CHAPTER 1
INTRODUCTION

1.1 MOTIVATION

Learning is a lifelong process for every person in this dynamic world. Traditional educational methods rely on knowledge, acquired by books and teachers, which must then be applied to real situations. In this digital era, innovation methods on teaching learning practices using advanced technology are of prime importance. Universities stress on implementing Information and Communication Technology (ICT) in classrooms. They are critical tools in science with a potential to influence science learning and teaching. E-learning activities along with software games, simulated laboratories provide an experience through three dimensional (3-D) virtual reality (VR) interfaces.

Corporations need to continuously train their employees. As the demand grows, many technologies and techniques are being explored for the new paradigm “Learning for Life”. The growth of the Internet is bringing online education to people in corporations, institutes of higher learning, the government and other sectors [1]. The proliferation of information over the Internet and the introduction of ICT in education altered the way people learn. The present web technology offers individualized instruction to any person at any time and place. Using the Internet to enhance learning can be termed as E-Learning.

The education system keeps evolving and transformed moving towards a participatory, interactive learning paradigm where students learn through social networks and by participation, collaboration and immersion in digital spaces to seek, share and create knowledge for self-realization. The majority of e-learning systems consist of HTML pages with embedded pictures, movies and Flash contents. They are all two-dimension in nature. Most web-based course delivery systems are based on the student reading the course material and watching static or animated illustrations. They lack interactivity.

The key advantages of e-Learning are flexibility, convenience and ability to work at any time and place where an internet connection is available. There are also cost and time benefits without having to commute to and from teaching campus. The developed e-courses would supplement and complement the class room teaching to
make learning more effective. Besides, it would also be the resource for updating the knowledge and skills of the field of study. The changing nature of digital information assets is transforming the way we think about creativity, innovation and pedagogy.

Learning can be enhanced by utilizing e-learning because it offers:

1) Removal of time and space barriers compared to traditional classes.
2) Self-regulated learning is provided.
3) Effective and interactive teaching and learning strategies are allowed for individualized learning based on personal needs and the possibility of project-based teaching.
4) Diverse educational information and services.
5) High assurance of information accuracy.
6) Interactivity in the process of communication.
7) Cost effectiveness compared to traditional classroom-based teaching and learning.

E-Learning is a form of technology where learning material is delivered digitally through the Internet that promotes learning by eliminating time, distance and socio-economic barriers. It is also a supportive learning tool to be used in a traditional class room. An effective e–learning system involves the development and adoption of learning standards. Many factors affect the learning: students' background knowledge, their motivation and interests, their learning strategies and goals, and overall learning context. The system must be a dynamic interactive representation, where learners can manipulate and take part in a particular activity within the discipline. Learners must be considered as not passive recipients of information, but engaged with the material that is responsive to their actions. Interactivity results in deeper learning because learners can test their understanding and learn by mistakes.

With a highly competitive and dynamic market, continuous innovation becomes a goal in which knowledge is seen as the core resource and learning is viewed as the most important process [2, 3, 4]. Therefore, a new way of training, learning and managing knowledge becomes imperative in today’s organizational operations. Focus should be placed on synchronous learning tools and e-learning technology will make training and learning in organizations much more accessible [5]. Skill and experience can only be obtained through practice and interactivity, which are the essential features for experimental E-learning systems.
E-Learning sometimes referred to as online learning, web-based learning, distance learning and technology-based learning, among other names, is a concept that has gathered significant global attention. E-learning is the only method of learning, where two distinct learning styles of auditory learners and visual learners are incorporated. In e-learning, content is delivered via the Internet, intranet/extranet, audio or video tape, satellite TV, and CD-ROM whereas online learning is done by only with the help of Internet and Intranet. In this method of learning students have to take more effort (self-motivation) because there is no face to face interaction between students and tutors or peers. Though these can describe learning content in a better way than sole text, they do not provide interactivity, which is necessary to gain skill and experience over the Internet. To solve this and make the online curriculum more interactive, Virtual Reality (VR) has been introduced.

Knowledge on Computer Graphics, Sound processing, and sensors, displays, computers, and graphics board is required to build and test VR systems. VR contents have to be optimized according to different goals such as its basic function, usability and presence. Students are able to explore and try out different virtual objects and immediately see their impact with respect to system performance, interaction usability, realism and presence. VR integrates computer hardware and software resources together, put the elements of real world to the virtual environment, people would feel like in the real world through the vision audition and interactive provided by the virtual world.

Industries plan their investment in training for employee development performance, such as training as they begin to recognize that the knowledge, skills and competencies of their employees give them an advantage that is difficult for competitors to imitate. The business organizations have devoted considerable expense in training, whether provided by in-house personnel or out-of-house experts. Priorities are given on trainee competence related to acquisition of desired knowledge and skills that provide a foundation for the retention of knowledge and skill to the employees. Industries use the e-learning technologies of training to deliver most of in-house training or across training via web. The training will be delivered and controlled via computer using a variety of methods, including text, sound, graphics, still photography and motion video.

