Chapter 2

Literature Review
2.1. Introduction

The main objective of any E-learning software is to reduce the necessity of the personal teaching process. The research community is finding new ways to replace the existing traditional teaching methods with the help of computer and information technology. The rapid growth of E-learning technologies creates various alternatives to optimize this process.

This research work focuses on replacing the entire classroom or personal or traditional teaching process with the help of existing and new technologies. To do this job successfully it is necessary to replace the teacher, who is the backbone of the teaching learning process. Thus the simulation of the teacher with the help of computer and information technology is required to achieve this target.

The literature survey has been carried out to find the research work, which has been done so far, for replacing the traditional teaching methods. This survey mainly focuses on:

- Existing software based effective and efficient methods for E-learning,
- Latest computer and information technologies for E-learning,
- Modern sophisticated E-learning software tools.

2.2. E-learning Technologies

2.2.1. History

The journey of E-learning has started from 1985. It grows rapidly along with the technology. The figure 2.1 shows the details.

Every day the new technologies are changing the dimension to e-learning. Today's e-learning system involves the major fields of computer science and technology like Internet programming, Multimedia, Data Base Management, E-commerce, Human-Computer Interaction, Object Oriented Programming, Software Engineering and Networking etc. The e-learning is an inter-disciplinary field. Apart from computer technology it involves pedagogy or educational sciences, human psychology and study of neuroscience.
Study of Effective Design Methods and Implementation of E-Learning Software

The d-learning (distance learning) is the origin of e-learning (electronic-learning) and moving towards m-learning (mobile-learning). The Education was the very stable field for centuries. But the Internet has made it dynamic. This field started with classroom teaching and then gradually moved towards synchronized, asynchronized and independent learning (see figure 2.2).

Thus e-learning software development is the most complex phenomenon. The figure 2.3 shows the elements of today’s e-learning system.

The e-learning can be broadly classified in to four categories

- Corporate Sector
- Life long learning
- Higher Education
- K-12

It has been predicted by International Data Corporation (IDC) that E-learning will be the largest industry in the world by 2011.

Jay Cross and Ian Hamilton have discussed step by step the history of e-learning [28]. In 2000, Tim L. Wentling as well as Brain W. Ruttenbur have predicted the future of E-Learning and the changes in the new economy [29-30]. Dr John Eklund (2003) has discussed in his research paper the state of e-learning, issues and implications for the use of technology, driving forces for e-learning etc [31]. Dr. James Z. Li and Richard Close (2000) have explained the E-learning and Knowledge management issues in his white paper [32]. This issue has again highlighted by E. Morales [33]. Keith Bachman (2000) has covered corporate e-learning in detail in his report [34]. In 2002, Dr. Dale Spender has provided the details of many important issues of e-learning in his report [35]. Warren Longmire in 2000 has explained the emerging strategies for effective E-Learning solutions [36]. Desmond Keegan in 2002 has published the book on E-learning to M-learning and focus on use of handheld devices in e-learning [37]. The use of new technologies for e-learning has explained by Arnold, J (2004) [38]. Robert S. Friedman and Fadi P. Deek (2003) have presented the pedagogical, technological, and business trends that together affect the direction of innovation in virtual education [39].

The second diagram is labeled as 'The transitions of e-learning'. It contrasts Classroom-based learning with Synchronous learning, Resource Center, laboratory training with Independent learning, and portrays the differences in TIME and PLACE. Classroom-based learning is shown to have the same TIME and PLACE, while Synchronous learning has different TIME and PLACE. Resource Center, laboratory training also has the same TIME and PLACE, but Independent learning has different TIME and PLACE.

These diagrams are sourced from 'Consulting Business Intelligence' and provide an overview of the evolution and transitions in e-learning technologies and methods.
Fig. 2.3: Elements of Today’s E-learning system

Similarly many other important issues have been discussed in the research papers or reports of Charles Clarke (2003), David G. Goldstein (1997), Joachim Schaper, Dongsong Zhang (2004), Serfontein (2004), Peter Zintel (2004) etc [40-53].

