CHAPTER 2
LITERATURE SURVEY

As technologies evolve, we tend to equip ourselves with the needed skills to adapt with the changing scenario. The ever growing information society has largely impacted the educational field. The conventional method of instructor led teaching is complemented with Computer based Training (CBT). The use of technology in education and training is transforming the way that people learn in today’s academic and corporate settings. The concept of the learning organization has grown exponentially with the technological era [16]. Advances in digital technologies have and continue to enrich the interactivity and media content of the web. Urdan & Weggen identified the knowledge-based economy, the paradigm shift in the way education is viewed and delivered, and huge knowledge gaps as significant trends that have given rise to e-learning. They added that a higher retention of content through personalized learning is possible because technology-based solutions allow more room for individual differences in learning styles. They highlighted improved collaboration and productivity among students as the online environment offers case studies, demonstrations, role-playing, and simulations among other tools [17].

E-learning provides an educational system where learning can be done anytime and anywhere without any barriers. This has facilitated many to acquire new knowledge. The e-learning material is mostly text, images, tables and videos which are two-dimensional in nature. There is a sustained growth in the deployment of e-learning initiatives in large and small organizations of every type: corporate, higher education, government and military, and non-profits. There is also a significant evolution in e-learning practice as improvements and innovations in design and delivery capabilities have led to more complex, more sophisticated and more far-reaching programs. Virtual Reality (VR) introduces the concept of three-dimension. VR technology is considered as a major technological advance that supports education. VR and computer simulations have been in use as educational tools for some time. Although they have mainly been used in applied fields such as aviation and medical imaging, these technologies have begun to edge their way into classrooms. Various researches have been done in developing virtual environments (VE) for learning and training purposes. This chapter deals with the previous related work on the use of virtual reality in e-learning systems.
2.1 E-Learning

The opportunities for learning and growth online are virtually limitless. Internet-based education transcends typical time and space barriers, giving students the ability to access learning opportunities day and night from every corner of the globe. Coursework can now provide material in highly interactive audio, video, and textual formats at a pace set by the student. E-Learning is making connections among persons and resources through communication technologies for learning-related purposes. E-learning does not only value planned learning but also recognizes the value of the unplanned and the self-directedness of the learner to maximize incidental learning to improve performance. A large part of the growth in e-learning activities has been as result of the phenomenal growth of the Internet. The World Wide Web has evolved, as a universal platform to serve the information needs of a variety of clients across diverse geography and contexts [18].

In recent years distributing knowledge via Internet and World Wide Web has become standard for universities, institutes and companies. Many of them offer E-Learning-Environments. The advantages seem to be obvious: easier distribution, independence of space and time, potentialities of hypertext and multimedia etc. The growing need for communication, visualization and organization technologies in the field of e-learning environments, has led to the application of virtual reality and e-Learning has changed the traditional teaching-learning mode gradually. Nowadays, people are required to learn all their lives. E-Learning system helps people learn what they wanted on their own initiative. Traditional passive learning is replacing by engaged learning.

The evolution of web design and the current trends in the field of e-learning seem to indicate a growing need for rethinking and renewing the concept of e-learning platforms as being more than functional platforms providing “easy-to-access” content. Techniques and technologies are explored on the e-learning platforms as mediums of communication and potential providers of sensuous experiences. Computer simulations are computer-generated versions of real-world objects (for example, a skyscraper or chemical molecules) or processes (for example, population growth or biological decay). They may be presented in 2-dimensional, text-driven formats, or, increasingly, 3-dimensional, multimedia formats. Computer simulations can take many different forms, ranging from computer renderings of 3-dimensional geometric shapes to highly interactive, computerized laboratory experiments. Therefore a shift
of the e-learning platforms from purely addressing function and usability towards a more aesthetical and user-experience oriented approach that addresses visual communication, sensory dimensions and cultural and aesthetic objects is being tried. Thus E-learning can be defined as the effective learning process created by combining digitally delivered content with learning support and services [19].

2.1.1 E-Learning Definition

E-learning as an approach is complicated by the plethora of definitions of its meaning and scope. A particularly interesting definition is that used in the “Wikipedia” on-line Encyclopedia: *E-learning most often means an approach to facilitate and enhance learning by means of personal computers, CDROMs, and the Internet. This includes email, discussion forums, and collaborative software, e.g. Basic Support for Cooperative Work (BSCW) or Computer Supported Cooperative Work (CSCW). Advantages are seen in that just-in-time learning is possible, courses can be tailored to specific needs and asynchronous learning is possible. E-learning may also be used to support distance learning through the use of WANs (Wide Area Networks), and may also be considered to be a form of flexible learning.”* [20].

Urdan & Weggen related that online learning constitutes just one part of e-learning and describes learning via internet, intranet and extranet. They added that levels of sophistication of online learning vary. It can extend from a basic online learning program that includes text and graphics of the course, exercises, testing, and record keeping, such as test scores and bookmarks to a sophisticated online learning program. Sophistication would include animations, simulations, audio and video sequences peer and expert discussion groups, online mentoring, links to materials on corporate intranet or the web, and communications with corporate education records. They also commented that online training is less intimidating than instructor-led courses. Online learning, they say, is risk free environment that supports trying out new things and making mistakes [17].

Web-based training is online training. Hall defined web-based training as instruction that is delivered over the Internet or over a company’s intranet. Accessibility of this training, related Hall, is through the use of a web-browser such as Netscape Navigator [21]. Hall and Snider define e-learning as the process of learning via computers over the Internet and intranets. Hall and Snider extended that e-learning is also referred to as web-based training, online training, distributed learning or technology for learning [22].
The NCSA e-Learning group definition: e-learning is the acquisition and use of knowledge distributed and facilitated primarily by electronic means. This form of learning currently depends on networks and computers but will likely evolve into systems consisting of a variety of channels (e.g., wireless, satellite), and technologies (e.g., cellular phones, PDA’s) as they are developed and adopted. E-learning can take the form of courses as well as modules and smaller learning objects. E-learning may incorporate synchronous or asynchronous access and may be distributed geographically with varied limits of time [23].

2.1.2 E-Learning Environments

E-learning environments are in constant evolution mostly containing an integrated set of communication and support tools for the learner. They are spaces where learners can interact with each other, based on the idea that knowledge is actively constructed by the learner and not simply passively received from a teacher. They allow for customization of learning experience for an entire class as well as for an individual. They can aid students in taking the time needed to fully interact with the object of study that may be normally not available to them. Well-designed e-learning environments can aid students in understanding of concepts that may be difficult for tutors to explain or to try and illustrate. Effective e-learning distributed environments should promote high cooperation.

E-learning environments would be appropriate vehicles to provide learning support in the form of:

- Modeling where students observe an expert and build their own conceptual model
- Coaching where hints are offered and new tasks are given to bring performance closer to that of an expert.
- Scaffolding where a teacher provides supports to help the student carry out the task.

Fields where technology is rapidly changing professional practice have a real advantage in terms of developing cutting edge and relevant e-learning environments. When doctors can operate on patients at a distance using the latest in miniature camera technology to perform laparoscopic surgery their student can also view the operation from any corner of the globe. A rapidly evolving, technology rich results-based profession is well placed to develop successful e-learning materials, tools and environments. Mathematics, biochemistry, genetics, and physics, are all fields where
learners can benefit from visual demonstrations of concepts or phenomenon. Mathematical and scientific ideas and relationships can be modeled and presented in a variety of ways, from fractal geometry to Fermat's Theorem [24].

Animations, modeling or simulations either during the lecture or available for students to study individually may provide real aids to understanding and support connections between theory and practice. Conway’s Game of life, for example, is a representation of emergent complexity or self organizing systems. In order to study how elaborate patterns and behaviors can emerge from very simple rules, students can input their own patterns into a Java applet and study the results. Level of participation and interaction, the amount and quality of feedback, the learning environment, and technology are frequently mentioned in the e-learning literature as aspects which have a significantly impacted the learner experience and level of satisfaction. While curriculum design is identified as the most critical component of e-learning, there are other aspects of e-learning courses that contribute to effectiveness. The learning environment and user interface design are frequently mentioned in the literature as key components to effective e-learning systems.