Database systems are used to create, store, manipulate and report on information stored in tables. They provide a powerful way to organize large amounts
of information and retrieve selected information. They operate rapidly and can be applied to real-time data entry situations where data is constantly entered, retrieved and updated. Most data is displayed in tabular reports and graphic displays in simple graphs and charts. While the graph is displayed, changes may occur in the data which will not be reflected in the graph in real time.

The concept of Virtual Reality (VR) in e-learning promotes interactivity. The technical content and artistic charm of VR inspire people to creation more and more interactive application. VR has already developed a strong and growing presence in education and in industry. The VR technology allows students to visualize abstract concepts, to observe events at atomic or planetary scales, and to visit environments and interact with events that distance, time, or safety factor make unavailable. The types of activities supported by this technology helps students to master, retain, and generalize new knowledge when they are actively involved in constructing that knowledge in a hand on learning environment. VR can range from simple environments presented on a desktop computer to fully immersive multisensory environments experienced through complex headgear and bodysuits.

*The goal of VR is to place the user in a three dimensional environment that can be directly manipulated, so the user perceives interaction with the environment rather than the computer* [6]. Web3D open standards such as VRML and X3D offer low-cost VR experiences with publicly available plug-ins for common web browsers, which can interpret and render interactive 3D scenes. They are a very powerful asset for e-learning applications, as students are immersed inside virtual worlds which provide the multimedia information specially designed to improve their learning process. Many VRML worlds are already designed and hosted on the Web, e.g. to facilitate shopping, to provide tourist and historic information, to ease the understanding of scientific models (geological, biological). The variety of experiments with VRML worlds is an indication of the increasing interest in the language for end visualization. The VRML representation of a scene includes, along with its geometric description, a full specification of the information associated to the 3D models and the way to present it to the student.

An affordance is a quality of an object, or an environment, that allows an individual to perform an action. The affordances of Virtual Worlds can be categorized into three forms. The first one is cores which are inherent. Those entities that are enabled from the core ones form the second category of potential types. The third
forms the entities that arise from their capabilities called emergent. A core of a virtual world is a 3D digital world, its presence and virtual ability. Presence in a virtual world or environment refers to a user’s perception of ‘being there’. Actions are enabled (agency), the world is made persistent and widely accessed (accessibility) through the internet. They form the second category.

A few emergent properties follow: Through VRML visual cues are established. The world can be scaled to any size. Simulation practices can be done in a virtual world. Agency includes interaction and creation. Persistence allows reflection which means “after action, review”. Activity introduces behavioral changes. Due to the accessibility of the 3D world, it becomes geographically independent. At the beginning, users were isolated in these virtual worlds since there was no support for interaction between them. When the world can be visualized by multiple users, it can extend to social form thus having anonymity, personal avatar and reputation. Worlds can be co-created by many users at the same time. Figure 1.1 depicts the schematic relationship.

![Figure 1.1 Affordances of Virtual Worlds](image)

**1.2 RATIONALE FOR SELECTING THE TOPIC**

The innovations in Information Communication Technology (ICT) have enhanced education and training. In traditional teaching conditions, students experiment has always been a relatively weak point. Every student cannot do the experiment by himself due to the lack of laboratory equipments. The students have to observe the plane image in the textbook in order to understand the principle of the experiment. Sometimes two-dimensional teaching software is used to learn how to
operate experiment, the software usually made by Flash. In the past decades, traditional user interface evolved and Virtual Environments (VE) emerged due to the rapid growth of the World Wide Web, the availability of powerful 3D graphics accelerators for PCs and high speed network devices.

The easy to understand visual representation yields high levels of trust on behalf of the user. VEs can provide a good level of realism and interactivity and provide life-like situated learning experiences that link experience to theory. VRML97 allows the description of dynamic worlds that can change with both the passage of time, and user interaction. Unfortunately, the current VRML usage model prevents its full potential from being realized. Today VRML is more or less used only to generate static scenes, mostly for demonstrational purposes. The VRML scene has no size limitation. Expansion and maintenance of the scene is very convenient. A model of VRML file can be distributed across network.

The dynamic generation of scenes depending on different access rights of different users, is not possible. In consequence, VRML is mostly used to only visualize static places because the development of tools and applications to support their generation is a costly effort. It is difficult to achieve the required level of interactivity and dynamics while creating computer simulations which resemble real environment situations. It is difficult to arrange for the world to change in response to external events. For example, if a virtual world models the current state of part of the real world (e.g., traffic flow in a city, footballers on a pitch) then movement of objects in the virtual world must reflect real-time changes in the real world.

A 3D virtual world is a computer generated environment where the user is free to explore and interact in accordance with one’s own free will. The main point of distinction with 3D virtual worlds is that they contain no inherent “goal” for the user to achieve. Rather, they are something like a virtual sandbox, where one is free to interact and explore at one’s will, learning by experimentally observing the effects of different actions. For instance, a freeform chemistry lab virtual world might teach the user important facts about chemical reactions by allowing them to freely develop chemical mixtures and then accurately portraying the consequences. In these learning tools, the emphasis is primarily on experimentation and “seeing what happens”. This research is to impart dynamism in e-learning through virtual reality by VRML. Domains considered are education, industrial training and visualization of database content. A comparative analysis is also made on the effectiveness of virtual reality in
e-learning. The implementation of VRML to visualize the 3D content is shown in Figure 1.2.

