CHAPTER 7 -
CONCLUSIONS AND FUTURE WORKS

This chapter presents the contributions, conclusions and recommendations for future work arising from the study of WBL system as a Web application.

Current literature is reviewed (Chapter 2) in the fields of e-Learning, Usability, HCI, Web Engineering and Green-IT as the main domain of interest. Chapter 2 builds up to Chapter 3- a case study, where the level of usability acceptance in a blended learning environment is measured. In chapter 4, we provide a mathematical model for estimating cost of rectifying usability defects based on the data acquired from WBL projects. In an effort to integrate and implement e-Learning in India, a business model is suggested in chapter 5. Additionally, we also present a ROI model for organizations (institutions) intending to establish an online learning system. As a social commitment towards environment, we verify and validate the greenness of online learning with recommendations for a Green-IT in chapter 6.

7.1 Summary of Contributions

This study has addresses the gaps recognized during the literature survey in the field of HCI usability and metrics. There are several significant points to be drawn from this research:

- Through a case study we have provided a better understanding of the student perceptions of usability in online learning system. Furthermore, we rank the factors that influence their perceptions. Also to our knowledge, this is the first study (utilizing Ridit analysis
for Likert type questionnaire) to have quantized usability characteristics. This case study on HCI usability preference contributes to knowledge base.

- The outcome of this study led us to investigate the effort put towards implementation of HCI features during the development of WBL system. Here we address the effect of unidentified/unresolved usability defects in initial phases of development on rework effort and cost. This work is unique since it provides a new perspective towards addressing HCI issues the field of Web Engineering.

- Our research revealed a lack of proper support, incentive and infrastructure to promote e-Learning in India. Understanding the strong need to adopt online learning in India, we propose G2B2B business model for country-wide implementation.

- In addition, the previous study is augmented by a ROI model. The ROI model provides an overview of the profits that can be expected over a time period. The purpose of this work was to promote and influence the adoption of online learning by institutions based on cost benefits analysis.

- The societal responsibility of this research has been the assessment of energy efficiency of WBL system. The empirical approach examines the energy consumption due to e-Learning (per course with an average subscription of 200 students) over a period of one year (164.25 kWh). We also look at the energy consumed by data centers that host multiple Web applications (432 million kWh). The negligible consumption of energy and CO₂ emissions in WBL system prompted us to recommend it as a viable and environment friendly mode of learning.
Summary

The motivation to conduct the research presented in this thesis has come from the under-representation of HCI usability factors in Web based applications—especially, online learning systems. This shortcoming has been due to:

- Minimal importance given to HCI usability during the development phase of WBL content
- Non availability of metrics to gauge the impact of HCI defects have on the overall development of WBL system- both at the user end and developer’s end
- Non availability of on-the-fly estimation mechanism for institutions to make a cost benefit analysis of WBL programmes
- Lack of incentives and encouragement for institutions to disseminate WBL

We therefore, address these factors in this thesis by taking a 360 degree approach towards implementation of usability factors in WBL system.

To summarize, usability analysis of WBL system from the end user perspective is performed to gain insight into user preferences. Also, usability issue in terms of usability defects detected in early stages of WDLC is addressed. Here, the impact undetected/unresolved defects have on the remedial efforts from the development perspective is analyzed. This information is extrapolated to analyze ROI for startup WBL system vendors. To enable and encourage e-Learning throughout India, G2B2B model - a consortium of Businesses, Academia, and Government is proposed. Also, the cost of developing a WBL system is envisaged. Further, the effect of online learning on environment in terms of energy consumption is explored before recommending WBL as a viable alternative to traditional learning.
7.2 Limitations of the Study and Future Research

In this study we have attempted to address the questions on HCI usability with an India-centric approach. We have consciously avoided comparison of Indian conditions with developed nations due to the range of difference that exist in socio-economic and political conditions. We do acknowledge the fact that the case study (Chapter 3) limited to one WBL provider, may be inadequate to generalize the trend and conditions of HCI usability for WBL environment in India.

The sample data set acquired for estimating the rework effort on usability defects is very small (number of projects under study=10). Also, this study was constrained by the non-availability of certain metrics to throw further light on the study (for e.g. developer experience in years, skill set, level of expertise, number of modules, functionalities, number of usability factors, categorization of defects into minor, major or critical, etc). We have to admit that this research only focuses on recognition of HCI defects during the initial phases of development and the effort required to fix them. Though one of the thrust areas of HCI research has been addressing the needs of users with disabilities, we chose to ignore this issue since most WBL applications cater to ‘average’ users. We assume these factors may have hindered the simulated results from providing an accurate estimate.

The success of the proposed business model depends on the contributions and benefits reared by the stakeholders. In this model, we have avoided an in-depth approach towards specifying the mechanisms for implementation along with temporal factors due to lack of our own exposure to business and governance. We wish to implore researchers in the field of business analytics and governance to take it up as an area of further study.

These factors apart, constraints of time may have inhibited us from thoroughly considering a wider array of research in this field.
**Future Research**

There are several promising directions to extend the work presented in this thesis. This potential exists since the online learning systems are becoming more cost-effective, user-friendly and platform independent. We would like to pursue further research in the following areas:

- Portability of WBL system to hand held systems without compromising usability and user experience in highly interactive systems

- Implementing a background process to capture time spent on each learning module and use online test grades to evaluate and predict the learner’s ability to learn

- Applicability of security, privacy and trust apart from methods to achieve ethical and technical standards.

- Estimation of energy consumption by text based, multimedia, highly interactive Web application vis-à-vis energy utilized (in India) during traditional mode of learning in a in-depth approach
List of Publications

Research contributions in peer reviewed International Journals and Conferences pertaining to this thesis.

Journal Publications


Conference Publications


