CHAPTER 1 -
INTRODUCTION

In a span of two decades, the World Wide Web (WWW) has become ubiquitous, growing continuously. The exponential growth of WWW is attributed to the Web-based systems and applications. The web has pervaded every aspect of our life in a short span of time. The initial development of web technology and services for scientific aspects has more or less become a necessity for the day to day activities. Banks, entertainment industry, hospitality industry, food and beverage sectors, retailers, enterprises, educational institutions, non-governmental and government organizations have made their presence felt on the web. e-Commerce has become the mantra of most organizations providing facilities to users at home at the click of a button. Most legacy systems are gradually migrating towards the web working on distributed systems or heterogeneous systems. These systems support a large number of heterogeneous users through the delivery of complex collection of different contents and functionalities leading to an increased demand on them.

Web creates a greater mesh between arts and science than general software development as it focuses on visual creativity [3]. The acceptability of Web-based system is based on its performance, reliability and quality. Poorly developed Web applications have a high probability of failure [4] since the software development processes have not been adapted into challenges of the internet leading to web crisis [3]. This in turn is achievable through the utilization of Web Engineering processes. Web Engineering is the application of systematic, disciplined and quantifiable methods during the development, deployment and maintenance of Web-based applications. During development, software architects must focus on Human-Computer Interaction (HCI) usability to augment the acceptability of the application. Also, cost effectiveness and energy efficiency of Web applications must be analyzed to reassure their economical and ecological
relevance. This thesis therefore focuses on assimilating HCI metrics and cost estimation of online programs with a recommender system for Green-IT.

1.1 Need for Web Engineering

The ubiquitous web has a significant impact on our personal and working life. It is engaged in commerce, industry, banking and finance, government and entertainment sectors [3]. The extent of web usage has triggered massive amount of web development and maintenance. However, this surge has also resulted in poor quality Web applications and systems due to the ad hoc nature in which the development and maintenance activities are carried out. More frequent among these is the failure to address users’ needs and issues such as content management, maintenance, performance, security and scalability of Web applications [5]. The origin of web system failure is the flawed design and development and poor management [6]. Also, having informal methods of development for large and complex systems can lead to serious problems and financial loss. These challenges have necessitated an engineering approach to the Web development in a disciplined and systematic manner [7] and hence the Web Engineering process. Practice of Web Engineering processes can capture the defects early on and mitigate risks arising later.

1.2 The Web Application Development Life Cycle (WDLC)

Internet has brought in the information era. The growth in ICT has resulted in information delivery to users anywhere in the world through Web applications. The Web application development process (WDLC) is a structured set of activities that transforms the requirements into a quality Web application. These activities involve (Figure 1.1):

*Analysis and Planning*: Planning and scheduling of tasks and monitoring their execution.
**Requirements Specification**: Understanding the purpose for which the application is built and determining their functional requirements.

**Design activity**: Finding the technical solution, preparing the blue print of the project and developing logic for coding.

**Implementation/Coding**: Involves actual coding.

**Verification/Testing**: Performed at different stages of WDLC to detect errors or to ensure their absence.

**Maintenance and Development**: A support activity for correcting errors that may be detected in actual operation. Involves adaptation to changing business needs through continuous update as requirements grow.

The Web development process can range between the simplest task of Web page construction to the complex activity such as Web Project planning and construction. Utilization of user interface, generally in terms of HCI is handled in detail in the first two levels of web page construction and web page design as shown in Figure 1.2. Web applications today must be appealing to wide variety of user base. Retention of users, user loyalty, increasing user base are of importance.
to most web based systems. Strategies to improve the application, policies to understand the unknown user behavior and expectation, providing quality system and maintaining security are crucial for a successful Web application.

**Figure 1.2. Levels in Web Development**

### 1.3 Motivation for the Research Work

Web 1.0 era was purely content-based, one-way broadcasting. The next generation Web 2.0 focused on providing the user an ability to collaborate and share information online. This was possible mainly due to the transition from HTML web pages to dynamic HTML, XML and RSS leading to a social web. For example: LinkedIn, facebook, YouTube. Combined with social web 2.0 services, web 3.0 provides the users all over the world to interact with other users through a variety of modes. For example, iPhone, iTV, 3G cellular, Wi-Fi networks.