![Figure 1.2 Visualization of 3D Content](image.png)

The research *Enhancing E-Learning using Virtual Reality for creating Three Dimensional Web Content* presents different schemes for circumventing these issues. The proposed schemes in this thesis have the following novelties. An adaptive 3D website is developed to create 3D primitive models on user’s input dynamically; the VRML coding is developed on the fly. The dynamic VRML scene is rendered in real time, the rendering speed being 30 frames per second in real time. The users can learn the concept of 3D graphics by easily interacting with the virtual world. Interaction in VRML scene is also very rich in content and form. In relation to learner interaction, an important aspect that is unique to 3-D VEs is the ability to undertake embodied actions, including view control, navigation and object manipulation. VRML supports images, sound, animations and other multimedia file formats to enhance the realism of virtual three dimensional environments.
Secondly, VRML worlds are developed for industrial applications simulating certain activities for training purposes. Our study in this research is to provide three-dimensional web-based technologies for managing, accessing, and viewing construction project information. The modeling of steel structures and construction equipment as objects for inclusion in construction-site world models was studied. Our work is to extend the power of VRML so that it is used not only for defining shape models, but also for creating structures for behavior.

Third, a comparative study is made on learning through traditional classroom teaching, e-learning through conventional websites and e-learning through desktop Virtual Reality. Finally, a graphics data processing system is developed to store and dynamically reconstruct a 3D virtual world using a database system. Hence our main thrust to introduce dynamism in static virtual worlds is accomplished. The research is limited to single-user virtual environments.

1.3 SCOPE OF THE STUDY

Information technology is used to support the teaching and learning process. Web-based learning is mostly textual and static in nature. Since multimedia content is large in file size, the download time is considerably high. The proposed research work makes use of VRML, the global standard for presenting virtual world data over the web. A VRML virtual world is defined and described in a text file using the VRML language and not in a graphical format such as bitmap, vectors or other complex numeric information. A VRML interpreter is provided as a plug-in to the browser.

3-D VLEs can be used to facilitate learning tasks that lead to the development of enhanced spatial knowledge representation of the explored domain. It can be used to facilitate learning tasks that lead to increased intrinsic motivation and engagement. Also it can be used to facilitate learning tasks that lead to improved transfer of knowledge and skills to real situations through contextualization of learning. A Web3D-based interactive teaching package on 3D primitive geometry shapes is developed that provides a dynamic and interactive environment to easily comprehend the 3D concepts.

Cost effective training methods are explored by industries for skill development purposes. Desktop and web-based e-learning applications offer industrialists new tools to raise maintenance-related knowledge and competence. Simulated learning through virtual 3D animations let employees comprehend the
internal mechanisms of the equipment and the co-relation between the different parts. 3-D VLEs can be used to facilitate experimental learning tasks that would be impractical or impossible to undertake in the real world. VRML can be used to control, interact and monitor manufacturing processes visually thus imparting training from a desktop computer. The proposed research deals with the simulation of the production of steel beams and columns presented to the subcontractors from a parent company.

A system is required that is easy to develop and to extend; it can be integrated into a VE and, besides the usability side, its interface, internal structure and interaction options gives the opportunity to effectuate experimentations in VR modeling. This can be done using novel graphics primitives, integrating the controls into the environment and with different manipulation options. An easy to use and natural interface technique is needed that provides a low learning curve and suitable for inexperienced users, but still provides an acceptable alternative for e-learning aimed at interactive systems. Interactivity promotes motivation that accelerates learning, enables knowledge transfer through retention, and provides manipulative experiences unavailable in a normal training environment. Interactivity can be experienced in different ways:

- Simple clicking/activity
- Making basic choices
- Problem solving
- Creation

These activities can be used sequentially, primarily to build learner confidence in the content or the instruction, or they can be used to complement one another. Thus interaction is a strategy to engage learners through a hierarchy of tasks beginning at the basic level of navigation and ending in a more dynamic interaction of creating in real-life simulations.

E-learning has emerged into a viable solution for continuous, on-demand training and organizational learning. The effectiveness of learning, students’ level of satisfaction with the activities carried out and the rate of student interest in education through e-learning using three-dimensional content must be analyzed. So a comparative study is done to compare learning an identical course in a traditional framework, conventional e-learning and learning through web-based 3D virtual
worlds. The proposed system also permits elements of a virtual world to be modified in real time based upon a changing source of data where information is retrieved from a table of a database management system.

1.4 NEED AND IMPORTANCE OF THE STUDY

Large educational establishments are responsible for facilitating the uptake, development and implementation of technology in teaching and learning. Development of new learning environments can promote active participation through repeated practice, encourage shared experiences and enhance student motivation. The World Wide Web is now a rich educational resource that promotes and facilitates student learning and is increasingly being used to deliver course content.

