CHAPTER 2 -
REVIEW OF LITERATURE

2.1 Introduction

For most users, the WWW has given the experience of navigating freely between decentralized networks of nodes of information connected by different links. The Web, not constrained by geographical boundaries is an efficient vehicle of services allowing all participants to work in a global scale. Exchange of services for commercial purposes involving commercial transaction is called e-Commerce. e-Learning could be taken as a special type of e-Commerce in which educational service is provided online. Just as the characteristic features of a product affect the customers’ preference in online shopping, the content features of a particular course could affect the students’ acceptance of the e-Learning approach [17].

The problem pertaining to e-Learning and the Web application development for online learning is the huge number of users with different interests, goals, needs and preferences. Though the user base is diverse, the content, navigation, presentation styles does not vary. Also, users browse with different devices, each having its own requirement in terms of resolution and interfaces.

This chapter reviews the literature on e-Learning as a Web application, its framework, modes of delivery, technology. The literature review also focuses on Web Engineering with respect to usability issues, Web application development and energy efficiency. The aim is to show the range of areas that have contributed to WBL. This systematic review aims at summarizing the existing research work in the area of e-Learning systems, status of e-Learning in India, Usability evaluation,
HCI, Business model for e-Learning and identifies gaps in the past research to suggest areas of further research. The review does not describe the method or procedure in detail [18]. The open issues in section 1.4 are a result of this literature survey.

A systematic approach has been followed to search literature in relevant areas. A number of distinct key search terms, literature available in books, journals, digital libraries and online repositories were selected for the review apart from papers in conference proceedings. Careful selection was done based on the relevance for literature survey and rest rejected (Figure 2.1).

![Figure 2.1 Literature Review Process.](image)

### 2.2 e-Learning – a Web Based Application

‘e-Learning’ as a term is a hybrid. Like many compounds, the two elements have worked together to create a new hybrid. Nevertheless, it is made up of two parts: e + Learning (Figure 2.2). The ‘e’ of e-Learning has a longer history than many may assume, including long-term efforts to capture voice and images, and to store and then transmit those recordings. With each capture – from records to CDs, film to DVD, conversation to text chat – there are trade-offs in quality, interactivity, and
transferability: trade-offs that mark both the pros and cons of technology mediation [19]. The information and communication systems, whether networked learning or not, serve as specific media to implement the learning process [20].

Figure 2.2 The Structure of e-Learning

The essence of e-Learning is sharing knowledge [21]. Today, technology has become the real enabler to host of initiatives like online training tool, performance assessment, discussions and other promising features. The advent of e-Learning revolution can be attributed to four other revolutions in the field of education:

1. Invention of reading and writing
2. Emergence of the profession of teacher/scholar
3. Development of moveable type (printing technology)
4. Development of electronic technology

This electronic technology is facilitating a major change in the way we store, process, and retrieve information, and the way we communicate [22].
2.3 e-Learning Framework

e-Learning framework supports the utilization of service-oriented approach for the development and integration of computer systems. It encompasses the sphere of learning, research and education administration covering the fields of Information technology, Research, Library, Administration in addition to Teaching and Learning [23]. To take advantage of the benefits offered by technical interoperability and flexible deployment, the e-Framework advocates the service-oriented-approach to provide open interfaces to numerous reusable services that perform business functions [24]. The aim of framework is to facilitate the integration of different open source components and applications within institutions and regional federations, by agreeing upon common service definitions, behaviors, data models and protocols.

The set of e-Learning services can be summarized as follows [25]:


The core task of creating a framework is to define a broad set of services required to support the business of a community. [26] provides a set of patterns
that can be used to implement e-Learning strategies with a focus on learning and teaching aspects of institutions and organizations. Later, [27] suggested a framework based on service-oriented factoring of a set of distributed core services required to support the e-Learning applications, portals and other user agents using either Web services or REST-type HTTP protocol.