While technology has changed rapidly over the past decades, progress in addressing the HCI factors for usability has been relatively slow in the area of WBL system development. Complex or confusing navigation, lack of brevity, insufficient support to user cause short span of visit to the web site, dissatisfaction and further leading avoidance of such Web services. The design and development of any Web application must be done on the basis of understanding the users and
their tasks. Hence, the usability factor as a web metric needs to be addressed from
the HCI perspective. WBL systems depend heavily on the use of HCI, multimedia,
graphics and gaming concepts. Following web-engineering processes for effective
WBL environment is desirable to increase the attention span of the learner, increase
the understandability of the content, pace up the process of learning, and
acceptability of the content.

In this scenario, the research is motivated by the following factors:

• The need to evaluate WBL system with respect to HCI attributes to
  improve its usability

• Necessity to enable en masse dissemination through of knowledge through
  WBL

• Ensuring a cost effective and eco friendly system of learning.

The spread of ICT through the world has not been even or equitable. ICT
has added one more layer of division between the haves and have-nots leading to
digital divide. This situation is quite common in India. While the costs of the
hardware and software are falling, often there are other costs that have often not
been factored into the deployment of e-Learning ventures\(^2\). The most important of
these include the costs of infrastructure support and its maintenance, and
appropriate training of staff to enable them to make the most of the technology [8].
Facilitating learning through delivery of appropriate contents with an effective and
efficient learning platform is essential. Also, implementation is a concern. A major
challenge to HCI researchers is to be able to engage novice learners and to support
their learning even at a distance [9] and consider ways in which usability and
learning interact [10].

The field of HCI has undergone a shift from interaction with information to
experience. Information is easier to understand whereas experience is not. Trying

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\(^2\) The terms WBL, e-Learning, online learning and blended learning are used interchangeably
throughout this thesis.
to understand experience transforms research methods since the focus shifts towards understanding the e-Learning course characteristics, measurements, and offering guidelines for experiences. Though usability studies have gathered and analyzed data on important issues like time to task completion, error rates, time to select a target on screen, usability surveys, think-aloud use protocols, etc [11], study towards understanding HCI characteristic preferences from the users’ perspective was needed.

The factors that have influenced this research work are:

1. Study of the rework effort for rectifying defects in usability factors through existing projects

2. Understand the impact of user interface design defects in the initial phases of WDLC

3. Predict a model for rework cost estimation of WBL application development

4. Address the scope of implementation of online learning in India in terms of infrastructure, technical and financial viability

5. Finally, the energy issues must be dealt with to either recommend or reject online learning programs.

1.4 Research Objectives and Problem Statement

Much of the literature on e-Learning application has focused on the learn-ability aspect, tools of delivery, e-Learning models and strategies of delivery. The value of e-Learning lies in its ability to train anyone, anytime, anywhere. Implementing and sustaining e-Learning programmes require more than merely promoting education and learning online [12]. Though India has seen tremendous growth in ICT with an increase demand for IT professionals globally, much is desired within the country in terms of utilization of its technical potential to disseminate education
to rural and backward areas. With millions of prospective candidates for online learning, commercially e-Learning can become successful if the individual learner’s needs are met. Powerful new learning resources are needed to build a knowledge society. At the same time, new level of accessibility is equally important to motivate the learner and remove the barriers created inadvertently by new technologies.

Researchers have so far focused on development of e-Learning applications, user category and related issues in a geographical or environmental context. Moon et.al, present a pedagogic framework and structured set of design features to accelerate learning in the workplace for SME managers [13]. Halachev and Mustakerov have provided a mechanism to evaluate the time needed to develop e-Learning course [14]. A study shows that effectiveness of game-based mobile learning model for children in underdeveloped regions is impacted by various factors like gender, group size affecting their ability to adapt and learn in unique set of interactive learning patterns [15]. Most of the research is pedagogical in nature which involves in finding teachers’ influence in the use of ICT at schools [16] and focus mainly on social and behavioral aspects of online learning.

Much research in the Indian context has focused on the different modes of e-Learning provided. They have ignored the issues such as the current scenario of online learning in India, methods to implement, suggestions for enterprises/universities/institutions to start up its own e-Learning portal, cost benefit analysis of such a venture or analyzing user perspective of available online learning mechanisms in terms of HCI usability metrics.