2.1.3 E-learning History

The roots of e-learning go back at least to the mid 1960es i.e. four decades. In a simplified summary, each era was marked by hopes and deceptions as follows.

The first decade (about 1965-75) was marked by behaviorist approaches i.e. sequences of content presentation followed by tests and, correspondingly, re-iteration or continuation in the presentation flow. Limits of early host computers with simple monitors contributed to the disappointing results of this dictatorship era. Nevertheless, late multimedia-augmented remnants of this era like CBTs and WBTs – coined as eTutorials below – represent the only commercially successful eLearning category today. Ivan Sutherland implemented the first virtual reality (VR) system in 1968 [25].

The second decade (1975-85) brought a vast amount of model-based learning systems such as intelligent tutoring systems, role games and simulations, Microworlds and plan-based programming or help systems, summarized as eWorlds below. Poor reusability and cost benefit ratio prevented commercial success. Overstated promises, nourished by the AI and cognitive communities (in the computer science and didactics/pedagogy camps, respectively), accelerated the rise and fall of hope for models that would suit the ‘brains’ of all learners including all possible
misconceptions – due this ‘one suits all’ attitude, the second decade can be coined as *communism era*. eWorlds concepts were advanced since, but the key problems mentioned remain unsatisfactory. Disappointing results with ambitious eWorlds resulted in overly modest pedagogic goals in the third era: instead of being guided, the learners were supposed to explore subject domains on their own. Constructivist research, much improved explicit representation of semantic structures (using the upcoming hypertext concepts) and improved presentation (as multimedia) all contributed to new – again exaggerated – hope for big success. But the era of explorative learning was way too much the *era of anarchy*.

Alas, the third decade (about 1995-2005) can be coined as *New Age* since old recipes are mixed with (once more exaggerated) new promises. The computer science camp jumped on the VR bandwagon just in time: serious budget problems in the private and public sector increase the temptation to believe that ‘virtual universities’ may be created where entire teaching departments can be replicated by means of keystrokes. At least the pedagogy/didactics camp tuned to modest expectations, despite two interesting advancements: firstly, an eLearning concept was shaped which was called as eProjects: support for discourse centered and project centered learning styles, applying computer and Internet based tools for project organization, cooperative work, etc. Secondly, adaptive hypertext was improved towards higher reusability and lower development cost for eTutorials and eWorlds; XML is likely to advance this field further [26].

**2.1.4 The Current State of E-Learning**

E-learning is currently undergoing a phase from a pioneering stage towards serious sustainable implementation. The demand for e-learning across various industries is on the rise, especially within education. Learning management systems are evolving as well as people begin to demand viable alternatives to Moodle, and other traditional LMS software. Current E-learning systems can be classified as theoretical and experimental E-learning systems based on the information type. Most E-learning systems nowadays are regarded as theoretical systems. This is because they still largely rely on moving text to the web. Skill and experience can only be obtained through practice and interactivity, which are the essential features for experimental E-learning systems. Many E-learning systems added large quantity of multimedia to gain these effects. These multimedia technologies include video, audio, images, flash animations, stream and media etc [27]. Though these can describe
learning content in a way better than sole text, they do not provide interactivity, which is regarded as necessary by the authors to gain skill and experience over the Internet.

To solve this and make the online curriculum more interactive, VR has been introduced. 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 [28]. Virtual reality, as a mature technology, focuses on three main research domains; they are immersive VR, semi-immersive VR and desktop VR. Application on e-learning falls into the domain of desktop VR. Virtual community is used to increase interaction and immersion in e-learning. This mode can help attract audience in e-learning and improve learning effect. They serve to raise the level of student engagement in a classroom, motivate students and promote enthusiasm for learning.

The inherent multimedia characteristics of the most common web browsers, which can interpret and render interactive 3D scenes described in standard languages such as VRML [29,30] thanks to publicly available plug-ins, enable the combination of different media within an e-learning application to improve its contents and thus the corresponding learning process.

2.1.5 Benefits of E-Learning

There are a number of benefits to learning through the web that are unique to the medium:

*Any time*: Participants can access the learning resources at any time that is convenient to them and not the specific hours that is set for a conventional course.

*Any place*: Participants do not have to meet in person, nor even be in the same country as the teacher. Students and teachers can be anywhere in the world. International sharing is feasible, and in fact, often makes the learning experience richer and more interesting to learners. Individuals can log on at work, home, the library, in a community learning center or from their hotel when traveling.

*Asynchronous interaction*: Unlike face-to-face or telephone conversations, electronic mail does not require participants to respond immediately. As a result, interactions can be more succinct, considered and to-the-point. Learners have time to craft their responses, and to think about what others in the course have written. This, in turn, can lead to more thoughtful and creative conversations.

*Group collaboration*: Electronic messaging creates new opportunities for groups to work together, creating shared electronic conversations that can be thoughtful and
more permanent than voice conversations. Such interactions provide powerful learning and problem-solving experiences.

**New educational approaches:** Many new options and learning strategies become economically feasible through online courses. For instance, the technology makes it feasible to utilize faculty anywhere in the world and to put together faculty teams that include master teachers, researchers, scientists, and experienced educators. Online courses also can provide unique opportunities for teachers to share innovations in their own work with the immediate support of electronic groups and expert faculty.

**Enriched learning through simulations, gaming and interactivity:** Academic and workplace research shows increased understanding and more enduring learning when learning activities engage students and immerse them in experiencing the activity or skill being taught. Simulations, games and online collaborations are being used increasingly in e-learning environments.

**Integration of computers:** The online learner has access to a computer, so computer applications can be used without excluding some participants. This means, for instance, that a mathematical model implemented in a spreadsheet can easily be incorporated into a lesson and downloaded so all participants can run, explore, and refine the model and then share their findings and improvements.

**Performance Support:** Some e-learning providers are also providing workers with on-the-job performance support to boost task performance directly related to business goals and the learning experience.

The message that consistently emerges from researches on e-learning is: “*The delivery mode we know for a fact does not impact the learning. It’s the design of the instruction that impacts the learning, and also what the students bring to the instructional situation.*”[31].

### 2.2 Virtual Reality

In the late 1980’s, Jaron Lanier coined the term Virtual Reality (VR) and his company, VPL Research, developed the first commercially available head-mounted display (HMD), a device that provides its user with an immersive virtual reality experience. In the following years, alternative immersive systems like the BOOM from Fakespace or the CAVE system, developed by the University of Illinois at Chicago, reached the market. These immersive viewing systems present the user with a full scale, stereoscopic representation of a three-dimensional environment that is computer-generated. Head-referenced viewing provides a natural interface for the
navigation in three-dimensional space and allows for look-around, walk-around, and fly-through capabilities in virtual environments.

Realistic interactions with virtual objects via data glove and similar devices support the manipulation, operation, and control of virtual worlds. Often, sound, haptic devices, and other non-visual technologies are used to enhance the virtual experience significantly. As a basic requirement, viewing, interactions, and other tasks have to be executed with real-time response and, therefore, require often significant computational power. The resulting illusion of being fully immersed in an artificial world can be quite convincing.

VR is an integrated technique that involves computer graphics and human-computer interaction. It uses the computer to create 3D virtual world, where people can experience in the virtual world as in real world. With the development of computer hardware, it is possible to use a normal personal computer to implement a complex virtual environment. It is believed that VR attains its power by captivating the user’s attention to induce a sense of immersion. This is usually done with a display that allows the user to look in any direction, and that updates the user’s viewpoint by passively tracking the user’s head motion. Desktop VR [32] is the use of animated interactive 3D graphics to build virtual worlds with desktop displays and without head tracking. Virtual reality offers highly interactive human-computer interfaces, which embodies the characteristic of interaction between real and virtual worlds [33] [34]. It offers E-learning users a large amount of interactivity, which could not be experienced before.