An e-Learning framework shown in Figure 2.3 has the following benefits [28]:

- The policy makers by providing a coherent view of how to integrate the systems to support organizational and cross-organizational processes enable effective e-Learning supporting and planning activities
- The organizations that manage learning/training by aligning the business processes with services and supporting the business model

![Figure 2.3 The e-Learning Framework][28]
• The communities of practice by supporting pedagogic diversity, pedagogy driven implementation and faster response

• The suppliers and developers of e-Learning content and services by increasing the ROI, lowering the cost of entry, supporting market differentiation

Of particular interest for this research study is quality assurance and user preferences in the HCI context. The benefits of following e-Learning quality principles are [29]:

• Make visible an initial quality expectation and minimum quality expectations

• Promote confidence and motivation in stakeholders to utilize the product

• Lead to ongoing improvement in design and planning processes having a positive impact on development process and avoid potential costly developments

• Be used to identify current quality of courses and potential for further development

• Promote and enhance reputation of the use of e-Learning

2.4 e-Learning Modes

Internet has turned into real network for the intercommunication worldwide, offering educational services which include virtual laboratories, environments for learning, and distance and asynchronous multimedia courses [30] enabling different modes of education. e-Learning enables both presentation of the content and facilitation of education through the use of computers or mobile phones or PDAs. The mode, method and theories applied thereof will be termed as wholly online, partly online, offline or blended learning. In the e-Learning framework as such, the learning theory for online, offline or blended mode does not change.
e-Learning methodologies, tools and procedures have increasingly supplanted traditional paper, face to face and round-table methods of learning [31]. By overcoming the limitations of time and space and customizing the learning environment to the specific (and changing) individual needs and learning styles, ICT transforms the learning experience and increases the speed, flexibility, and efficiency of the knowledge transfer [32]. Hence, content delivery in either asynchronous or synchronous mode (Figure 2.4) is decided by the content provider based on the purpose of learning. Asynchronous mode enables learning through variety of delivery methods without time constraint 24/7. Synchronous mode enables self-learning similar to asynchronous mode also involving the tutor-learner interaction at predetermined time or a peer-peer interaction online. This commitment ensures that the learner performs his task of learning prior to his/her interaction and mandating the completion of certain modules unlike asynchronous
where student interacts with tutor or peers through e-mail or blogs. However, students get a chance to speed up or slow down their pace of learning based on their competency, skill and interest. The geographical obstacles, travel cost and time is eliminated. The accessibility and affordability of education 24/7 enables large number of candidates to enroll into e-Learning programs.

2.5 e-Learning Technology

A combination of text, video, audio, graphics and animations can be integrated into e-Learning system. Media selection is critical due to the cost factors involved in developing non-textual e-Learning materials [33] [34]. A relatively new e-Learning media is the streaming media considered effective due to ‘streaming’. Streaming allows large files to begin playing even before the entire file has been downloaded, creating an interactive learning environment [35]. ICT today, supports learning technologies to achieve desired goals. The Computer Based Learning (CBL) technologies have some unique advantages [36] like:

- High speed computation
- Interactivity – for games and simulations
- Networking with global reach, allowing worldwide collaboration
- Digital representations/transformations
- Repeatable procedures
- Storage and retrieval
- Individualization/customization/flexibility resulting in personalized content
- Constant availability-24/7
- Simulation of complex processes
2.5.1 Learning Management Systems

Learning Management System (LMS), Learning Content Management System (LCMS) are relevant applications of Technology Enhanced Learning (TEL). Due to the digital nature, direct association of the content provider and receiver is not necessitated. IEEE, One of the standardization bodies has drafted the Learning Technology System Architecture (LTSA) specifying the architecture for ICT-supported learning and training. The Figure 2.5 represents the architecture for ICT-supported learning and training. The Figure 2.5 represents the different activities (Delivery, Evaluation), actors (coach, Learner entity), Repositories (Learning Resources, Learner Records) and activities between these entities (Multimedia, Assessment, Behavior, Locator, query, transfer of learner and catalog info, history, content transfer and locator).