The objectives of this research work have been therefore to investigate further and address the following open challenges:

- Evaluate the influence of HCI characteristics in WBL content
  - To what extent does HCI affect usability in electronic mediated learning situation?
  - Estimate the level of acceptability and usability of WBL system taking HCI characteristics as a major area
• The evaluation of rework effort on defects detected in HCI functionality during the initial phases of WDLC?
• An appropriate model for promoting WBL by service providers
• Analysis of cost factors for the production of electronic content and ensuring ROI for sustenance for service providers
  • Arrive at a ball park estimate of cost estimation and ROI based on the development effort estimate through the Web Application Development Life Cycle (WDLC)
• Ascertaining if WBL is green or eco-friendly
  • Does WBL contribute heavily to CO₂ emissions? Is it green?

The purpose of this research work is to address these open challenges by understanding the extent of HCI influence on WBL application usability. This in turn leads to a proposal of model to estimate the cost of rework effort in correcting HCI usability defects and estimated cost of developing a WBL application and appraise the ROI.

1.5 Approaches

Throughout this research different methods are used to collect data and test the premise. These methods include literature analysis, investigation through case studies, development of new model and applying simulation to verify the results. The case study involved a questionnaire to test the usability metrics in HCI. The qualitative data gathered through the questionnaire is converted into quantitative data through RIDIT method. The sample data is analyzed statistically and simulated using MATLAB.
1.6 Key Contributions

This thesis has made the following significant contributions:

1. A case study to identify user perception of HCI usability in a WBL system as per ISO/IEC 9126 standard. This study highlights the user preferences in terms of the Human-Human, Human-Computer and Computer-Human interactions in a blended learning environment. The study also notes that technology behind e-Learning has no impact on users’ capability to learn or use an e-Learning application.

2. Utilizing HCI defects data from projects compliant to ISO/IEC 9126 (part 2 and 3); we provide rework effort and cost estimation models through statistical analysis. Further, the mathematical model is simulated to verify goodness of fit.

3. Our initial investigations led us to believe that ICT in universities and colleges is used only as a means to communicate basic information of their activities. To overcome this shortfall, we suggest a collaboration of Businesses, Academia and Government (BAG). A G2B2B Business model which is a consortium of Government, Business and Institutions to promote e-Learning locally within the institution or university is proposed. In this thesis the level of involvement for each stake holder is recommended and the symbiotic benefits of this model are presented.

4. For startup organizations, especially academic institutions intending to develop WBL system, a costing model for estimating Cost per Program/Module (CP), Total Expenditure (TE) and Internal Rate of Return (IRR) is provided.

5. The social obligation of this research has been to check whether WBL is an environment friendly option. An empirical exploration of the energy consumed by WBL system users versus energy consumption by data centers is performed. The evaluation of power utilization at the user end
and at the data center in general, led us to conclude that WBL is environment friendly and truly green thus adding to Green-IT initiative.

In summary, the novelty and the contributions of this thesis leads towards understanding the impact of HCI factors in WBL system; estimate rework effort and cost for defects detected during the early phases of WDLC; estimate cost (costimate) of developing a WBL system; utilize the proposed model to implement WBL in India and an assessment of the impact of online learning on the environment.

1.7 Thesis Structure

Chapter 1 gives a brief overview of the content and structure of the study. This includes research problem, methodology used, key contribution and the thesis structure (see Figure 1.3).

Chapter 2 reviews the relevant research in the area and provides background information on e-Learning: framework, modes and technology, Web Engineering, e-Learning in India and Green-IT. This chapter provides a general foundation for succeeding chapters. Chapter 3 starts with a discussion of Usability, WBL research. It then addresses the usability factor implementation in WBL through a case study leading up to a detailed analysis and comparison of user preferences and acceptability through usability evaluation methods. Here usability criteria for evaluation of WBL applications are synthesized, focusing on usability issues from HCI perspective. Chapter 4 is based on the outcome of chapter 3. This chapter shifts to development domain of WBL with a focus on usability quality metrics. We analyze the cost of rework effort accrued due to unresolved usability defects through a mathematical model and simulation.

Based on the foundations provided by chapters 2 to 4, a descriptive model for the implementation of WBL in Indian universities is put forth in chapter 5. This chapter also proposes a detailed mechanism to evaluate cost per program and ROI thereof to propagate e-Learning. In chapter 6, focus is on the energy issues related to WBL. The energy consumption in online versus traditional mode and also in
data centers is evaluated. This chapter concludes by advocating measures towards Green-IT.

Chapter 7 concludes with the summary of contributions and areas for further work.

Figure 1.3 Structure of Thesis