The technical content and artistic charm of Virtual Reality inspire people to create interactive applications. The real-time interactive features allow users to be aware at the response of user’s action any time, so as to achieve the effect of virtual reality. The use of a visualization tool promotes interest and curiosity. Using virtual reality environment, the applications appear to be promising to e-learning tasks more nature and interactive. When users work with a 3D viewing capable browser it is possible to get a 3D environment with the ability to view the whole environment in 360-degree with the ability to zoom the scene, and quickly navigate through the various places in the world and viewing the world through different viewpoints. The effect of 3D objects modeling appears in increasing the user attention and interactivity with the objects as in real world. Hence a system is required to provide a rapid and efficient creation, modification and updating of a virtual world.

The proposed research allows learners to interact in the virtual world which resembles the realistic scenes by exploring them from many angles through different viewpoints thus gaining knowledge. Cost effective training methods are explored by industries to train their employees to acquire the required skills. In-depth knowledge of the functions in a factory is of vital importance for greater safety and better efficiency. Desktop and web-based e-learning applications offer industrialists new tools to raise maintenance-related knowledge and competence. The extensive use of the computer encourages the need for virtual machines and a factory to supplement an engineering coursework. Industries utilize this feature to impart training by simulations of a factory and the construction process of steel structures like beams and columns from raw iron blocks.
As the demand for building and maintaining ongoing capabilities increases, e-learning has played an increasingly important role among all the technologies supporting a knowledge management system. Most of the e-learning systems are based on HTML which is less attractive to students. The technology of virtual reality can be exploited to present a vivid 3D graphics real-time environment. An assessment is made on comparing the different educational techniques like traditional (classroom) learning, conventional e-learning and e-learning through virtual reality. Analysis is done on the effectiveness of learning, students’ level of satisfaction with the activities carried out and the rate of student interest in e-learning. Students’ opinions of the effectiveness of activities and elements of education were investigated. Due to the fact that much information is stored within databases it could be visualized by means of a dynamic generation of three-dimensional scenes. A number of emerging scientific studies have shown that traditional 2D training methods are just simply not as engaging to today’s learners as 3D.

The evolution of human learning has a smiling curve based on the learning media and learning effect as shown in Figure 1.3. Learning in prehistoric times was from nature. For example, learning to be a hunter involved going to the jungle to trace and practice killing animals if learning to be a farmer involved going to the field to plant wheat or rice, and learning how to fertilize and harvest. The learning was very important for survival, food and reputation. Therefore, the learning effect was strong. The invention of writing tools such as characters and paper made the learning easily acquired and available. However, the meaning of black characters on white paper is hard to visualize. The process of learning from reading is tedious and boring and the

![Figure 1.3 Smiling Curve of Human Learning](image-url)
learning effect is limited. The invention of television led to teaching programs, which have been welcomed because the learner can learn more from the colorful, dynamic and pleasant images than from textbooks. The computer age has led to the adoption of computer-based teaching or training. E-learning on the Internet has been a widely discussed topic for education and training since the Internet started to become widely used in 1996. Web-based e-learning can provide a learning on-demand model without time or location constraints.

The strong growth in 3D graphics, Web accessibility and networking creates new opportunities for education. Various studies have considered the next stage in the development e-learning on the Internet as 3D e-simulation on the Internet. The 3D virtual reality simulation on the Web can provide the learning environments that simulate natural reality. Learner can learn various subjects via the 3D simulation since they have strong motivation on the specific topics. The 3D simulation and learning on Web open a wide range of opportunities to enhanced educational experiences [7]. Teaching methodologies in engineering should evolve by following the development of the information technology to enhance the efficiency and effect of the learning by the students.

1.5 STATEMENT OF THE STUDY

VR has been proposed as a technological breakthrough that holds the power to facilitate learning. This project explores the ways in which VR may be used as a means of enhancing, motivating and stimulating students’ understanding of certain events, especially those for which the traditional notion of instructional learning have proven inappropriate or difficult.

1. To design a 3D learning tool for visualization of 3D geometry which can be generated dynamically through user driven input for the various parameters thus enabling an explorative learning of primitive 3D shapes.

2. To design a Virtual industry training model comprising of a factory and construction process of building steel beams and columns.

3. To study and compare the different learning methods and analyze the effectiveness of e-learning through virtual reality.

4. To design an application for the three-dimensional visualization of information stored in generic databases providing interaction and dynamic refresh of 3D worlds.
Different platforms are used for the implementation of the proposed designs. The Virtual Reality Modeling Language (VRML) provides a means to integrate virtual reality technology with World Wide Web technology. VRML is the industry standard description language for storing and delivering 3D information over the Internet. Using VRML, virtual worlds can be defined in human-readable text form and in a device independent manner.

Interactive and dynamic generation of virtual worlds is implemented as specified to explore and learn about 3D concepts. 3D visualization of a factory and the 3D models of the construction of steel beams in various stages are also designed individually and finally grouped together for the user’s easy comprehension. The scope of e-learning has been studied and a comparative analysis done to ensure the effectiveness of the proposed system. Dynamic rendering of virtual worlds of information retrieved from real-time databases is also implemented successfully. The field values of the various nodes Hence the benefits of using virtual environments at e-learning applications are demonstrated.