The main players of e-Learning platforms are learners and authors; others include trainers and administrators. Authors (instructors) create content, which is stored under the LMS and typically in a database [37].

Figure 2.5 IEEE Learning Technology Systems Architecture Components
(Source: [37])
The e-Learning platform aids the administration of the process of online training. They help to execute, administrate, distribute and control educational plans by using a system which integrates a series of tools and characteristics. Hence, the e-Learning platforms are either LMS or LCMS as shown in Figure 2.6. A complementary tool to LCMS is the Content Management System (CMS). CMS is software which allows the modification, editing and publishing of content along with the maintenance of the content on the web. Most CMS are available as enterprise solutions which provide powerful and complex functions. Some of the common e-Learning systems available are WebCT, Blackboard, Drupal, and Joomla; from the open source there are: Modular Object Oriented Dynamic Learning Environment (MOODLE) and Sakai.

![Figure 2.6 Schematic Operation of LMS and LCMS](image)

The LMS is software used for delivering, tracking and managing education. These systems provide functionalities ranging from managing educational records to software for distributing courses over the internet and offering features for online Collaboration. Plug-and-play configuration of classes and courses is appreciated as the number of authors and students increase. Managing the Learning Objects (LO) and meta-data on objects is critical to the success of LMS. Hence, standardization efforts like Learning Object Metadata (LOM) by IEEE and Sharable Content Object Reference Model (SCORM) are brought in place. SCORM and LOM provide a collection of specifications adapted from multiple
sources to provide a comprehensive suite of e-Learning capabilities that enable interoperability, accessibility and reusability of WBL content [38].

Computers can be programmed and organized in many ways. For one data set or application to work with different data set or applications, it needs to adhere to architectures, framework and standards. While overall technical design of a computer system defines the architecture, frameworks are overall design frameworks for implementing e-Learning within a specific architecture. Standards or protocols refer to the design of a system so that they can communicate with one another.

### 2.5.2 Service Oriented Architecture

Architecture can limit or expand the possibilities of what can be done within a computer system. An emerging architecture that is particularly relevant to online learning systems is the Service Oriented Architecture (SOA). SOA for e-Learning provides adaptable, interactive, extensible, distributed, collaborative and intelligent e-Learning system to effectively realize the learning anytime, anywhere [39]. Using SOA one can build durable e-Learning content regardless of changes or evolution in technology. The simplest system architecture shown in Figure 2.7 by [40] consists of a fiber optic backbone network connecting desktop networks via switches. Each network is serviced by local servers which are connected to a central server which host the course. The software tools for the courses are plugged through linking mechanism allowing only relevant tools to be loaded.

![Figure 2.7 A simple SOA for e-Learning](image)
However, the SOA has limited utility since it is a closed model and making it difficult to users to access third party tools that are available elsewhere.

[41] Proposes a novel architecture for e-Learning systems based on web services and intelligent agents providing a flexible integration model connecting all learning components and applications that are loosely distributed on the internet. Researchers claim this architecture can customize the learning content to fit the special learning needs of users, through the use of intelligent agents. Based on their UI architecture model, [42] develop a web-based e-Learning system adaptive to user characteristics confirming the proposed architectural model’s capability through a prototype.

Summarily, the basis of e-Learning is its integration with the internet, placing emphasis on software and hardware platform of e-Learning systems, functional structure, security management and training, integrating information technology with teaching [43], network environment of the campus [44], semantic web technology based on multi agent system [45]. In [46] the authors propose e-Learning system architecture based on cloud. Other researchers working in the similar field have suggested the migration towards utilization of cloud computing architecture and combining the features of e-Learning [47] [48].

2.6 Web Engineering

“Web engineering is multidisciplinary and encompasses contributions from diverse areas: system analysis and design, software engineering, hypermedia/hypertext engineering, requirement engineering, HCI, user interface, information engineering, information indexing and retrieval, testing, modeling and simulation, project management and graphic design and presentation” [5].