VR is a way for humans 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 applications of VR run a wide spectrum, from games to architectural and educational purposes. One of the most recent applications of virtual reality is the interface to e-learning applications [35]. Using this technology, it’s possible to get a sense of a three dimensional environment. A few web sites are equipped with 3D object viewing. When users work with a 3D viewing capable browser, the whole environment can be viewed in 360-degree with the ability to zoom the scene, and quickly navigate through the various places in the virtual world and view 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.
Ainge and Song et al. both provide evidence that virtual reality experiences can offer an advantage over more traditional instructional experiences – at least within certain contexts [36]. Ainge showed that students who built and explored 3D solids with a desktop virtual reality program developed the ability to recognize 3D shapes in everyday contexts, whereas peers who constructed 3D solids out of paper did not. Moreover, students working with the virtual reality program were more enthusiastic during the course of the study. Song et al. reported that middle school students who spent part of their geometry class time exploring 3-D solids were significantly more successful at solving geometry problems that required visualization than were peers taught geometry by verbal explanation. Both studies, however, seem to indicate that the benefits of virtual reality experiences are often limited to very specific skills. For example, students taught by a VR approach were not any more effective at solving geometry problems that did not require visualization [37].

2.2.1 Virtual Reality Definition

Virtual Reality (VR) has been described in many different ways but maybe the most expressive of these is when VR is seen as the science of integrating man with information. VR does not necessarily aim to recreate reality as we know it but rather create an artificial reality. Three distinct characteristics of VR are that it is three-dimensional, interactive and computer-generated [38]. This implies that the user of a VR system is immersed in a computer-generated environment (also referred to as a virtual environment) where the user is allowed to interact with the environment or objects therein. VR grew “from the basic human desire to explore alternative realities” [39].

The term Virtual Reality initially referred to immersive systems. Alternative terms like Virtual Worlds or Virtual Environments (VE) emerged and reflect more appropriately the wide range of possible applications and the fact that the technology is still far away from simulating "reality." The latter term, Virtual Environments, is preferred by the academic community. With time, the meaning of VR broadened and, as of today, VR is also being used for semi-immersive systems like large screen projections (with or without stereo) or table projection systems like the Immersadesk and similar devices. Even non-immersive systems, like monitor-based viewing of three-dimensional objects, are called VR systems. The rapid development of the World Wide Web in the recent past has created additional versions of virtual reality as, for example, in Apple's QuickTimeVR or, more importantly, with VRML, the
Virtual Reality Modeling Language for the World Wide Web. The boundaries are becoming blurred, but all variations of VR have gained importance and are slowly merging into a very broad spectrum of technologies used to view and interact with three-dimensional worlds in real-time.

**Virtual Reality** [40, 41] can be viewed as a software paradigm that offers to one or more users to explore and interact with a computer generated environment. Different types of devices allows to users to perceive and manipulate the visual objects as in the real world. The natural manner of interaction makes the participant to feel embedded in the environment. The virtual worlds are given by mathematics models and software programs. Virtual reality differs from other computer simulations by the necessary use of the interfaces for special devices for image, sound and sensation transmission from environment towards users.

VR has been defined in many different ways and now means different things in various contexts. VR can range from simple environments presented on a desktop computer to fully immersive multisensory environments experienced through complex headgear and bodysuits. In all of its manifestations, VR is basically a way of simulating or replicating an environment and giving the user a sense of being there, taking control, and personally interacting with that environment with his/her own body [42, 43, 44, 45, 46, 47].

In addition to simulating a three-dimensional (3D) environment, all forms of VR have in common computer input and control. It is generally agreed that the essence of VR lies in computer-generated 3D worlds [42]. Its interface immerses participants in a 3D synthesized environment generated by one or more computers and allows them to act in real time within that environment by means of one or more control devices and involving one or more of their physical senses [43, 45, 48]. The result is "... simultaneous stimulation of participants' senses that gives a vivid impression of being immersed in a synthetic environment with which one interacts" [45]. The 3D model will allow the student to understand aspects of the teaching material that is not evident in the pictures, because they are hidden.

### 2.2.2 Virtual Model

At the core of most of the VR systems is a computer model that is usually generated using three-dimensional modeling techniques as, for example, supported by many CAD/CAM systems. The model needs to be a polygonal representation of all geometry involved. Only such a representation allows for fast rendering in real-time.
If an object has been created using Constructive Solid Geometry (CSG), it must be first converted into its boundary representation (B-rep). If the boundaries are curved surfaces, a polygonal approximation can be derived using a tessellation algorithm that substitutes the surface by a mesh of polygons (usually triangles). The number of polygons, the so-called polygon count, for the entire model is a critical factor in any VR application since it determines the rendering speed. Real-time rendering requires the generation of at least 20 to 30 frames (perspectives views) per second. A laptop computer can render several thousand polygons in real-time. For the most complex models (up to a million polygons), powerful computer systems with special graphics hardware are required. In general, increasing complexity (higher polygon count) of the model requires more computational power.

To view and interact with the geometry, the computer model needs to be completed with information describing the appearance of objects (color, reflection characteristics, and textures), the lighting environment, possible animations, interactions, sound, as well as behavior and functionality. This augmented polygonal representation of a three-dimensional computer model is referred as the "virtual model."

Once the virtual model has been defined, it can be used, at least conceptually, with any of the existing VR systems. Different data formats and missing standards make the transition from one VR system to another still difficult, but this situation is improving rapidly as appropriate tools are being developed. In an ideal situation, a virtual model initially developed on a desktop personal computer can be viewed using the desktop's monitor (non-immersive VR), but can also be utilized using systems involving an HMD or even a CAVE, thereby, providing the features of fully immersive VR, like full scale representation, stereoscopic viewing, and head-referenced navigation.

The creation of a virtual model is still a labor intensive and time consuming task. Even if a three-dimensional model already exists (e.g., as a CAD model), additional efforts are required to derive a polygonal representation with acceptable polygon count and to define supplementary information regarding appearance, lighting, functionality, and other properties. The fast generation of a virtual model, also known as rapid virtual prototyping, is still a topic of ongoing research and development.
A potential solution for a standardized virtual model is the most exciting development of VRML, the Virtual Reality Modeling Language, a new addition to the World Wide Web. While HTML, the Hypertext Markup Language, is the current standard for authoring home pages, VRML supports the distribution of three-dimensional models over the Internet. These models have all the characteristics of virtual models as described. They are based on a polygonal representation and can be animated, can include functionality and dynamic behavior, and can be interactively controlled by the user. In the future, home pages may be replaced by "home spaces" with hyperlinks to other spaces or pages located on any server within the worldwide Internet.

A VRML model is defined in one or more VRML files. A VRML file is a regular text file that describes a virtual model using a standardized syntax. The content of a VRML file is being viewed interactively through the use of a VRML plug-in available for all common Web browsers (like Netscape or Internet Explorer). This plug-ins can be downloaded from various Web sites and are usually available at no cost for different computer platforms.

When accessing a VRML file on the Web by clicking on a corresponding link, the file is downloaded on the user’s computer and the plug-in is activated and displays an initial view of the virtual model on the computer's monitor. The plug-in provides standard navigational tools like walk-trough or fly-over. These tools enable the user to move through the model in an arbitrary way or along a predefined path. Navigation as well as interactions is usually controlled via the mouse input device.

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 Internet and more powerful desktop and laptop computers with 3D graphics acceleration will remove these limitations gradually in the near future.

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.

2.2.3 Virtual Reality Simulations

Training systems based on VR have been used in several areas [18]. The user is immersed into a virtual world to have realistic training and realistic interactions. VR refers to real-time systems modeled by computer graphics that allow user interaction and movements with three or more degrees of freedom [18, 49]. More than a technology, VR became a new science that joins several fields as computers, robotics, graphics, engineering and cognition. VR worlds are 3D environments, created by computer graphics techniques, where one or more users are immersed totally or partially to interact with virtual elements. Due to high cost of presentation and haptic devices, most of applications do not use high-end equipment, but simple stereovision solutions or no equipment at all, displaying the picture on a normal, flat screen.