1.6 OBJECTIVES OF THE STUDY

VR is a way for persons to visualize, manipulate and interact with computers and extremely complex data. The visualization part refers to the computer generating visual, auditory or other sensual outputs to the user of a world within the computer. The potentials of VR and web technologies can be utilized to provide highly realistic virtual worlds in the field of e-learning. The evolution of Web technologies such as HTML, JAVA and VRML has paved the way to the use of real-time, interactive, 3D graphics. VRML as a descriptive language does not include event handling method, but it can achieve the effect by the support of Web-standard embedded or referenced in other programming languages, so as to achieve its “programming” features. VRML is mostly used to only visualize static VR environments and dynamically generated VRML scenes do not exist in many applications.

The Virtual Reality aspect of VRML is centered on the metaphor which it pursues: human space. That space is 3-dimensional and defines the ways we move in it, perceive it and interact with it. VRML accordingly includes many of the things that are required in making the virtual world: a way of describing the geometry which creates the objects and spaces we move around in - light, texture and sound. Learners
will be able to acquire new knowledge, manipulate and change it through interactivity and enrich it through feedback.

The design of a VRML scene consists of a number of nodes: description of geometry, illumination of the model, materials and textures. Dynamics can be introduced with a combination of other nodes like sensors, routes and interpolators. Sensors detect viewer actions (e.g., mouse move, click, and drag), time changes and viewer positions (visibility, proximity, collision). Routes direct captured events to interpolators to alter some fields (color, position, orientation, scale). While appropriate for direct animations, the mechanism is insufficient for descriptions of complex actions, e.g., the control of sequential clicks with the mouse on an object. In case of complicated movements and manipulations, the script node referring to Java applets and Java Scripts, may be employed. The proto node supplies the user with a tool to design one’s own sensors and interpolators.

Web-based instruction requires transformation from traditional teaching strategies to directed independent learning. Much attention must be given to the creation of effective interactive learning experiences that support student-to-student and student-to-faculty interactions. Evaluation must be done of how content is learned, the effects of the use of computers on learning, and perceived barriers to learning.

The main objective of this research is to develop dynamic VR systems. The development strategies of this research are

- To enhance e-learning techniques in the fields of Education and Industry by constructing interactive dynamic VR models.
- Innovative design with interaction to learn the basic concepts of primitive 3D geometry figures. The parameters of the figures are altered dynamically so that the student is capable of understanding the concept in a perfect manner.
- Development of VR simulation of a factory constructing steel beams and columns for training purpose.
- Comparative analysis on the different educational methodologies to study the effectiveness of the developed modules.
- Visualization of information retrieval from dynamic databases.

The objectives were implemented successfully.
1.7 ASSUMPTIONS AND HYPOTHESIS OF THE STUDY

The present e-learning technologies are mostly two dimensional with textual content. Multimedia content with graphics, audio and video take a long time for downloading. Very few e-learning sites with virtual reality are available. They are mostly static in nature. Students must be captivated by the content of the e-learning website. Hence e-learning should be enhanced by three dimensional web-content through virtual reality. Industries have to be on the edge always to cope up with the current technology breakthroughs to stay in the global market. They have to train their employees on the use of recent technological innovations in their respective fields.

Recently, the industry has embraced many kinds of web-based technologies, but information still uses document-based model. It is believed that transition to model-based information can be done through web-based 3D user interface. Visual technologies have enhanced the preparation of workforce specialists and technicians by bringing into classrooms and laboratories a breadth and depth of realism that has enhanced comprehension, increased learning performance, and reduced training time. The capabilities and possibilities for virtual reality (VR) technology may open doors to new vistas in industrial and technical instruction and learning, and the research that supports them. Information is stored within databases and it could be visualized by means of a dynamic generation of three-dimensional scenes. Today the dynamic generation of two-dimensional HTML pages is a standard functionality of all database systems. Therefore, the idea is to generate VRML scenes in a similar way.

Lessons on complex systems and processes should be made interactive and dynamic for clear understanding. The hypothesis is that VR can successfully be used to support such complex understanding by stimulating and exploring all human senses whereas traditional notions of learning tend to focus on purely intellectual skills. Challenged learners gain interest and are motivated leading to repeated practice and further conceptual and skill development.

Industrial applications can be modeled to visualize its operations. Virtual Reality can effectively be used to visualize, monitor and control an Industrial steel plant. This research project aims to prove its viability by making use of VR models. Database systems generally have limited report-generating capabilities and lack dynamism. VR models are developed to modify a graphical world with respect to the change in source data.
1.8 RESEARCH DESIGN

The 3D virtual reality simulation on the Web can provide the learning environments that simulate natural reality. Learner can learn various subjects via the 3D simulation since they have strong motivation on the specific topics. The 3D simulation and learning on Web open a wide range of opportunities to enhanced educational experiences [8]. Teaching methodologies in every subject should evolve by following the development of the information technology to enhance the efficiency and effect of the learning by the students.