Though Web engineering involves programming and software development, it is not software engineering as “web development is a mixture between print publishing and software development, between marketing and computing, between internal communications and external relations and between art and technology” [49]. However, it uses software engineering principles
encompassing new approaches, methodologies, tools, techniques and guidelines to meet unique requirements of Web-based systems. Adoption of disciplined and sound development methodology by web developers is essential to successfully build large-scale and complex Web application systems. The emerging field of Web Engineering addresses these needs and focuses on successful development of Web-based application system while advocating a holistic, disciplined approach to web development [5].

The web information systems engineering differs from the traditional information systems because of its unique technological platform and design philosophy [50], containing different types of components and need to be largely platform independent. The difference can also be compared in terms of the timescales and life scales [49]. Since the structure and functionality of a Web-based application change constantly over time due to changing information and web-site structure, it is not possible to specify a priori what the requirements are and the system will contain. Hence, evolutionary web development process is a viable approach. The following characteristics make Web applications different from the traditional software [51]:

1. Development life cycle of Web applications tend to be shorter

2. User interface and aesthetics are given a higher importance due to their greater role

3. Web based systems are generally more content driven compared to software projects

4. Security is the major issue

Thus, investment in a Web application like e-Learning- design, delivery and evaluation needs to be planned if the expected benefits are to be realized by the stake holders [52]. These factors have to be guided by a broad understanding of quality in teaching and learning [53]. However the concern should not be limited
to only quality of delivery but also how technology can improve the quality of e-Learning [54] by following proper standards and metrics.

### 2.6.1 Web Engineering Metrics

The science of web measurement tries to measure different attributes of web to gain knowledge of it in order to optimize and improve its capacity for delivering information more effectively [18]. [55] defines *webometrics* as “the study of web based content with primarily quantitative methods for social science research using techniques that are not specific to one field of study”.

Work in Web Engineering metrics can be classified into three major areas [56], viz:

i. **Software Metrics:**

Measuring Web application development has become complex because of the engineering that must be followed in a field that also has an ‘artistic’ component [57]. Early works in this field was taken up by Pressman, Somerville, Boehm, Booch and others in the field of software engineering to predict, evaluate and estimate the characteristic features of software like lifecycle, costing, estimation of man power, skill attributes, etc. Some of these factors can also be extended to the web providing the web a ‘software-like’ appearance.

ii. **Hypertext:**

The best known implementation of the hypertext is the WWW with a rich content of audio, video, graphics, computation and interaction. Hypertext blended with additional media is hypermedia. Several works have been proposed aiming to present metrics and new development methodologies useful in applications of WWW, prior to which a study by Botofogo et al. [58] attempted to address the problem of defining metrics for hypermedia systems [59] proposes ten steps to be followed during a Web application development with a focus on resource measurement and development process control. Metrics can be gathered at the different phases of WDLC as [60] proposes metrics to be used in the requirements
gathering phase. Much analysis of metrics is done on e-commerce applications to understand the behavior of clients; web navigation pattern has been studied to classify the quality of the web site [61]. Mendes et al. have worked extensively in the field of Web engineering ranging from Web effort prediction [62] [63], cost and productivity [64], size [65] through case studies. Mendes has further extended the work in effort estimation [66] by comparing four effort estimation techniques and identifying the best [67].

iii. Human Computer Interaction:

Usability is integral to HCI relating to how the system interacts with the user. Scholars have pointed out the need to attend to user behavior in information technology research [68] and have attempted to tie user factors, usability and HCI to the system development life cycle [69] [70]. HCI also innately represents the interaction between the Human and the Computer. Traditionally, HCI studies, especially research captured by ACM SIGCHI (Special Interest Group on Computer-Human Interaction) were concerned with designing and implementing interactive systems for specified users, including usability issues [71]. To build a system with desired level of usability, practitioners use the design-evaluate-design cycle. This process involves the science of defining the target usability level in advance and also ensuring that the software developed reaches that level called Usability Engineering [72]. Usability engineering is “a process through which usability characteristics are specified, quantitatively and early in the development process and measured throughout the process” [73].