As VR has continued to develop, applications that are less than fully immersive have developed. These non-immersive or desktop VR applications are far less expensive and technically daunting than their immersive predecessors and are beginning to make inroads into industry training and development. Desktop VR focuses on mouse, joystick, or space/sensor ball-controlled navigation through a 3D environment on a graphics monitor under computer control. Desktop VR began in the entertainment industry, making its first appearance in video arcade games. Made possible by the development of sophisticated computer graphics and animation technology, screen-based environments that were realistic, flexible, interactive, and easily controlled by users opened major new possibilities for what has been termed unwired or unencumbered VR [48].

Early in their development, advanced computer graphics were predicted, quite accurately, to make VR a reality for everyone at very low cost and with relative technical ease [46]. Today the wide-spread availability of sophisticated computer graphics software and reasonably priced consumer computers with high-end graphics hardware components have placed the world of virtual reality on everyone's desktop. Desktop VR systems can be distributed easily via the World Wide Web or on CD and users need little skill to install or use them. Generally all that is needed to allow
this type of VR to run on a standard computer is a single piece of software in the form of a viewer [45].

2.2.4 Learning Outcomes of VR Simulations

There is substantial research reporting computer simulations to be an effective approach for improving students’ learning. Three main learning outcomes have been addressed:

- Conceptual change - One of the most interesting curriculum applications of computer simulations is the generation of conceptual change. Students often hold strong misconceptions – be they historical, mathematical, grammatical, or scientific. Computer simulations have been investigated as a means to help students confront and correct these misconceptions, which often involve essential learning concepts. For example, Zietsman & Hewson investigated the impact of a microcomputer simulation on students’ misconceptions about the relationship between velocity and distance, fundamental concepts in physics [50]. Conceptual change in the science domain has been the primary target for these investigations, although we identified one study situated within the mathematics curriculum [51]. A simulation-orientated computer environment (CHANCE) was designed for middle and high school students to learn introductory probability and a teacher experiment to evaluate its effectiveness. CHANCE is composed of five experimental sub-environments: Coins, Dice, Spinners, Thumbtack and Marbles. The results indicate that the teaching and learning activities carried out in the experimental environment provided by CHANCE were successful and supported the authors’ belief that CHANCE has great potential in teaching and learning introductory probability. All 3 studies that we directly reviewed supported the potential of computer simulations to help accomplish needed conceptual change [50, 51, 52]. Computer simulations have considerable potential in helping students develop richer and more accurate conceptual models in science and mathematics.

- Skill development - A more widely investigated outcome measure in the computer simulation literature is skill development. Of 12 studies, 11 reported that the use of computer simulations promoted skill development of one kind or another. The majority of these simulations involved mathematical or scientific scenarios (for example, a simulation of chemical molecules and a
simulation of dice and spinner probability experiments), but a few incorporated other topic areas such as history (a digital text that simulated historical events and permitted students to make decisions that influenced outcomes) and creativity (a simulation of Lego block building). Skills reported to be improved include reading, problem solving, science process skills, 3D visualization, mineral identification, abstract thinking, and creativity and algebra skills. On reading, the author capitalizes on the notion of student motivation and engagement in developing this descriptive study. Observations focused on type of reading (silent, coral, aloud, sub-vocally, and in turns), group discussions about the content, vocabulary development (use of terms and language specific to varying simulations), and outcome of the simulation (could the group help the simulation survive). The author concludes that these preliminary indicators favor the use of simulations to stimulate learner interest and cooperation to read and understand the content of the life like computer simulation [53]. Problem solving approach is discussed in the reference given [51, 54]. The effects of computer-simulated experiment (CSE) and the problem-solving approach on students’ chemistry achievement, science process skills and attitudes toward chemistry at the high school level. Four instruments were used in the study: Chemistry Achievement Test, Science Process Skill Test, Chemistry Attitude Scale, and Logical Thinking Ability Test. The results indicate that the computer-simulated experiment approach and the problem-solving approach produced significantly greater achievement in chemistry and science process skills than the conventional approach did. The CSE approach produced significantly more positive attitudes toward chemistry than the other two methods, with the conventional approach being the least effective., science process skills (e.g. measurement, data interpretation, etc.; [55,56], 3D visualization experiment was investigated to find the effects of using molecular modeling on students’ spatial ability, understanding of new concepts related to geometric and symbolic representations and students’ perception of the model concept [57]. Simulation researches on mineral identification [58], abstract thinking [59], creativity [60], and algebra skills involving the ability to relate equations and real-life situations [61] were studied. Verzoni investigated the development of student’s to see connections between mathematical equations and live like
problem solving environments. The reported results suggest that simulation activities developed student abilities to make essential connections between algebraic expressions and real life relationships. Generally, they compared simulated explorations, manipulations, and/or experiments to hands-on versions involving concrete materials. The results of all 7 studies suggest that computer simulations can be implemented to as good or better effect than existing approaches. Thus, as a whole, there is good support for the ability of computer simulations to improve various skills, particularly science and mathematics skills.

- Content area knowledge. - Another potential curriculum application for computer simulations is the development of content area knowledge. According to the research literature, computer programs simulating topics as far ranging as frog dissection, a lake’s food chain, microorganism growth, and chemical molecules, can be effectively used to develop knowledge in relevant areas of the curriculum. Eleven studies investigated the impact of working with a computer simulation on content area knowledge. All 11 researched applications for the science curriculum, targeting, for example, knowledge of frog anatomy and morphology, thermodynamics, chemical structure and bonding, volume displacement, and health and disease. Students who worked with computer simulations significantly improved their performance on content-area tests [55, 57, 62, 63]. Working with computer simulations was in nearly every case as effective [64,65] or more effective [62, 55, 56, 66, 67] than traditional, hands-on materials for developing content knowledge. There is reasonably good support for the practice of using computer simulations as a supplement to or in place of traditional approaches for teaching content knowledge.

2.3 Virtual Environments

Virtual environments (VEs) also known as virtual worlds are non-real (computer generated) environments containing three-dimensional VR models. It is possible to represent complex engineering models and then manipulate and interacting with the models using a standard input and output devices to a PC, i.e. mouse, keyboard and monitor. VEs have a great potential for learning and training purposes, by allowing one to circumvent physical, safety, and cost constraints. VEs offer the possibility to recreate the real world as it is or to create completely new worlds, providing
experiences that can help people in understanding concepts as well as learning to perform specific tasks, where the task can be repeated as often as required and in a safe environment.

VEs allow for powerful learning experiences to overcome the previously one-dimensional view of the earth and space provided in texts, and maps. The possibility of providing highly interactive experiences is thus one of the best-valued features of VEs. When we interact with an environment, be this real or virtual, our type of experience is a first-person [68] one, that is a direct, non-reflective and, possibly, even unconscious type of experience. On the contrary, third-person experiences [68] that are the result of interaction through an intermediate interface (e.g., someone else’s description of the world, a symbolic representation, a computer interface that stands between the environment and the user,), require deliberate reflection and cannot provide the same depth of knowledge as the first-person ones. In many cases, interaction in a VE can be a valuable substitute for a real experience, providing a first-person experience and allowing for a spontaneous knowledge acquisition that requires less cognitive effort than traditional educational practices.

Research in human learning processes demonstrates that individuals acquire more information if more senses are involved in the acquisition process [69], i.e. we are more receptive when we see, listen, hear and act at the same time. In VEs, one can exploit this human capability by providing multisensory stimuli, such as three dimensional spatialized sound or haptic stimuli (e.g., vibration, force). The use of three dimensional graphics allows for more realistic and detailed representations of topics, offering more viewpoints and more inspection possibilities compared to 2D representations. With an educational VE, one can provide a wide range of experiences, some of which are impossible to try in the real world because of distance, cost, danger or impracticability. In general, Web3D technologies allow the development of Web based educational VEs that provide the knowledge-building experiences discussed by Winn [68] and related to the concepts of size, transduction and reification.

