



## Comparing Software Usability Attributes in Virtual Environment and Non-Virtual Environment

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**Abstract:** Now a day's many software applications are being developed in Virtual Environment (VE) such as; education, entertainment, medical, aeronautical, defence etc. And, in this era of user centred development it is highly appreciated to incorporate usability software attributes to develop even an effective VE based application. Therefore, in this paper we have focused on the identification of usability attributes applicable to the virtual environment applications. At the same time, we put efforts to showcase the usability attributes used for development of application in Non-Virtual Environment (NVE). A comparison of usability attributes contributing solely in VE and those used in VE and NVE both is also presented in this paper.

**Keywords:** usability; attributes; virtual environment; non-virtual environment

### I. INTRODUCTION

Software quality attributes play vital role while creating an environment for a user in computing area. There exist various quality attributes available in the literature such as, readability, understandability, robustness, readability, learnability etc., which sets the foundation for creating an environment. Each and every environment possesses its own set of attributes providing help to the developers to create a specific environment. In software development, software quality attributes may cause the different types of impacts in the environments such as Virtual Environment (VE) and Non-Virtual Environment (NVE). Also, two different environments may have some common attributes for developing an environment. VE provides the illusion of the actual system to the user and may create a place where user can interact with the system as if it is a part of real world [1, 2]. It is a computer generated, three-dimensional and simulated environment in which the response may be in real time depending upon the request of the users [3, 4]. VE applications use wide range of specialized input and output devices such as bodysuits, earphones, data gloves etc. which are used as both for transmitting and receiving data [4, 5]. VE provides an ability to design effective Human Computer Interactions (HCI) in entertainment, education, training and other computer assisted applications. VE also overcomes the limitations of the traditional/ standard HCI such as absence of physical presence, natural form of interaction etc. On the other hand, NVE supports 2-Dimensional interaction, which is easier form user point of view. In contrast, application does not provide real world illusion to the user in this environment. NVE applications provide much focused view and limited information to the user without any "world" distraction for the interaction. Developing an NVE application is simpler than VE application because of limited requirements. Standard input devices such as keyboard, mouse, joystick etc. are used

for receiving the data. Devices such as monitors, speakers etc. are used as output devices in NVE.

Usability is one of the important quality factors for VE as well as for NVE. There exists several usability attributes used in developing usable software. These attributes are discussed for VE and NVE in Section 2. These usability attributes may be considered common to both of the environments or may be entirely different. In Section 3, a study about comparison of usability attributes in VE and NVE is discussed. Finally, the result of the comparison of attributes in aforesaid environments and conclusion is presented in Section 4.

### II. ENVIRONMENT BASED USABILITY ATTRIBUTES

In general, usability is associated with usability attributes such as Learnability, Efficiency, Memorability, Errors, Satisfaction etc. [6]. Usability is an important quality factor of software amongst several quality factors. It is recommended to incorporate usability during the early stages of software development life cycle to produce usable software. In literature, usability and its attributes have been defined but not in consistent manner across different standards. Also, usability as an attribute is most widely used term with different meanings by different users and hence, it is utilized with different aspects such as improvement in usefulness, provision of ease of use in the system, its incorporation in interface and functional design, data and metadata etc. [7, 8]. Thus, there is a need to concentrate upon the role of usability attribute in different environments also. The usability attributes existing in non-virtual and virtual environments are discussed in subsequent subsections.

#### A. Usability Attributes in Non-Virtual Environment

NVE applications are not able to relate the user with the real world scenarios and therefore unable to satisfy user completely. Usability software attributes defined in NVE are not capable of producing more interactive environment for the

users. Following are identified as the commonly used usability attributes of any software in NVE:

**Learnability:** It is used to measure the comfortness of a user for accomplishing the basic task. These basic tasks may differ from application to application. In NVE, the user of the application may or may not be known to the developer. Therefore, it is required that application should possess a functionality which guides the user how to proceed with the basic tasks of the application. For example, Microsoft office application provides different menus to user for accomplishing different task.