Usability demands human centered development approach for the system where the quality is defined by user satisfaction. The user oriented approach focuses on external attributes like look, feel and interaction, and takes a multidisciplinary approach to include users, customers and User Interaction/Interface (UI) design experts [74] and systems to make it a Human-Computer interactive system. According to Bashir Qureshi in [75]:

“User interface design or user interface engineering is the design of computers, mobile communication devices, software applications,
websites with the focus on the user’s experience and interaction. The goal of user interface design is to improve users experience with simplicity and efficiency ... known as ‘User Centered Design’. The term user friendly is often used as a synonym for usability which denotes the ease with which people can employ a particular tool ... in order to achieve a particular goal.”

2.6.2 Need for Usability Study

As the user base increases, the user interface becomes a larger portion of the software in a computer system. Building a good user interface is integral to the process of building the system at the design phase. Ad hoc development strategies for user friendliness leads to poor design, increased defects and training period, decreased user satisfaction and retention of knowledge. The basis of a good user interface design is to work on the users’ capabilities and limitations rather than machines’ [76]. Though the term ‘good’ is subjective having different meaning for different people, a good user interface encourages an easy, natural and engaging interaction between the user and the system to carry out the required task. However, it is the usability factor that makes the user interface good, bad or poor [77] and usability evaluation remains the “gold standard” for evaluating interactive systems [78].

2.6.3 Usability Metrics

Usability is a software quality metric assessed throughout WDLC and provides a quantitative basis for making decisions about software quality. It is a quality attribute that assesses how easy user interfaces are to use. The word "usability" also refers to methods for improving ease-of-use during the design process [79]. Usability is defined in Part II of the ISO 9241 standard [80] as,

“…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.”
Effectiveness is the accuracy and completeness with which specified users can achieve specified goals in particular environments. Efficiency is defined as the resources expended in relation to the accuracy and completeness of the goals achieved. Satisfaction is the comfort and acceptability of the work system to its users and other people affected by its use.

ISO has developed two categories of standards on usability: Product-Oriented (ISO 9126 and ISO 14598) and Process-Oriented standards (ISO 9241 and ISO 13407). The property of interest and their definition with regard to usability varies with the target audience which may be an end user, developer, HCI designer or team leader.

The essential activities to achieve usability in human-centric design are described through four main principles by Human Centered Design Processes for Interactive Systems, ISO 13407 as:

1. The active involvement of users
2. An appropriate allocation of function between the user and the system
3. The Iteration and design solutions
4. Multidisciplinary design teams

ISO 13407 further elaborates on the essential human-centered design activities as follows:

1. Understand and specify context of use
2. Specify the user and organizational requirements
3. Produce design solutions (prototypes)
4. Evaluate designs with users against requirements

Adapting to these guidelines ensures users’ perspective is a part of HCI design and development process influencing the usability of the final product. Several studies for comparing usability of web development have been reported in literature. In [81] seven methods of measurements and tools of usability in software products and software artifacts in the Web are discussed. The first investigation towards measuring size metrics using function point analysis method
was conducted by Rollo [82]. Subsequently, the architecture for website usability analysis was proposed by [83] and the theoretical model to study the universal usability of the web to a wide range of audiences was projected by [84]. The authors also defined a set of universal usability metrics (UUM) to be applied into web portions at different abstraction levels.

Web metric for usability evaluation techniques include Heuristic Evaluation [85] Cognitive Walkthrough for the Web (CWW) [86] in which CWW is particularly used in the design and usability evaluation of websites [87]. Web metrics assimilation by researchers so far has been generic in nature varying from a simple web site to an e-Commerce application. In research based on online learning environment, metrics focused more on the performance measurement of the learners or costimation [1] of commercial web development activity. These studies measured readability and maintainability of hypermedia applications, [88] page size of Web application [89], size metric towards predicting effort in hypermedia and web applications [90, 91, 92, 93, 65].