In a VE, users can change their size to gain a better point of view on the explored subject. For example, they can grow until they can see interplanetary spaces or they can shrink until they become able to see atoms and molecules. The concept of transduction is somewhat deeper and more complex. A transducer is a device that converts information into forms available to our senses. A VE can convert every type
of data into shapes, colors, movements, sounds, or vibrations, i.e. into something that we can see, hear or feel as a haptic sensation. VEs can therefore be considered as transducers that widen the range of information accessible through a first-person experience. Through transduction and changes in size, users can perceive even what in the real world has no physical form. Finally, reification refers to the process of creating perceptible representations of abstract concepts. As Winn points out, the above mentioned three kinds of knowledge-building experience “are not available in the real world, but have invaluable potential for education”.

![Figure 2.1 Essential Components of a VLE](image)

There is a trend in Virtual Learning Environments (VLE) towards flexible and adapted learning experiences that modify their contents and behavior to suit the needs of different learners. Figure 2.1 shows the essential components of a VLE. Nowadays, adaptation to the needs of different learners and contexts is becoming an increasingly important aspect of VLE [70, 71]. This is a result of the need to reach users anywhere and anytime combined with the flexibility of web technologies. Typical adaptation mechanisms build student profiles based on learner preferences, portfolio, previous knowledge, educational objectives, and, in some cases, even different learning styles [72, 73]. Modern Virtual Learning Environments, often labeled as LMS, provide facilities for the interaction between instructors and students, detailed tracking of the students’ progress, and a simple path for the delivery of
content through the web. In addition, their use is getting more and more generalized in diverse contexts, not only as an alternative to face-to-face learning, but also as a rich complement.

From an industry perspective, VEs can be an attractive solution for reducing training expenses [74]. Instead of working with physical objects, these are represented by virtual objects that can then be placed in a virtual environment accessible to many users. The users, represented by avatars, can then manipulate and interact with the objects as in the real world, gaining valuable experience and training before using the real equipment. In addition, the virtual environment allows simulation of hazardous scenarios. The user could visualize the machining conditions and get impression of the importance of safety by closing the door during machining.

2.3.1 Classification of VE

A very important aspect of virtual reality is the environment in which it takes place and must be carefully engineered to achieve a convincing experience. There are several types of virtual environments.

- First, a VE can be static or dynamic. The static ones contain just fixed objects, that don't have movement elements (e.g. a building). If there is a object that changes its position as the time pass than the environment becomes dynamic (e.g. a pigeon that is flying).

- The dynamic virtual worlds can be interactive or non-interactive. The user can interact with objects from environment and change their state. These objects can be considered as the part of the environment and can have artificial intelligence features or not. A special class of virtual environments is those who permit to modify the virtual scene, by creating or destroying objects.

- The interactive virtual environments can be single user or multi user. In the single user case, each user can explore the environment, but he/she cannot interact with other users from same place. In fact, there is an instance of virtual world on the user's computer. It is like viewing a HTML document: each user can view independently a web page.
2.3.2 Educational Virtual Environments (EVEs)

Educational VEs (EVEs) provide students with visual, experiential, and self-directed learning. Students can

i) experience directly some physical proprieties (e.g., shape, size and time duration) of objects and events,
ii) change point of view to access new and/or unusual perspectives [75],
iii) Interact with objects either to discover and study their hidden elements [76] or to evaluate the effects of manipulations [77].

Moreover, EVEs for training can [78, 48]:

i) provide a low-cost alternative to creating full-scale physical training scenarios,
ii) offer the opportunity to create a wide variety of scenarios including those rarely (or never previously) encountered in the real world,
iii) simulate training scenarios that can be run repeatedly,
iv) Include a monitoring of progress during training sessions to evaluate learners’ skills.

A thorough discussion of the pedagogical basis and motivations for EVEs is provided in [79]. Advances in computer graphics and hardware performance in the last 10 years have made EVEs economically more feasible and several new EVEs have appeared in the literature. For example, Bell and Fogler [80] have developed Vicher, an EVE for chemical engineering education that deals with the topics of catalyst deactivation and non-isothermal effects in chemical reaction engineering. In this context, the EVE provides students with unlimited access to virtual chemical manufacturing facilities, without risks and without disrupting real operations.

VRPS (Virtual Reality Physics Simulation) [81] allows one to learn physics concepts, such as wave propagation and relative velocity. The application interface brings together 3D models of real apparatus and a visualization of physical situations in an interactive manner. Students can investigate the functioning of AC/DC electric generators; they can watch the output voltage in a voltmeter while switching the direction of the magnetic field, changing the intensity of the magnetic field, and adjusting the frequency of revolutions.

Virtual Water [82] exploits the same EVEs advantages; the application introduces students to the molecular bonding and structure of water by employing 3D
graphics to represent different scientific concepts (e.g., molecular geometry, orbitals and densities). It is interactive and learner-centered. Sensory immersive interfaces for enhancing the learning of molecular concepts in Physics and Chemistry were explored. Students are motivated by implementing learning-by-doing activities that stimulate students’s fantasy and curiosity in a manner familiar to them because they are supposed to be familiar with videogame environments.

An interesting Web3D EVE (based on the use of VRML and Java) has been developed by Ong and Mannan [83]; the proposed Web-based tool allows students to experience with CNC (i.e. Computer Numerical Control) control machine tools, which deal primarily with the numeric control of the motion of cutting tools in manufacturing. This application allows learners to enhance the understanding of the topic without requiring machining a new work piece every time a student needs to test new code.

In Germany, a desktop VR system-VEST-Lab was designed for safety training in chemistry laboratories by Zayas [84]. The training scenarios included prevention and investigation of accidents, identification of safety hazards and response to emergency situations. VEST-Lab represented objects and environments with a high level of realism in terms of the appearance of objects and the scale and proportion of the simulated environment.

There have been several efforts for diffusing information visualization tools, techniques and knowledge and using them on individuals’ education and training. Roussou has carried out long term R&D work, for instance, through the NICE (Narrative-based, Immersive, Constructionist/Collaborative Environments) an interactive virtual learning environment for young children that has served as a test bed for exploring virtual reality (VR) as a learning medium [85]. Her work has integrated psychology, cognitive sciences and learning theories as active learning theory, constructivism and constructionism, focusing on using the sensorial possibilities related to VR possibilities for supporting individuals’ learning through interacting with 3D computer generated environments.

Roussou et al. [86] have created and compared interactive immersive and non-immersive VR environments potential for educating. The work has expanded through designing and offering children exploratory learning activities via 3D interfaces. And analysing children’ tasks based on Vygotsky’s Zone of Proximal Development (ZPD), which concerns the internalisation of social rules. For instance, taking in
consideration that an individual using a 3D virtual environment can collaborate and learn with support from a more able peer, “but is not yet able to complete the task unaided” [87].

Bricken & Byrne have developed experimental study using VR for conducting a summer course with k-12 education students [88]. Students’ activities have centred on hands-on exploration of new technology. Researchers have created virtual worlds and explored human’s sensorial capabilities, which permit step inside to see, hear, touch and modify them. The investigation has evaluated VR's usefulness and appeal to students ages 10 - 15 years, documenting their behavior and soliciting their opinions as they used VR to construct and explore their own virtual worlds. As tools individuals have worn a head-mounted, audio-visual display, position and orientation sensors, and tactile interface devices, which allow inhabit actively an inclusive computer-generated environment. Bricken [89] has outlined a spatial algebra by mapping the structure of commutative groups onto the structure of space, considering interactions with spatial representations through natural behaviour in an inclusive environment that enforces the transformational invariants of algebra, which the spatial representation affords experiential learning.