In this thesis, efforts are made towards researching visualization on e-learning and dynamic interaction modalities for the purpose of developing easy to use, three dimensional and integrated modeling systems aimed at enhancing e-learning using virtual reality for creating three dimensional web-content. The innovations in Information Communication Technology (ICT) have enhanced education and training. Computer simulated 3D models are available for better comprehension. Interactive 3D content can be delivered over the web. The classroom environment limits the learning experience to industrial application. Recent advances in computer graphics offer a simulated solution of student interaction with VR models.

On a computer, virtual reality is primarily experienced through two of the five senses: sight and sound. Although numerous and powerful graphics editing systems exist for this purpose, our system takes an approach that is more academically oriented. Similar to many academic visualization, interaction and other types of projects, we make use of the open standard 3D (three dimensional) description language VRML. This content description language and its extensions for scripting and programming provide us with a 3D visualization modality, an event-based interaction framework and last but not least, a platform that is web-enabled, allowing for a wide-spread web-based access and consequently interaction. The user in the VRML scene is perceiver and creator at the same time, in a world where the object of perception is created by actions.

VRML worlds can be developed not as static collections of points, but with predefined movable parts, built-in animation controls, built-in sound effects, and parameters to vary the shape, style, or functionality of the model. User’s actions can be monitored using sensor nodes and the parametric descriptions of the 3D models can be achieved with PROTOs in VRML. Prototypes allow the set of VRML node
types to be extended by the user. Prototype definitions can be included in the file in which they are used or defined externally. Prototypes may be defined in terms of other VRML nodes. By setting values for its fields, several slightly varying copies of an object can be created. The different features that need to be personalized will correspond to fields of the PROTO. The 3D model in a VRML world is generically represented as a PROTO in which colors and textures have to be passed as values of some fields.

The scenes can change dynamically in response to user inputs, external events and the current state of the scene. Some VRML nodes generate events in response to environmental changes or user interaction. Event routing gives authors a mechanism, separate from the scene graph hierarchy, through which these events can be propagated to effect changes in other nodes. Once generated, events are sent to their routed destinations in time order and processed by the receiving node. This processing can change the state of the node, generate additional events, or change the structure of the scene graph. Animation is accomplished by defining a path for the flow of events among nodes. This is done by (1) using the ROUTE declaration to wire an output event from a sensor node to the input event of an interpolator node, and then (2) using ROUTE again, but this time from the interpolator node to a Transform node. VRML 2.0 also supports complex 3-D animations and behaviors by allowing Java and JavaScript programs to act upon VRML objects in a Script node.

An initial event is generated when the user interacts with an object, or when a specified time has elapsed. This is tracked by a sensor node. Interpolator nodes are usually used in conjunction with sensors to generate values between defined starting and ending points, which can then be used as events. This initial event is sent to subsequent nodes through route connections. Nodes receiving events may respond by generating other events. The basic method to build dynamic scenes is to route events between fields in an arbitrary fashion and combining that facility with sensor and interpolator nodes, as just described.

The use of a programming language is needed to perform more complicated logic operations. The Script node bridges VRML to access a programming language while allowing the world to be independent of the language that is accessed. A Script node contains a program called a script, written in a VRML browser supported programming or scripting language such as JavaScript, VRML Script or Java. The script node is an event engine which has a set of user defined fields and events sent to
them will be automatically passed, by the VRML browser from the Script node, to an associated piece of programming code. Thus scripts can receive incoming events, process the information in the events and produce outgoing events based on the results. In this way it is possible to change an event In of a node without using a route. Efficient use of scripts can improve rendering performance. Sensors and script are used to activate expensive items such as animation, lights and sounds so that they occur only when required by the user.

Interactivity in Virtual Reality worlds traditionally means employment of three of our five senses: sight, hearing, touch. Combining targeted impressions on these senses produces perceptions of space and interaction with objects located in that space. For example, incremental enlargement of an object produces a perception of movement towards that object. What a user expects to do in a virtual world is to move freely about, manipulate objects as one does in the real world and experience a spatial sense of sound. A spatial sense of sound means that the sound has a source fixed at a single point (a node) in the virtual environment. Moving towards that source increases the volume of sound and moving away decreases the volume. Also, the perception of the source of the sound is experienced relative to the user's position in the world. By shifting position in the virtual environment, the user's perception of the direction of the sound source changes. User interaction in VRML world is gained by using standard predefined VRML sensors. Sensors can be considered as special kind of nodes designed to react when properties of the Virtual Environment change or when a user operates a sensor in a predefined way.

The quality of e-learning was evaluated and measured. Outcomes/impacts are the perceived or measured benefits of e-learning. The impacts were coded on a positive to negative scale and included:

1) Achievement
2) Motivation/satisfaction
3) Interactivity/ communication
4) Meeting social demands
5) Retention/attrition
6) Learning flexibility and
7) Cost.

Graphical data processing is also implemented by storing, dynamically reconstructing and navigating 3D worlds using a database system. VRML does not
support connection to a database system. So JSP is used as an interface between a
database system and VRML. The field values of the VRML nodes are stored in
database tables which can be updated anytime by the user. JSP connects to the
database, retrieves the parameter values and creates a VRML text source file on the
fly and renders the 3D world in a VRML plug-in browser.