2.2.2. Multimedia and Content Development

The multimedia technology provides the most effective way of developing E-learning solutions. Learning with multimedia technology has introduced an important paradigm shift in education that will have a very important impact on the educational system and the way teachers teach and students learn.

Multimedia provides a means to supplement a presenter’s efforts to garner attention, increase retention, improve comprehension, and to bring an audience into agreement. Multimedia offers an excellent alternative to traditional teaching. By allowing the students to explore and learn at different paces, every student has the opportunity to learn at his or her full potential. The interactive multimedia learning displays several
characteristics that would make it a more effective way to teach and learn, such as the following:

- It incorporates multimedia and interactive features which is a fundamental departure from the traditional presentation of educational content.
- It establishes a two-way interaction between the computer and the user, thus enabling he/she to be an active learner instead of being a passive recipient of information as in the traditional mode of learning.
- It is a visually-based module which allows the user to see the concepts and information presented in a more graphical and interesting manner.
- It contains materials that allow students to view them at their own pace, time and place.
- It contains features that allow students to control the flow and path of the navigation and be responsible for the information acquired [54].

The well known researchers Roxana Moreno and Richard E. Mayer have shown these things with the help of experiments [55]. Mayer and his colleagues have conducted a decade’s worth of research investigating the nature and effects of multimedia presentations on human learning [56]. In 2003, Glenn D. Blank, Soma Roy, Shreeram Sahasrabudhe, William M. Pottenger and G. Drew Kessler have shown that Multimedia can accommodate diverse learning styles [57]. The neuroscience supports these theories. Over the past decade, functional Magnetic Resonance Imaging (fMRI) has emerged as a powerful new instrument to collect vast quantities of data about activity in the human brain [58]. Michael M. Danchak has discussed the challenges of dealing with the human and technical aspects [59]. In 2003, Ian W. Gibson presented his ideas on “intersection of pedagogy and technology” [60]. Improper use of multimedia technology can create memory overload problems and can hamper the learning process. Tabbers H. K (1999) have nicely presented the research findings on Cognitive Load theory [61].

The streaming multimedia technology is needed for web based E-learning solutions. In 2004, V. Uskov and A. Uskov have provided the details [9]. Many research findings are available on this topic [62-71].
2.2.3. Instructional Design Theories and Software Engineering

Instructional design is a systematic, repetitive process of activities aimed at creating a solution for an instructional problem [72]. Development of interactive e-learning courseware has focused largely on the instructional design approach of multimedia applications and has brought about a substantial amount of success in producing engaging multimedia educational resources [73].

In contrast to software engineering, which relies on relatively well-established development approaches, there is a lack of a proven methodology that guides Web engineers in building reliable and effective Web-based systems. Currently, Web engineering lacks process models, architectures, suitable techniques and methods, quality assurance, and a systematic approach to the development process. As a result, Web engineering is still struggling to establish itself as a reliable engineering discipline. Said Hadjermouit (2005) has discussed this issue in his research [74]. The research work carried out by Charalambos Vrasidas (2004) presented the complicated issues of Design in e-learning Systems and Pedagogy [75].

Development of interactive e-learning courseware has focused largely on the instructional design approach of multimedia applications and has brought about a substantial amount of success in producing engaging multimedia educational resources. Muthu Kumar (2004) has explored how the multimedia instructional strategies and processes can be enhanced by incorporating the principles of cognitive psychology in the design phases. Human cognitive architecture involves both, a limited working memory with visual and auditory channels, and a permanent long-term memory for storing multiple schemas. Understanding and tapping the rich potencies afforded by the human cognitive architecture would result in a more purposeful instructional program embedded in multimedia-mediated learning environments [76].

Pais, C.; Pires, V.; Amaral, R.; Amaral, J.; Martins, J.; Luz, C.; Dias, O.P. (2004) have presented a project with the objective of implementing an alternative solution to teaching methods. This solution involves the assistance of computers working as pedagogical tools complementary to the traditional methods that are used in the teaching of subjects such as Mathematics, Electrics and Electronics. Besides the background that has motivated the
realization of this project, this work presents not only the strategies, principles and philosophy which were defined for the courses content but also the way in which a solution was implemented, as well as the strategy expected to be carried out to test the solution and evaluate the results of these tests. In addition, it will also explore the alterations that this type of strategy may cause in the roles traditionally attributed to teachers and students and the effect that these changes bring about in the teacher-student relationship. Finally, this work also contains a brief presentation of the organizational structure of the solution, the phases and main tasks that this project involved, other phases expected to be carried out in the future, as well as its conclusions [77].