Experiential algebra permits algebraic proof through direct manipulation and can be readily implemented in virtual reality. The techniques used to create spatial algebra have brought about supporting to explore experiential learning of mathematics in virtual environments. The Laboratory for Virtual Reality, Psychology, Rehabilitation, and Social Neuroscience at the University of Southern California's Institute for Creative Technologies has engaged in a broad program of R&D applying computer-mediated instruction for learning sciences, taking into account ways how people learn and methods of teaching that facilitate more effective learning experiences [90]. “This is where ICT's learning sciences are making a difference. Through design, guidance, mentoring, and assessment -- we provide education that is both useful and unforgettable” [91]. The research has also investigated human brain mechanisms that underlie neuro cognitive functioning and emotion regulation in persons throughout the life course using as tools a cross-disciplinary environment and an interdisciplinary team integrated by computer scientists, writers, engineers, producers, administrators and artists, including a combination between virtual and augmented reality, psychology and social neuroscience.
A considerable problem is that developing and delivering applications with proprietary VR technologies can be very expensive, and thus not accessible to many learners. An emerging solution is provided by Web3D open standards (such as VRML and X3D) that allow the delivery of interactive VEs through the Internet, reaching potentially large numbers of learners worldwide, at any time. Web3D VEs can also be independent from the platform and require only a plug-in for a Web browser to be displayed. Desktop virtual reality environments are presented on an ordinary computer screen and are usually explored by keyboard, mouse, wand, joystick, or touch screen. Web-based “virtual tours” are an example of a commonly available desktop virtual reality format.

2.3.3 Development Platform

There are a number of platforms available for developing a 3D VE depending on the way interactivity and simulated behavior is programmed. Some of these are as follows:

- Programming using an Application Programming Interface (API) such as ‘OpenGL’ or ‘DirectX’.
- Using one of the many computer game ‘engines’ as the rendering software, and defining the environment using the proprietary file format defined for the specific engine [92].
- Using the ISO standard Virtual Reality Modeling Language (VRML) as the development platform and a VRML browser as the rendering software.

Writing program code directly using an API is very difficult and time-consuming, but provides the greatest performance. The user interface is programmed from scratch in this approach which allows control over the user interface. Using a game engine is normally much easier than programming the environment directly. The user interface for motion control is provided with the engine, along with built-in capability for common game features, such as shooting of bullets, explosions and so on. The rendering performance of game engines tends to be very good. The programming task becomes quite complex when specific object behaviors, or tailoring of the motion control or object manipulation interface is required [93, 94].

VRML provides a platform independent file format for specifying the geometry, lighting and material properties of a 3D environment, as well as a scripting interface for specifying object behaviors [95, 96]. The VRML standard also allows for
distributed 3D environments, that is, environments delivered from a web server and hyperlinked to environments on other servers. 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. Scripting of object behaviors and enhancements to the user interface are normally carried out using the Java or JavaScript programming languages.

2.4 VRML

Virtual Reality Modeling Language (VRML) is the 3D language of the Web. Its purpose is to provide information to web pages in a three dimensional format. VRML is an ASCII-based three-dimensional modeling language, often described as the HTML of virtual reality. Because objects in this environment are 3D, they can be viewed from any angle, including close ups. The basic concept is that any object can be modeled by grouping such basic shapes as: cones, cubes, cylinders and spheres, and custom shapes called Indexed Face Sets. By specifying the construction method in the VRML file (as a grouping of shapes in relation to each other with different textures, reflectivity, and colors), the creator can develop a small, compact model. Once created, the object can be treated as a single unit much like a macro.

Although in the past most research concerning 3D worlds has been devoted to solve effectiveness and efficiency problems related to the rendering of static 3D scenes, in the last few years significant research has been focused on accessibility and usability issues for interactive 3D environments [97]. A current problem facing the widespread adoption of VRML in e-learning is the necessity for a client-side plug-in to be installed on the learner’s computer. This problem hopes to be solved by the development of international standards for VRML, currently being drafted by the Web3D Consortium [98].

VRML 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. Nevertheless, accessing this multimedia information via Internet can easily be translated, from the student’s viewpoint, into having to download huge files before being able to start visualizing them. This problem is not only inherent to 3D graphics applications, but to any other rich and potentially bulky content that cannot be streamed and that might be associated to the different virtual models to enhance the information provided to the student by the
virtual scene (e.g. an audio clip could be played when the user clicks on the 3D model of an ancient musical instrument [99]).

With the current VRML specifications, it is possible to add animation, sound and links, and to interact with both the environment and other users. Indeed, many sites attempt to demonstrate this capability, but, even with good bandwidth and high-performance computers, the animation and exploration are slow and jerky. VRML supports an extensibility model that allows new dynamic 3D objects to be defined allowing application communities to develop interoperable extensions to the base standard. There are mappings between VRML objects and commonly used 3D application programmer interface (API) features.

2.4.1 The VRML Technology

The aim of VRML is to bring to the Internet the advantages of 3D spaces, known in VRML as worlds whether they compromise environments or single objects (and using the file suffix .wrl). These are built to be shared between widely distributed users. VRML defines a set of objects and functions for modeling simple 3D graphics. These are known as nodes, which are arranged in hierarchies called scene graphs. There is a top-down arrangement in which nodes that are described earlier in a scene affect later ones, but this can be limited by the use of separator nodes. Objects can be reused within the code (USE) or by Inline nodes where coding is used from an external file.

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 the user 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 the user move around in - light, texture and sound. Users can approach objects from different angles and can hear the sound from different positions.

A VRML file is an ASCII file which is interpreted by the browser and converted into a 3D display of the described world. VRML is designed to fit into the existing infrastructure of the Internet and the WWW. It uses existing standards wherever possible, even if those standards have some shortcomings when used with VRML. Using existing standards instead of inventing new, incompatible standards makes it much easier for the Web developer, who can use existing tools to help create VRML content. It also makes it much easier for somebody implementing the VRML
standard, since libraries of code for popular standards already exist. VRML files may contain references to files in many other standard formats. JPEG, PNG, GIF, and MPEG files may be used as texture maps on objects. WAV and MIDI files may be used to specify sound that is emitted to the world. Files containing Java or Javascript code may be referenced and used to implement programmed behavior for the objects in the world. Each of these is an independent standard, chosen to be used with VRML because of its widespread use on the Internet.

The layout of the scene is described in text files which contain information about an object's attributes (position, location, color and orientation). Java script can also be embedded in VRML source code to allow even more flexibility. Each object can communicate with other nodes via events. Events are triggers that can be activated by the proximity of the user (an automatic door for example); the proximity of other objects (a moving node representing a car perhaps); the passage of time (a chiming clock is a good example); or by deliberate action (the user clicks on the object with the mouse). Events allow users to interact with the virtual world while the nodes within it react to each other. VRML gives the ability to create own behaviors to make shapes move, rotate, scale, blink, and more. Almost every node can be a component in an animation circuit. Nodes act like virtual electronic parts and can send and receive events. Wired routes connect nodes together.

In VRML world the user is represented by a virtual figure called Avatar. It can move through the space in one of several modes - WALK, FLY or EXAMINE. When the Avatar is set to a mode WALK it can go only on foot. A FLY mode clears the gravity so the Avatar can fly free except through objects. The last mode EXAMINE disables the collision detection and it makes possible to explore the whole scene even inside the objects.

2.4.2 The functionalities of VRML

Objects in the world can act and react to each other under program control, or they can respond to the user’s actions in some way. For educational purposes, this will in many cases be essential. The features are:

- International character sets for text can be displayed using UTF-8 encoding.
- A set of new nodes has been added to increase the realism in models that are intended to represent the outdoor world around. It will be possible to
create ground and sky backdrops, adding distant mountains and clouds, for instance. The effect of distance can be further enhanced with fog effects. In addition, there will also be the option of defining an irregular terrain rather than being constrained to a flat ground plane.

- Sound generating nodes will also enhance the sense of realism.
- New sensor nodes will set off certain events when one enters specific areas, or click on certain objects. So, for example, as the viewer approaches an object it can be triggered to start some action or make a noise.
- Collision detection ensures that objects can act as if solid. That is, the user will not go through walls and floors.
- Script nodes allow for the animation of objects in the world and the interaction of the world with other applications, for example databases.
- Prototype constructions define new VRML nodes in terms of already available ones similar to macros.