1.9 DESIGN CHALLENGES

The cost-effective development of online 3D environments which allow
flexible motion control and complex object manipulation presents a number of user-
interface design and programming challenges. Many 3D environment studies have
reported unexpected difficulty by participants in using the 3D environment.
Consequently, the design of the interface for navigation and motion control in the
environment and for manipulating objects within the environment is very important.
VRML browsers provide only basic motion control capability and limited support for
the manipulation of objects.

A key contribution of this paper is the description of a mechanism for
enhancing the motion control and object manipulation capabilities of VRML, in a way
that allows reuse in other applications. The Internet Based E-learning Interface is a
HTML based website generated by ASP (Active Server Pages) [8], which integrates a
VR browser, and is used by the learner to view and manipulate objects and
environments. This interface connects the library, which enables objects and
environments to be managed through the website. The .NET platform with C# as the
programming language is used as EAI for initializing the scene of study. With EAI,
one can dynamically build VRML worlds with C# as well as update any application’s
data through the VRML interface. This interaction can be very useful for scientific
visualization. EAI basically allows an external program to access nodes in a VRML
scene using the existing VRML event model.

The dynamic VRML scene is rendered in real time. PROTO and
EXTERNPROTO structure of VRML are utilized for change of color, angle of
rotation and axis of rotation. In the design of Educational e-learning website,
Dynamic E-learning through Virtual Reality, the VRML coding for the primitive 3D
figures is generated on the fly as the parameters are given as input. The color of the
primitive figures can be changed dynamically using a color mixer. The figure can be
rotated through an angle dynamically about an axis. The direction of the axis can be
chosen dynamically. PROTOs are designed for a slider, color mixer, coordinate axes and setting the angle of rotation along the x, y and z directions. The coordinate axes show the location of the origin which is useful for a beginner who is new to 3D graphics since VRML has no visible axis reference of its own.

The scene designed according to VRML is stored in an ASCII file. Specific visualization software, i.e., VR browser is necessary to display data on the screen. The role of VRML document and VR browsers is different. The VRML document supplies the parameters for scene design and the dynamics of objects while the VR browser takes care of scene rendering and the interface to navigate through and interact with the model. Initially, the basic function of the VR browser, besides visualization, was only real time navigation through the model, i.e., provision of virtual reality techniques: fly-over, walk-through, pan and zoom. Plenty of freeware versions of VR browsers can be downloaded from the site of the 3D Web consortium. The potential of VRML and VR browsers for 3D modeling is still underestimated. The couple VRML-VR browser mostly was considered a system for visualizing 3D graphics on the Web which can allow real-time exploration. This impression is created mostly by e-learning vendors, which offer export of their models in VRML.

The VRML rendering software, a VRML browser, normally runs within a web browser, as either a plug-in or an ActiveX control. The VRML browser provides the motion control interface and facilitates the rendering of views via the graphics hardware. Simple VRML documents are applicable only for end visualization in e-learning, i.e., no further information is to be provided. This type of virtual reality can be employed as a useful tool for on-line learning. The second type extends the ability to interact with the model almost unlimitedly. For example, each object in the current VRML document can be a clickable object invoking Java applets, CGI or Java scripts. Consequently, a new query to the database (on the server) or query of the VRML document arrived (on the client station) could be the next action. The new query could result again in a complex VRML document. Scripting of object behaviors and enhancements to the user interface are normally carried out using the Java or JavaScript programming languages.

One of the most interesting issues for e-learning applications is the dynamic composition of a complex VRML document. The first basic operation is the identification of a certain object. The browser reacts on user actions (other than navigation) only if they are initially and explicitly described in the VRML document.
A particular sensor has to be attached in the design to a particular object before the user is able to interact with that object. The next step is the composition of the response. What does the user want to achieve by selecting this object: text, graphics, image, and spatial analysis, and attribute information, data about the selected object or about other objects? In this approach, the decision on the type of sensor, the target object and the resulting event (CGI script or Javascript, or appropriate VRML nodes, or files on remote servers), has to be taken by the CGI script during the dynamic creation of the document [9]. So far, only a user action has been considered as a possible input event to initiate an action. To avoid or reduce the undesirable effects of CGI scripting and facilitate management of dynamic interactions, the system can store appropriate supplementary information about behavior of objects in the database [10].

The behavior defines dynamic changes and interactions related to characteristics of objects such as shape, position, color, etc. However, behavior can be extended to comprise changes and interactions in the virtual world. Thus, a variety of parameters, scripts, small VRML files, animations, etc. per object that facilitate and simplify the work of CGI script can be captured in the database. The result is a possibility of CGI scripts standardization, which consequently decreases their number and reduces their size. Large worlds can be partitioned into several smaller ones by assigning behavior to specific objects (doors, windows, etc.). The world can be reconstructed afterwards on user request as only one script is sufficient to deliver the entire file. VRML cannot access data from Server's database directly. Therefore, we must apply other technology, such as ASP or CGI that can be access data form Server's database and to solve this problem of accessing the data from the database and substitute the data in the prototype.