Many E-learning systems fail to satisfy the learners' needs and requirements due to the absence of key human and technological issues in the engineering process. The successful development of E-Learning systems requires the identification of human issues such as, social and cultural factors, quality components and pedagogy requirements as well as, technological issues such as the learning environment. Stephanos Mavromoustakos, Katerina Papanikolaou, Andreas S. Andreou, George A. Papadopoulos (2005) have examined these issues and presented the importance of developing a learner-centric environment through the use of an E-Learning engineering process [78].

Yannis A. Dimitriadis, Juan-Ignacio Asensio-Pérez, Alejandra Martínez-Monés, and César A. Osuna-Gómez (2003) presented the Component-Based Software Engineering (CBSE) approach. The use of Information and Communication Technologies in the education domain has been characterized by the need of providing flexible systems that are adaptable to particular learning situations. In this sense, CBSE has emerged as a software development paradigm suitable for obtaining reusable, flexible, and customizable distributed applications, which would provide great benefits to the e-Learning domain [79].

Courseware systems are software systems that support intended instructional processes. In order to build a courseware system of high quality, teachers need an easy to use courseware engineering tool. Whereas there exist a lot of tools for the implementation phase (authoring tools, learning management platforms) the design phase of courseware system development is neither supported by methodologies nor by tools. Judit Bajnai
(2005) has shown an approach to conceptual courseware system modeling and presented eduWeaver as a tool for computer aided instructional modeling [80].

The software engineering approach for e-learning content development has been discussed in several theories [81-85]. The rapid evolution of e-learning models increases the number of decisions that have to be made when developing web-based learning systems. ADISA is a web-based system for a project team designing an e-learning system while working on the web. It is based on the MISA method that defines 35 main tasks through which the user produces the design specifications of a learning system, describing knowledge, skills and competencies, learning scenarios, activities and resources, learning materials, and finally, the delivery processes. The innovation in MISA and ADISA is three-fold. a) A key component of ADISA is its object-oriented knowledge modeling approach sustained by a graphic model editor. b) The processes embedded in the method encompass all the dimensions of a telelearning system. c) Software engineering principles are integrated to support systemic design by the project team. Gilbert Paquette, Ioan Rosca, , Heana De la Teja, Michel Léonard and Karin Lundgren-Cayrol (2001) describes both the pedagogical and technical aspects of the ADISA system [86]. Many researchers have contributed there valuable research in this area [87-96].

2.2.4. Simulation Technologies and techniques

2.2.4.1. Simulation

Computer simulations is an instructional context involve using the computer to model real-world phenomena in order to help students gain insights into the behavior of complex systems. Students interacting with an instructional simulation gain a better understanding of a real system, process or phenomenon by exploring concepts, testing hypotheses, and discovering explanations [97].

Fu-Kwun Hwang, Francisco Esquembre (2003) have developed “theEasy Java” Simulations (EJS) software tool for the creation of computer simulations. A computer simulation is a computer program that reproduces a natural phenomenon through the visualization of the evolution of its state. Each state is described by a set of variables that
change in time due to the iteration of a given algorithm. EJS was developed for an Open Source Physics Project at the University of Murcia, Spain. EJS, and the simulations created with it, can be used as independent programs under different operating systems, or be distributed via the internet and run within html pages by most popular web browsers [97].

Herbert L. Dershem, Ryan McFall, Ngozi Uti (2002) have described a project to develop a visualization of the algorithms for implementing methods of the Java Linked-List class. This visualization will serve as a prototype for visualization of any Java Collection Class. The Java Collection classes consist of a hierarchy of interfaces and classes representing Abstract Data Types (ADTs), originating with the Java Collection interface. In these classes each class consists of an API containing the methods of the class, but are relatively independent of the implementations. The prototype, called JVALL (Java Visual Automated Linked List), was developed as an extension of the Java Linked-List class. In this approach a user-written Java program is submitted to the Jeliot server, which produces an animation of operations that the submitted code performs on a data type. Jeliot provides animations for all Java primitive types, arrays, stacks, and queues [98].