It is obvious that the VRML technology has all the features and functionalities that are suitable for creating an interactive VE. There is already a series of virtual worlds being made available, experimenting with increasing functionality, mostly based on the VRML format. They include either scripting and construction facilities or additional communication which are textual, audio or even video. Most of these take VRML models and allow them to be used within multi-user shared environments. These shared worlds, based on VRML, will be very important in the future. The ability for students to not only visit another VRML to explore it, but also to possibly meet its authors is very exciting. In the educational sector, it will remain the case that much learning is achieved through student-student and staff-student communication and social worlds can facilitate this.

2.4.3 The role of VRML in education
Applications of ICT in education are the induction of movement techniques, movements with graphics, and simulations, the development of visual experiments, speedy exploration of data and observations storing, the development of multiple reconstructions etc. The greatest contribution however, of ICT in the educational process is the potential of modeling and simulating phenomena and procedures that facilitate scientific research and the exploration of the real world [100], in contrast to
the procedure of simply acquiring knowledge out of a book manual. According to Brant et.al, [101] modeling is a computing process which includes a manageable and interactive environment and it corresponds to a real phenomenon or a theoretical system [102].

VR through VRML "worlds" broadcast over the internet have many potential uses in instructional and educational settings. VR is showing outstanding promise for the medical profession, for engineering and structural design, as well as in projects where "being there" is all but impossible. VRML in education will likely find exposure as a means of exploring complex mathematical "terrines", giving unique views of very small, very large or otherwise inaccessible spaces such as navigating along a DNA helix, probing inside of a human brain, a human heart, and at the other extreme, exploring virtual astronomical spaces like solar systems and galaxies. There are plenty of obvious applications for educational simulators in a number of fields: physics, planetary exploration, archaeology, biology, and chemistry all can benefit greatly from better visualization technologies. The point of these systems is not necessarily the amount of things that can be done with them but the fact that students can have the power to create them on their own and can find it fun and motivating to do so. Any textbook or course materials that have 3-D graphics, such as architecture and engineering, may benefit from VRML. VRML, along with the Internet in general, offers a number of attractive features for the education sector:

• It has cross-platform compatibility.
• Much of the software for creating VRML content can be downloaded for free.
• As VRML sits upon existing World Wide Web tools, existing student knowledge of these is applicable, easing use.

VRML gives teachers the opportunity to enhance their students’ knowledge, while simulated spaces can help students visualize information in new and realistic ways, give abstract concepts a realistic flavor and encourage cross-cultural, global communities.

2.5 Dynamic E-learning through Virtual Reality in Education Domain

Virtual reality simulations and animations were developed and appropriately placed in the teaching materials to enhance the student understanding of complex concepts. E-Learning is dynamically evolving, thanks to the incredible achievements in highly powerful and intelligent tools and technologies that are rapidly emerging.
These developments have expanded the possibilities of taking e-learning to great heights more than ever. These advancements that have the potential to not just play a pivotal role, but drastically transform the learning domain due to the following reasons:

• They fundamentally change the conventional landscape.
• They produce something new and more efficient.

Dynamic website generation started in 1993 with simple Common Gateway Interface (CGI) programs that could dynamically generate HTML code. In 1995 the Personal Home Page (PHP) scripting language emerged, which was easier to write than CGI programs. Microsoft followed suit in 1996 with its Active Server Pages (ASP) technology [103]. This release was considered a break-through in dynamic website generation, because ASP could be implemented by using relatively easy to learn scripting languages (Visual Basic Script or JavaScript) on the most common operating system: Windows. Finally, in 1999 during the JavaOne conference, Sun Microsystems presented their version of dynamic content generation tools: Servlets and Java Server Pages (JSP). JSP is based on the Java programming language; hence it inherited all its merits: object-orientation, scalability and platform-independence.

Interactive VR is engrossing because there is the opportunity for deep involvement, which captures and holds learner interest. It is also engrossing because it is multi-sensory by incorporating sounds, images, and text. It is individualized, allowing users to navigate through information to build their own unique mental structures based on exploration. The use of animation to create interactivity provides stimulation, activity, and visibility. E-learning establishes activity through interaction because learners participate in active learning instead of the typical passive learning in traditional training settings. Learners are active because they navigate through the training, complete tasks, apply their knowledge, and conceptualize in a “live” environment.

Since human beings are creative, inventive and curious, the e-learning environment is designed to motivate, arise curiosity to complete the real-life simulated tasks. The VRML standard provides for basic object manipulation. Various mouse sensors can be defined in VRML and routing the events be generated by these sensors to objects within the environment. Objects can be rotated, dragged within a particular plane and moved in an animated path when clicked upon using the mouse.
The VRML External Authoring Interface (EAI), which defines an interface between a VRML world and an external environment, is used. It provides a set of methods that an external application can be used to interact with, and dynamically update a 3D scene in real time. VRML events generated, for instance, after a user action, can be caught and handled. Using the EAI we can control the VRML scene from outside. That means that the application can insert/remove objects (VRML nodes) into/from scene and otherwise influence the parameters of the scene. In order to start any operation using the EAI we must establish the connection between the application and the VRML browser.

2.5.1 EAI

Remote VRML browser control using EAI describes an implementation of experimental system, which allows multiple users to cooperate within one VRML world. The program is built up on architecture client/server. A Java applet is used for communication between several users connected by a network. The applet uses the External Authoring Interface (EAI) to influence/control a VRML world in a browser embedded in a HTML page. The EAI provides a Java interface that communicates with an external HTML Web browser. EAI applets can send information to and from VRML scenes embedded in an HTML page. Using EAI, a Java applet can handle any new world from “outside” without going “inside” it to change its specification for events and fields.

EAI uses the existing VRML event model to access nodes in the scene. This model is based on sending and receiving events (eventOuts, eventIns). We can use four methods of accessing VRML worlds:

1. Accessing the functionality of the Browser Script Interface [14], this is used by built-in script nodes. These functions provide a mechanism to get or set browser state. Functions such as getName(), getCurrentSpeed(), loadURL(), createVrmlFromURL(), addRoute() are available.
2. Sending events to eventIns of named nodes inside the scene.
3. Reading the last value sent from eventOuts of named nodes inside the scene.
4. Getting notified when events are sent from eventOuts of named nodes inside the scene.

The first three access methods are conceptually identical to Script Authoring Interface, as described in ISO Standard [14]. The only difference is the way of
obtaining the reference to a node through which its eventIns and eventOuts can be accessed. A script node can get a pointer to a node defined by DEF and USE statements (called instancing). An applet has no access to instancing mechanism; it has just a method to get the pointer to a node defined by DEF statement only. The last access overcomes the problem, that ROUTE statement cannot be used for sending events from VRML scene to an applet. The applet has to implement a registered method which is to be called when specified eventOut occurs (i.e., callback mechanism).

JavaApplet access the scene mainly use vrml.external package encapsulated in the Browser class. To access the VRML scene using EAI in JavaApplet, need to get an instance of Browser first of all, it can be achieved by calling static methods getBrowser() of the Browser class. After the browser instance, to control the node in the VRML scene, we need to call getNode() method to obtain the entrance address of the node in the system. In VRML, only the node named by DEF structure can obtain node address when the external EAI program call related method. In a reference to be accessed node, it can be transmitted in event to the node, read and monitor out event of the node. Calling getEventIn() method can send an event to a node in VRML scene event entrance, thus changing the scene. Calling getEventOut() node method can read a domain value send by node in VRML scene export. Callback() method of interface class Eventoutobserver automatically invoked when out event occurs.

The Java applet has four methods:

1) An init method,
2) A start method that looks for a VRML browser and special nodes as defined in the program,
3) An action method that waits for Java events, and
4) A callback method. The Java applet and a VRML file are loaded at the same time in a HTML document.

The first function of the applet (after initializing some instance variables) is to recognize the VRML world and some specific nodes that will be used and changed. This is done by the start method. Then the callback and action methods are called whenever something new happens. The action method is used to recognize the user and send to VRML the color of the Node. The callback method, constantly watching for VRML event, is activated when the user clicks in the VRML world to drop a node. Callback records the position of the click and sends these co-ordinates back to the
VRML files where a new sphere appears. It is more practical to utilize VRML and EAI with Java for quick prototype development to create and manage the interaction in our virtual environment.