The online delivery of a system is a result of meticulous adherence to WCDLC/WDLC from conceptual level to story boarding to deployment. WDLC is integral to Web engineering- the application of engineering principles to develop quality Web applications. Web is a delivery platform for Web hypermedia applications and Web software applications [1]. Web application combines the characteristics of both. Web Size Metric and Cost estimation is an area of large interest to researchers due to utilization of diverse technologies both at the client end and server end such as Java (Java, servlets, EJB, applets, JSP), JavaScript, XML, XSL, PHP, Perl, Python, etc. Botafogo et al [58] proposed size metrics to measure connectivity (link) and organization into a single reading path of a hyper-document while, authoring and maintenance problem metrics was brought forth by Yamada et al [94].

2.6.4 Observations

Most of the work in Web Engineering has focused only on few specific areas due to highly disparate nature of web systems which has inherent difficulties in coupling the heterogeneous components cogently. Though initial phases of web
development focused mainly on delivery, technology, costing and framework, quality of the applications was not considered with seriousness until the adoption of web for legacy and enterprise applications. The focus on quality has therefore diversified into relatively distinct areas like development, usability, documentation, reuse, functionality, etc.

The outlooks on activities in webosphere elsewhere and the dire need to propagate education en masse motivated us to survey a Web application such as e-Learning and understand the level of its implementation in India. An e-Learning platform is of interest since it is a system which provides integrated support for creation, organization, delivery, communication, collaboration and assessment - in an educational context [95]. The next section focuses on online learning scenario in India.

2.7 e-Learning in India

The Advances in ICT has made it possible today to provide a whole range of high-quality and cost-effective services. These services are related to video, voice and data content through a single communication channel using appropriate terminal equipment [96]. Thus opening up a whole realm of possibilities for provision of e-Government, entertainment, education, telemedicine, e-Commerce, info-services, etc. ubiquitously.

Efforts are being made in the field of education all over India by the Government of India (GOI) to implement the advances in ICT. But, lack of coordination, inadequate workforce, inadequate emoluments, etc has hampered many projects. Also, absence of strong control and monitoring has affected many ambitious projects. In 2007, about 10.7% (out of $42128 million, Figure 2.8) of the government’s expenditure was spent on education which is mainly non-profit. But, the effectiveness of such investment was hard to evaluate. With a lot of investment in progress in this area, it is worth pondering over how education and training is imparted and evaluate how to make a good business sense.
Today, India has about 400 universities and more than 20,000 colleges and the student enrolment crossing 12.9 million. About 63% of higher education providers in India are private institutions, rest governed by the Central or State government India, being a recognized player in communication technology, it is quite a surprise to find that e-Learning in India is still in its nascent stage.

### 2.7.1 Academic Scenario

One-fifth of the budgeted public education expenses in India by the government are spent on tertiary education. Only some premier government funded institutions like the Indian Institute of Technology, Indian Institute of Management, etc., offer course in e-Learning apart from IGNOU which offers distance learning programs. Other initiatives from the government are the Edusat, NPTEL programmes. The private investment in online learning for higher education is very low and is not able to cope up with the growing demand and global competition.

Though Report Buyer [97], an UK based company in its report “Indian Education Services-A Hot Opportunity” summarizes the Indian education scenario as a revolution which has come around with the emergence of a whole new class of education providers, including private institutes, distance education providers, self-financing courses in public institutions and foreign education providers, the impact is yet to be felt.

The Indian education system offers tremendous opportunities for various universities worldwide to enter the rapidly growing education service market in the country. This is because India has all the resources and potential to become a
regional hub. However, the sector particularly lacks in proper investments, which is a constraint in coping with growing market demand and global competition.