**Efficiency:** Once user learns the software, efficiency of that software can be measured. The software should be able to identify the operations to satisfy various users without degrading the throughput and response time. In other words, this attribute defines the capacity to produce appropriate results on the bases of given input [9]. The users of an NVE application may have different expectations regarding the output generated by the application. For example, in mathematical calculator application, one user may require the result in integer form, while another user requires result in fraction format. The system should produce the result for the same operation according to the requirement of the user.

**Memorability:** It refers to the ease of remembering the way software must be operated. In NVE, generally applications are developed for a wide range of users. It is not feasible for user to learn the application every time when he/she uses it (even after a long period of time). Hence, application should have a quality to get memorize. For example, in MS-DOS user has to remember all the commands to work with the software and therefore, user find it difficult to work with it. On the other hand Windows operating system provides graphical user interface which help users to remember the working of software.

**Consistency:** Consistency attribute defines the system uniformity and coherence [9]. In other words, application should produce the same result for the same input and operation given by different users. It also deals with consistent use of fonts, text, color, graphics, sequence of layout etc. [10, 11, 12]. Number of users and their capabilities are not known to the developer at the time of application development in NVE. Thus, it is required that application should produce consistent results irrespective of user and its capability. For example, cut option in file menu of word application will always cut the selected data from the document.

**Readability:** Readability attribute defines whether the contents are readable or not. To make content readable it is required to make proper choice of font type and size as well as content should be properly formatted. It also requires consistent use of fonts, text, color, graphics, sequence of layout etc. The users of NVE applications belong to different age groups, therefore the content available in the application should be visible to everyone. For example, content of news website is readable to everyone.

**Accessibility:** This attribute defines the range or level of users who can use the system irrespective of any physical characteristics they have [9]. Unless it is not defined, applications developed in NVE can be used by everyone. Hence, application should provide all possible means to access itself. For example, the application without voice assistance cannot be used by blind user.

**Safety:** It is the capacity of a system to avoid risk and damage from the use of the system. The safety attribute is divided into three sub attributes namely; user, third party and environmental safety [9]. Applications developed in NVE do not provide any illusion of the real world environment.

Therefore, NVE applications did not consider environmental safety. For instance, timer software used in household appliances is not dealing with environmental safety (increases noise pollution).

**Helpfulness:** Helpfulness attribute is defined as the manner system provides help to the user while using the system or application. In other words, system should sufficiently help the user to make the system operationally feasible [6, 9]. NVE applications are used by wide range of users including naïve and expert users. Therefore, application should provide proper help to the user to make application operationally feasible. For example, help provided in Word Star application.

**Universality:** It is the degree of acceptance of the system. It is required that the system has to be universally acceptable. Users of NVE applications may come from any corner of the world, thus it is necessary that application should be accepted worldwide. Universality attribute incorporates accessibility attribute [9]. For example, Google search engine has universal acceptance.

**Robustness:** This attribute deals with the capacity of the system to resist from errors and adverse conditions. Robustness is classified with internal errors, invalid users, third party abuse and environmental problems. In NVE applications, illusion of real world scenario is not created and therefore, environment is not going to change on the basis of the operations performed on it. Hence, NVE applications do not consider the environmental problems [9]. For example, error message can be displayed when some internal error occurs rather than exit from the system.

**Understandability:** It is a capability of software to enable the user to understand the suitability of the system. User should also understand how and when to use the system. In NVE, applications are used by different classes of users thus, it is required that application should be understandable to all the classes of users. For example, VISTA operating system had low degree of understandability in compare to Windows operating system.

**Ease of Use:** This attribute measures the degree of ease to use the system without any assistance from expert user. It is not acceptable that every time user of NVE application will be assisted by an expert user. Hence, the application should be easy to use. Simple NVE gaming applications such as car race does not require any assistance.

