability Inspections
- Pluralistic Walkthroughs
- Feature Inspection
- Consistency Inspection
- Standards Inspection

Q 5: At which stages of web development life cycle you use UEMs? Tick all appropriate

- Analysis
- Design
- Coding
- Testing

Q 6: Who evaluates the usability of web applications in your company?

- Developers
- Testers
- Usability Experts
- Project Manager
- If others specify

Q7: What are two major constraints in making usability evaluation methods as an integral part of web development projects?

- Less time
- Less budget
- Lack of Usability Expert
- Too much conservative management
- If others specify

Comments:

APPENDIX 2: E-MAIL SURVEY FORM

Name	
Organization Name	
Designation	
Contact	

<u>Instructions:</u> The purpose of this Rating Email Survey is to assist authors' research work. Distribute 100 point among following four listed combinations of web usability evaluation methods.

Sr.	***Web UEMs***	***Points***
1	Heuristic Evaluation + Remote Usability Testing	
2	Heuristic Evaluation + Performance Measurement	
3	Feature Inspection + Remote Usability Testing	
4	Feature Inspection + Performance Measurement	

APPENDIX 3: TEN PRINCIPLES OF WEB USABILITYBY HUMAN FACTOR INTERNATIONAL

1	**Motivate** Design your site to meet specific user needs and goals. Use motivators to draw different user "personae" into specific parts of your site.
2	**User taskflow** Who are your users? What are their tasks and online environment? For a site to be usable, page flow must match workflow.
3	**Architecture — it's 80% of usability** Build an efficient navigational structure. Remember — if they can't find it in three 3 clicks, they're gone.
4	**Affordance means obvious** Make controls understandable. Avoid confusion between emblems, banners, and buttons.
5	**Replicate** Why reinvent the wheel? Use ergonomically designed templates for the most common 8–12 page types.
6	**Usability test along the way** Test users with low fidelity prototypes early in design. Don't wait until the end when it's too late.
7	**Know the technology limitations** Identify and optimize for target browsers and user hardware. Test HTML, JavaScript, etc for compatibility.
8	**Know user tolerances** Users are impatient. Design for a 2–10 second maximum download. Reuse header graphics so they can load from cache. Avoid excessive scrolling.
9	**Multimedia — be discriminating** Good animation attracts attention to specific information, then stops. Too much movement distracts reading and slows comprehension.
10	**Use a stats package** Monitor traffic through your site. Which pages pique user interest? Which pages make users leave? Adjust your site accordingly.

APPENDIX 4: CHECKLIST BY WEB USABILITY TESTING INSTITUTE, UNIVERSITY OF WISCONSIN-STOUT

Sr. No	Characteristics	Checks
1	**Load Time**	
	adheres to 8-second rule	
	progress bar is shown during load time	
	images optimized properly	
	reasonable picture response	
	hit counter load times are reasonable if counter is used at all	
2	**Navigation**	
	organization of navigation labels	
	limited amount of links in list(5-9)	
	uses hyperlink text accurately to describe the linked pages	
	uses anchors on large documents/return to top	
	always has back to home on every page	
	hyperlinks are standard color	
	hyperlinks change with viewing	
	forms of navigation feed back are employed	
	no dead links	
3	**Structure/Layout**	
	arrangement is prioritized on the screen	
	has constant design	
	consistent in organization	
	pages are designed in a way to maximize the use of space	
	layout is not fixed width	
	uses no more than one extra browser window and only when necessary	
	avoids frames except for navigation	
	avoids long scrolling pages by using columns	
	no “under construction” pages	
3	**Content**	
	site is well focused around it’s uses and content	
	provides access to the webmaster and site owner	
	avoids redundancy	
	has up to date information	
	tells user when last updated	
4	**Visuals**	
	pages fit onto low resolution screen (800x600)	
	font is readable size	
	background is not busy	

	has appropriate contrast in color between text and background	
	colors are controlled in an aesthetically pleasing way	
	no excessive glitz	
	visuals serve purpose and are not strictly decorative	
5	**Learnability**	
	is designed with different user levels in mind	
	memorable URL for home page	
6	**Non-HTML Features**	
	site permits access to any software required to view it or operate it.	
	no JavaScript errors	
	no applet errors	
	javaScript is only used when appropriate	