Objects in the virtual world can act and react to each other under program, or they can respond to the user’s actions in some way. For educational purposes, this will in many cases be essential. VRML provides a mechanism for creating reusable geometry or reusable behaviors by creating a prototype node. These prototypes, which are similar conceptually to classes in an object oriented language, can then be used from within any VRML environment. The combination of prototypes and script nodes provides a powerful mechanism to encapsulate content and behavior in a reusable entity. In addition to enabling encapsulation and reuse, the previously mentioned VRML prototype mechanism also enables authors to extend the language by introducing what are essentially new nodes. VRML also supports external prototypes.
External prototypes function much like a regular prototype, except instead of residing in the current file; they reside in another URL-identified VRML file. This feature allows developers to extend VRML with logic and content residing and possibly evolving at a specific URL.

External Authoring Interface (EAI) is an interface that allows communication between a VRML world and its external environment. EAI defines a set of functions on the VRML browser that the external environment can perform to affect the VRML world. Presently, the only truly working style of an interface is between an embedded VRML world on an HTML page and a Java applet on the same page. The dynamic interaction based on Java-VRML interface techniques is vital to system stability and user accessibility. Because this system is implemented by Java applet, any client with Java-enable browser including VRML browser plug-in can utilize the new style of 3D function in the virtual space. EAI is a kind of Application Programming Interface (API) to allow the Java applet or application to interact with the VRML scene. This interactivity enables Java applet to build and update dynamically the data in VRML. This nature of EAI makes itself to be applied for various fields using dynamic visualization [11]. While, EAI is the interface between a VRML browser and an external mechanism such as Netscape's LiveConnect interface, or Microsoft's ActiveX interface [12], EAI offers generalized method to access nodes and event structure from outside of VRML browser.

With EAI, we can utilize the functionality of VRML browser featured mainly by the navigation functions. VRML file can be dynamically built and updated via the EAI, based on data received by Java applets, and in turn, the applet's data can also be dynamically updated through the VRML interface. The web-based 3D applet utilizes EAI and VRML can easily be accessed by any platform. The EAI provides the API to allow the Java Applet to interact with the VRML scene. The EAI classes are shipped with an EAI enabled browser, of which CosmoPlayer is the only one presently available [13]. All actions in VRML are called Events. Any input into the scene are called EventIn’s and outputs or the resultant scene changes are called EventOuts. The Java EAI classes create an interface between EventIn’s / Out’s and the scene nodes and can commensurate with these changes updates the attributes of relevant nodes accordingly [14].

Data visualization can be easily supported in that the objects can use the Anchor node to point to textual, tabular material describing the data in other forms.
This ability will extend the range of subjects that can benefit from VRML to include those that deal not with spatial objects, but call upon quantitative data that can be spatially represented, such as the social sciences. 3-D front-ends have been introduced that use VRML to explore and access data [15]. Through the integration with Java VRML can be used to build a hardware independent client for the access and visualization of 3D data warehouse information. However, accessing not only 3D visual data but also additional information is not supported very well in VRML. In its current state, VRML does not provide support for interaction and on-line access to databases. A fusion of the VRML, Java, and Database technologies is used to design applications for the visualization of information stored in databases in three dimensions.

Viewing a VRML model over the World Wide Web on a monitor provides only a non-immersive VR experience. However, the syntax, data structures, and features of the Virtual Reality Modeling Language are powerful and comprehensive modeling tools that allow for the description of a complete and often sophisticated VR application. This description is in most cases sufficient to run the application on fully immersive systems, if appropriate translators are available. Using VRML on the World Wide Web provides an excellent tool for sharing virtual models with remote users and for supporting collaborative work and concurrent engineering. It is extremely cost effective since the required infrastructure (networked computers) exists almost everywhere and the viewing software (VRML plug-in) is available to everyone. Today's limitations are dictated by network capabilities (download times for large VRML files describing complex virtual models) and the speed of the user's local computer (responsible for real-time rendering and interactions). The current development trend towards high capacity networks like Internet2 and more powerful desktop and laptop computers with 3D graphics acceleration will remove these limitations gradually in the near future.

1.10 OVERVIEW OF THE THESIS

The body of this thesis is split into seven chapters, which are outlined below:

Chapter 1 presents the introduction to the thesis.

Chapter 2 reviews the literature on Enhancing E-Learning using Virtual Reality for creating Three Dimensional Web Content.
Chapter 3 deals in depth the processes involved in the designing and implementation of dynamic Content Generation and Enhancement of User Interaction in the Virtual World.

Chapter 4 discusses the industrial application of virtual reality and the implementation procedure of constructing the website related to a steel industry.

Chapter 5 details a framework to measure comparative effectiveness between the learning environments Classroom Learning, Conventional E-learning and Enhanced E-learning through Virtual Reality.

Chapter 6 presents the detailed architecture involved in the design of the system of Dynamic Information Visualization with VRML and Databases.

Chapter 7 offers conclusions to the work described in this thesis and offers recommendations for future research and/or developments.