**Interactivity:** With the help of interactive attribute, user can explore the world via input and selection of choices. Interactivity is present in applications to support meaningful learning [10]. In NVE applications, only limited information is given on one page/ window and hence, to explore the application more interactivity is required such as URL given in the document to explore the information.

**Affordance:** It specifies the set of possible actions of an object [13]. Various operations can be performed on an object under consideration. The users of NVE applications may require different operations on the same object. Therefore, all possible sets of operations for the specific object should be defined in the application. For example, in paintbrush application a picture can be rotate on left or right side, zoom or crop.

**Navigation:** Supports the way learner moves through the instruction. The instruction should be designed to facilitate the understanding of organization and the structure of content [10]. In NVE, user might not aware how to move within the application. Hence, navigation attribute is highly required in applications so that user can explore the application at its maximum. For example, next or previous buttons can be used by user to navigate.

**Satisfaction:** It is subjective opinion of a user for a system. Satisfaction attributes incorporate most of the attributes defined above, only the degree of these attributes vary from application to application. In NVE, satisfaction of a user is very challenging, as wide range of users will use it and everyone will have different expectation from the application. For example, in car racing application various levels are available to satisfy variety of users.

### B. Usability Attributes in Virtual Environment

In literature review, it has been observed that there exist some usability attributes that are present in VE only. These are discussed as follows:

**Presence:** It is an important attribute of VE that has an ability to create a sense or experience of 'being in' computer generator environment [14]. Training simulators developed in VE highly required this attribute to train the user. For example, plane simulator is used to teach pilot to fly and handle a plane.

**Interactivity:** This attribute deals with content related interactions and tasks that support meaningful learning [10]. In VE, research activity for interactivity is split in two areas; one is development of interaction devices and second is its associated aids. Mainly, there exist three task categories of VE interaction such as; viewpoint motion control, selection and manipulation [15]. It is suggested to use different combinations of interaction dimensions in VE. In other words, multisensory interaction channels are required [11]. For example, educational application uses three pathways of learning through eyes, ears and sense of touch. Students simultaneously see the letter(s), hear the sound, feel how it is formed with their lips, tongue, and throat, and feel the form as the sound is traced or written.

**Active distraction:** It is used in order to draw attention away from the perception of pain in the stressful environment. There exist various medical applications which address the use of distraction attribute especially for burn and cancer patients [16]. Need to establish a peaceful virtual environment while treating the patients rather than simply playing audio-video which supports the role of distraction attribute in VE.

**Expose:** This attribute used to expose the user to the environment. The attribute is generally used to cure phobic clients. Clients expose themselves to feared stimuli within the safety of VE. By repeatedly exposing to the stimuli clients are able to understand the environment properly. For example, VE based flight simulator provides full exposure to the trainee pilot.

**Navigation:** It is not acceptable that all the users are aware how to navigate (move) in the VE. There are two different types of navigation problems experienced by naive users. The first problem is aimless movement in which user is moving without any specific aim. Second problem arises when user is stuck between two virtual objects and unable to move in specified time i.e. disability to move [17]. It supports the user to navigate inside the VE without being lost in VE [18]. For example, directed arrows or audio assistance is provided in most of the VE based games.

**Affordance:** Affordance attribute contains a set of possible actions of an object [13]. Also provides information how to interact with 3-Dimensional objects and environments [19]. Different affordance can be used to inspect the product like, touch; smell, taste etc. In VE, the product can be examined easily by zoom in and out, or by rotating the product and visualize it from different angles. It is possible to have different affordances for same product or different affordances

for different products. For example, in car racing game various alterations in car equipment are possible.