Java applets, embedded in course web sites, can enhance educational material with animations, applications that are responsive to student choices, and provide interactivity to engage students in active learning. The interactivity inherent in these applets allows a student to explore, to make errors, and seek their own solutions. They can all be incorporated into online assessment to allow students to interact with real tools. Geoffrey Crisp (2002) in his research papers has explained this concept [99]. Ashley George Hamilton-Taylor, Eileen Kraemer (2002) have done similar work. They developed SKA (Support Kit for Animation) software for visual data structure library, a visual data structure diagram manipulation environment, and an algorithm animation system [100]. Similarly, David Abraham, Liz Crawford, Leanna Lesta, Agathe Merceron, Kalina Yacevi (2001) have developed the Logic Tutor, a tool to support computer science students in their learning of logic and more specifically in their learning of formal proofs [101].

In 2004 Kuc, R., Jackson, and E.W. Kuc, A. have developed a flexible method of teaching introductory robotics. Students program an autonomous mobile robot to
complete a set of tasks of increasing complexity, including multirobot tracking. Two proximity detectors and a pair of photo-sensors provide six sensory inputs to logic circuits, which control two drive motors and two internal memory flip-flops. The robot brain is a digital logic circuit programmed by loading an ASCII code that specifies the logic circuit configuration, similar in approach to a field-programmable gate array. The logic circuit design evolves with task complexity. Two internal set/reset flip-flops can be used to design a finite-state machine to implement a memory. One novelty of the method is that students develop and test their logic circuits on a Web-based graphic simulation before downloading the code to an actual robot. The simulation is written in JavaScript to acquire sensor readings and control robot motors to interact with the environment in a flexible manner. The simulation is downloaded with the Web page and runs smoothly on the client's machine, eliminating the need for high-speed connections [102].

The Structural Mechanics Division at the University of Zaragoza provides different courses on the Digital Teaching Web (DTW), including Structural Mechanics and Finite Element Method for Structures. All necessary tools and documentation are included on the web and teachers and students can interact directly. The main objective is to use the DTW to teach Structural Mechanics within the curriculum of Mechanical Engineering. Software is also included to easily simulate the behavior of a wide range of simple structures [103].

L. W. Pettersson, N. Jensen and S. Seipel (2003) have specified a 3D network-distributed virtual environment (DVE) where students learn computer graphics programming. The client/server software consists of a programming environment, the 3D DVE that is used to develop dynamic link libraries (DLLs) to generate 3D graphics. The software distributes a DLL to remote clients in an automatic way, and allows students to view the output of the DLL together in the interactive 3D DVE [104].

The programming approach is perhaps the most popular approach in teaching introduction to computer graphics courses. However, it suffers a significant drawback. Students must learn a lot before they can write their first program. Worse, they may not even know if their images are correctly produced. Additionally, the programming approach depends on an API (e.g., OpenGL) that may only support local illumination models. Consequently, students will miss important topics that are associated with global
illumination models. To overcome these problems, a pedagogical system GraphicsMentor was developed. GraphicsMentor allows students to modify parameters of the camera, objects, and light sources interactively, and visualize the rendered result on-the-fly. Moreover, it is able to export a scene to POV-Ray, a very popular ray tracing system, for rendering. GraphicsMentor is being extended to include photon mapping and radiosity. In this way, with the help of GraphicsMentor, a student should be able to grasp the fundamentals of computer graphics quickly and easily in a learning-by-doing way [105].

B. Pham, J. unnn, I. Anderson, H. Mays and D. Bell (1996) have described the work involved in a project funded by a 1996 CAUT grant, for development of a software package to supplement and enhance the teaching of Computer Graphics. The material which demonstrates fundamental concepts in computer graphics, is designed in a modular way, and aims to utilize the capabilities of interactive, computer-enhanced learning environments. These environments are learner-centered and engage learners in experiential, problem-based approaches to learning [106]. Similarly the other solutions are provided by S. Grissom (1996) [107-109].