2.7.2 Corporate Scenario

Growing globalized market and fewer resources have driven many corporate in India to use e-Learning as an effective learning strategy reducing the training cost and hours. Competition triggered the corporate to implement online training to employees. The success of the business depends more on high quality employee performance which in turn depends on high quality training. Corporate e-Learning is one of the fastest growing markets since the companies are exploiting advances in technology to train the employees more rapidly, more effectively and at less expense [98].

The growth in corporate e-Learning has simultaneously triggered the market for online educational services providers in India, many of whom provide services abroad. Some of the major players providing offshore services are NIIT, Aptech, Tata Interactive Systems, etc. Gurukul online solutions, provides job-oriented vocational education in a variety of domains via e-Learning [99]. Revenue from the Indian e-Learning off-shoring industry was more than USD 341 million at the end of calendar year 2008. It is estimated that the total revenues in the e-Learning offshore industry exceeds USD 603 million in 2012 [100].

The future of e-Learning industry within India can grow as the number of internet users grow and the number of reputed firms shows interest in e-Learning business. However, the reasons for the lack of progress in e-Learning in India can be attributed to low PC and Internet penetration and awareness of IT environment. India is ranked 23rd out of 52, in its peer group of resource and efficiency-driven economies in the use of connectivity technologies to enhance social and economic prosperity. The connectivity scorecard (a global ICT index) of India at 2.14 fairs slightly better than its neighbour Pakistan (connectivity scorecard-2.09). But, India trails far behind Brazil, Russia and China among the BRIC nations. Though India’s population is a huge disadvantage, we consider that India has a huge market potential when it comes to ICT implementation.
Use of ICT substitutes other processes or activities: e-mail instead of paper mail, video conference instead of face-to-face meetings [101]. With more and more IT driven services, new ICT infrastructure comprising servers, storage systems, physical and wireless networks are in use [102]. This facility that centralizes an organization’s IT operations and equipment, storing, managing and disseminating data is called the data center. Large scale dissemination of education in Massively Online Open Courses (MOOC) such as edX, Coursera requires data centres. It is therefore interesting to know if online learning supports Green-IT.

2.8 Green-IT

Green Computing, Green-IT or ICT Sustainability, is the study and practice of environmentally sustainable computing of IT [103]. The data centers facilitating IT are heavy consumers of energy. Many businesses and organizations which depend heavily on technology have realized the off-shoot of problems which may be ecologically unviable. Hence, it is essential to deal with computers and its subsystems effectively and efficiently with minimal or no impact on the environment [104]. In order to mitigate the side effects of technology, Green-IT focuses on methods to decrease waste and pollution generated during the life cycle of technology gadget and software utilization.

The energy consumption of India’s ICT infrastructure is close to 4% of country’s overall consumption and accounted for 2% of overall carbon emissions in 2010. It is estimated that these emissions will grow at a compound rate of 6.5% and 6.3% respectively through 2015 [105]. Similarly, hosting WBL systems on data centers consumes energy. Hence, it would be of interest to compare the energy efficiency, CO₂ emissions due to WBL with respect to the data center and traditional mode to verify whether WBL is environment friendly.
2.9 Discussions and Perspectives

This chapter reviewed the literature regarding the framework, modes, technology of e-Learning as a Web Application. The development of any Web application follows Web engineering processes which was discussed in section 2.6 followed by an overview of the e-Learning scenario in India. The research work in this area so far have focused on technology or services, user experience, usability from the developer’s angle, web cost estimation and effort to produce Web artifact. The survey enabled us to find the gaps in research in Indian WBL environment based on usability of HCI characteristics in online learning environment. This issue is addressed in chapter 3. While rework estimation due to HCI defects and cost estimation for WBL applications is addressed in chapter 4, business model for e-Learning in India and ROI evaluation for institutions starting online learning programs is proposed in chapter 5. Further, chapter 6 focuses on the issue of eco-friendliness of WBL and suggests measures towards Green-IT as a social endeavor to substantiate the research study. Chapter 7 concludes with a summary of the research contributions and scope for further research.