### III. A COMPARATIVE STUDY AND DISCUSSION

Based on the discussion in earlier sections, the summary of comparison of usability attributes in NVE and VE is shown in Table-1. While comparison, it has been observed that there exist some usability attributes playing the role in NVE and VE both. Such attributes of importance include learnability, memorability, satisfaction, safety, efficiency, understandability, affordance, helpfulness, navigation, interactivity, ease of use, robustness, universality, accessibility, consistency and reliability (it is depicted by '\*' in Table-1).

Considering example of satisfaction as one of the common usability attributes in VE and NVE, this fact is highlighted that user satisfaction is the ultimate aim of any usable software. Gaming application in NVE and simulation application in VE proves to have this attribute of importance with common aim of achieving user satisfaction. Further, ease of use attribute also possesses the same affiliation for the above mentioned applications in NVE and VE with different type and experience of uses.

It has been observed that similar to the usability attributes showing common appliance in VE and NVE there exist some usability attributes solely present in VE. For instance, presence is the usability attribute that acts to create an illusion of real world to the users that has no importance in NVE. Expose is another usability attribute being solely used in VE as it provides the user an exposure to use the system in the artificial environment created by illusion. For example, exposed methodology is used to address mental health care disorders such as Post Traumatic Stress Disorder and Obsessive Compulsive Disorder. Similarly, the observations have been drawn for other usability attributes identified for VE and NVE applications.

**Table-1: Comparison of Usability Software Attributes**

Attributes	NVE	VE
Active distraction	Passive distraction is used to reduce the pain	Produces distractive environment and also provide a means to restrict the visual presence of the condition
Presence	Does not exist	Create a sense or experience of 'being in' computer generator environment
*Affordance	A set of actions which can be performed on 2-dimensional objects and environment	A set of actions which can be performed on 3-dimensional objects and environment
*Navigation	Allows the user to move in the given environment	More complex
*Interactivity	One or two	Multisensory interaction

	standard interaction channels are available	channels are required
Expose	Does not exist	Used in mental healthcare applications. The attribute is used to cure phobic clients.
*Understandability	Difficult	Easy
*Ease of use	Varies from application to application	Varies from application to application
*Satisfaction	Less degree	High degree
*Robustness	Deal with internal error, invalid user and third party abuse	Also deal with environmental error
*Helpfulness	Only textual help is available	Images or graphical representation is also available
*Universality	Limited degree	Higher degree
*Safety	User and third party safety is provided	Environmental safety is also provided.
*Accessibility	Range of users is limited	Wide range of users is available
*Consistency	Low degree	Higher degree of consistency is required
*Reliability	Depends upon the degree of consistency	Depends upon the degree of consistency
*Learnability	Difficult	Difficult
*Memorability	Difficult	Easy
*Efficiency	Less degree	Higher degree of efficiency is required

#### IV. CONCLUSION

In the proposed work, a comparison of software usability attributes of VE and NVE has been presented. It has been observed that most of the attributes exist in both VE and NVE. Hence, it is concluded that the set of usability attributes of VE is almost a subset of NVE usability attributes, as shown in Fig. 1. However, typical nature of VE leads to additionally

include some specific attributes exclusively. The objective of the proposed comparison was to identify the applicability of the usability attributes in specific environment and therefore does not focus on the behavioral aspect of the attributes in VE and NVE. And hence, there remains a scope of identifying the role and behavior of usability attributes in VE and NVE and comparison as well.

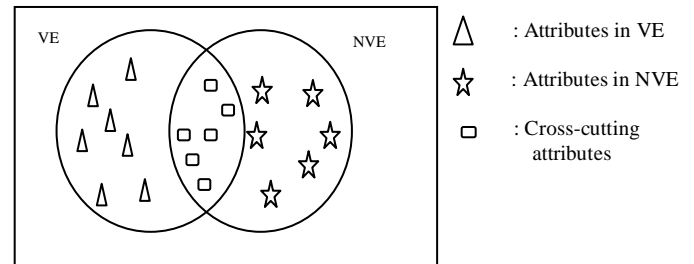


Fig. 1: Attributes in VE and NVE.

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