For teaching the Microprocessor and computer architecture many researchers have developed interesting solutions [110-113].

2.2.4.2. Virtual and Remote Control Labs

Christof R’ohrig and Andreas Jochheim (2000) have presented a platform independent approach to remote experimentation. It addresses a wide area of problems occurring in conjunction with remote laboratory experiments, starting with access management procedures via remote control to network based analysis of measured data. It has presented the architecture of the remote laboratory at the University of Hagen. Students have access to the experiments via Internet from anywhere at any time. They have controlled the experiments exclusively with their standard Web browser, no additional software is needed. The remote laboratory is based on a client/server architecture, which is mainly implemented in the Java programming language. The methods and software modules developed for the lab are generic and frequently used in several remote experiments at German universities [114].
C. Schmid (2000) has presented remote laboratory approaches for control engineering using virtual reality on the Web. Extensions like plug-ins and Java applets, which has used MATLAB/SIMULINK for simulations, have been integrated into the Web browser [115]. Many other researchers have involved in developing virtual and remote control laboratories [116-123].

For software simulation many tools have been introduced in the market and will be covered in detail in chapter 3.

2.2.5. E-commerce based Distribution and Management Systems

In the web based E-learning software the contents are distributed through the E-commerce based Learning Management System (LMS) [124-130]. The LMS is the very costly affair. The Open Source LMS like Moodle is the most cost effective solution [131].

2.2.6. Networking and Collaborative Systems

The major advantage of classroom teaching is the collaborative learning activities between students and among the teacher and students. This can be achieved through Peer to Peer (P2P) and Client Server technology [132-142]. Recently many tools have been introduced for P2P based collaborative activities like Presence-AR [143], Groove Workspace [144] etc. Out of these tools the Groove Workspace software is more popular and having good facilities.

2.2.7. Reusable Learning Objects (RLO) and E-learning Standards

R.I.O is the latest e-learning content development technique, where first time the principles of software engineering and object oriented programming have been applied to the e-learning field. The main idea of R.I.O is to break down the educational content into small chunks that can be reused in various learning environments, in the spirit of object-oriented programming. They are much smaller units of learning, typically ranging from 2
minutes to 15 minutes. There are enormous benefits of RLO technique and used extensively for developing E-learning solutions [145-159].

SCORM stands for Sharable Content Object Reference Model. SCORM is a set of specifications created by the Advanced Distributed Learning initiative (ADL). It's a specification for standardizing the reusability and interoperability of learning content. SCORM specifies how content can be built and reused across any Learning Management System (LMS), and how LMS can be constructed to use any Sharable Content Object (SCO). The lot of research work has been carried out in the recent years on this topic [160-167].

2.2.8. Mobile computing

Mobile telephone ownership and usage is now almost ubiquitous amongst student communities, but until now has been largely passed over as a technology for supporting student learning. As increasingly powerful networks and handsets are developed, it is claimed that "m-learning" (mobile learning) will be one of the largest applications [168].

Mobile learning is an emergent paradigm in a state of intense development fuelled by the confluence of three technological streams: ambient computing power, ambient communication and intelligent user interfaces. The pedagogy of mobile learning, however, has yet to become clearly established [169].

The mobile technology is emerging quickly in the university environment of the handheld technology, well-known as PDA (Personal Digital Assistant) or Pocket PC. Consequently, the application of these technologies in the teaching (m-Teaching) and learning (m-Learning) imply significant changes in the current methodologies [170]. A lot of research work is going on in this field [171-178].

2.2.9. CD Security

In the last decade lot of research work had been done in the field of “Use of computers for teaching” through out the world. Hundreds of softwares and Teaching tools have been developed. Many of them have been distributed with the help of CDs. But unfortunately,
the CD piracy has hampered the growth and discourages the developers. It is impossible to develop the generalized CD security mechanism, which can protect all types of CDs from piracy. There are many CD Protection mechanisms available in the market but they cannot provide hundred percent protections [179-189].