2.5.2 Prototypes

VRML supports the definition of new node types, called prototypes, in terms of existing node types. Existing node types may be either built-in or previously defined prototypes. The combination of prototypes and script nodes provides a powerful mechanism to encapsulate content and behavior in a reusable entity. These prototypes, which are similar conceptually to classes in an object oriented language, can then be used from within any VRML environment. Prototypes (PROTO and EXTERNPROTO) allow creation of new VRML node types by authoring combinations of nodes and fields from other preexisting node types. In this sense, a PROTO definition is somewhat analogous to a macro definition. In order to avoid completely copying a PROTO for each file where it is used, the EXTERNPROTO definition specifies remote URL where the original PROTO is defined, along with the interface to permit local type-checking by browsers during scene loading. The EXTERNPROTO mechanism thus allows construction of PROTO libraries for easy access and reuse.

Unlike a prototype, an external prototype does not contain an inline implementation of the node type. Instead, the prototype implementation is fetched from a URL. The other difference between a prototype and an external prototype is that external prototypes do not contain default values for fields. The external prototype references a file that contains the prototype implementation, and this file contains the field default values.

A visual interface has been developed to provide a means for users to visualize the steel structure represented by a CIMsteel Integration Standards Release 2 (CIS/2) file. A CIS/2 file provides for the electronic exchange of data directly between various steel CAD software applications. Using a web-accessible translator, objects in a user’s CIS/2 file are mapped to application-specific VRML (Virtual Reality Modeling Language) nodes in a VRML file that can be interactively navigated in 3D using freely available VRML browsers [106]. A major part of the research in visualizing structural steel product models was to develop a mapping between CIS/2 entities to application-specific VRML nodes. Typically the VRML that is generated by a CAD program or steel-related application describes the geometry of the structure through a
collection of Cartesian coordinates and an index array that describes how the coordinates are connected together to create faces or polygons.

The VRML prototype mechanism (PROTO) adds extensibility to VRML for creating new geometric nodes similar to the built-in VRML geometric primitives. This is the primary basis for developing application-specific VRML nodes to model information stored in a file. The advantage of using the prototype mechanism is that the VRML necessary to model a steel structure can be in terms related to steel such as length, width, depth, and section dimensions rather than only the coordinates that define the faces of a part. The VRML exported by CAD packages use the latter method. Previous work by the authors [107] showed how VRML PROTOs could be used to model a complex steel structure. The visual presentation comprising of all the VRML concepts are shown in figure 2.2.

![Figure 2.2 Presentation of VRML Concepts as a scene](image)

The EXTERNPROTO section provides the interface definition and the URL of where the actual implementation of the PROTO can be found. By keeping the implementation of the PROTO separate from its use, the implementation can be changed without having to change any of the VRML files that use it. However, if the interface definition changes, for example by adding a new input parameter, then the VRML files that use the PROTO must be modified to account for the new interface definition.
The PROTO is used to represent all members of a manufacturing model regardless of whether it is a beam, column, clip angle, or gusset plate. The main input parameters for the PROTO are its cross section, length, and features. A cross section is specified by its dimensions and optional parameters such as a cardinal point, offset values, and a flag to indicate if the cross section is mirrored. Rather than have an individual input parameter for each value that could be used to describe a cross section, a single text string is used to specify multiple cross section parameters. The text string is generated from the given information. The PROTO parses the text string to retrieve the parameters. The same is true for the input parameters to specify features that are applied to parts.

2.6 Virtual Reality in Industries

Effective training of the usage of various facilities and design become crucial for the success for an industry company. Virtual prototype of facilities and their layout could benefit the potential users and experts to interactively evaluate its goodness prior to a real deployment. A study conducted by the Institution of Structural Engineers in the UK reveals that civil engineering education should include practicality and feel for construction engineering [108, 109]. In reality, many civil and construction undergraduate programs fail to provide students with an arena where they can acquire the skills and experience necessary to successful professional practice and on-site performance [110, 111]. Most civil engineers need to spend many years in the field in order to assimilate an adequate knowledge about actual construction performance. Therefore, it is imperative for civil engineering (and construction engineering and management) educators to promote these education enhancement factors to undergraduate students in the classroom [112, 113, 114].

Many of the commercial CAD systems used by the construction industry are primarily geometry modelers, rather than object modelers [107]. Regardless of the file format used to export a model (including VRML), they frequently export the 3D model as only a collection of surfaces representing the geometry that contains far too many polygons and unnecessary details. They also fail to preserve the aggregation of geometry elements into objects and the relationship between objects. There is no possibility of accessing and viewing information in the 3D model other than the geometry. Intelligently constructed VRML representations of steel structures can be done in an object-like fashion. A VRML Prototype is used to create a Beam object that provides a simple way to specify thousands of different types of beams with only
a beam designation and position; at the same time providing access to other non-graphical information sources. The prototype encapsulates the details of the implementation of the Beam object. Object-like VRML representations make it easier to update models or to extend the implementation of the object without having to change the model.

Steel structures are characterized by a variety of basic structural elements including beams, columns, plates, and pipes. With the exception of plates, basic structural elements are typically much longer than their overall cross section dimensions. Complex structures, such as trusses, are built from a combination of basic structural elements. Mechanical and chemical process equipment is often built from a combination of basic structural elements as well. The VRML prototype mechanism allows for the creation of application-specific geometric objects similar to the built-in primitives such as boxes, spheres, cones, and cylinders. Research at NIST [115,116,117] has developed a mapping between the CIM steel Integration Standard (CIS2) [118] and VRML. CIS2 is a logical product model [119] for describing steel structures and has been adopted by the American Institute of Steel Construction as their standard for electronic data interchange [120]. VRML prototypes have been developed that correspond to CIS2 entities such as parts (beams, columns, braces, clip angles, plates), bolts, holes, welds, and locations.

2.7 Analysis of e-learning techniques

A primary goal of providing training and education is to bridge the gap between current and desired knowledge, skills, and attitudes (KSA’s). In order to measure if desired KSA’s have been attained, learner achievement needs to be measured. Learner satisfaction is a major component of successful training and particularly important to e-learning courses, careful analysis of the different aspects of learner satisfaction is an important component of evaluating e-learning courses [121]. A simulation can be a valuable substitute for the real world at least in the first period of training. In fact, few systematic empirical studies have been carried out to show this and have not led to clear conclusions about “what sort of training shows transfer, in what conditions, to what extent and how robust the transferred training has proved to be” [122].

The Kirkpatrick model for training evaluation defined the four levels of evaluation as follows [123]:
Level 1 evaluation, **Reaction**, involves measuring how participants react to or feel about a training program. This is basically a measure of customer satisfaction. “Smile sheets” provided at the conclusion of a training event are an example of evaluation at the reaction level.

Level 2 evaluation, **learning**, measures the extent to which participants’ knowledge, skills, and attitudes change as a result of training. The use of pre and post tests to measure learning is an example of a level two evaluation design.

Level 3 evaluation, **Behavior**, examines the extent to which change in behavior has occurred because of attending a training program. In essence this level attempts to measure on-the-job changes in performance resulting from training. Using a control group in order to assess behaviors prior to and following completion of training is one of the best ways to gather data at this level.

Level 4 evaluations, **Results**, can be defined as the final results that occurred because employees attended the training program. Results may include increased production, decreased costs, improved quality, reduced turnover, higher profits and return on investment.

The learning process and the learning outcomes must be measured. Throughout the learning process, student’s progression is monitored through activities within the virtual environment. Asking students to make verbal predictions about a certain activity, to describe what they observe when performing the activity, and to compare their predictions to their observations had been a useful way to monitor the learning process [124]. Questionnaires and interviews are used to gather users’ perceptions about the learning experience. By focusing on the students’ experience as well as their learning, we gain insights that guide the refinement of the user interface and aid us in understanding the strengths and limits of VR’s capabilities for conveying complex scientific concepts.

### 2.8 Dynamic Reconstruction of 3D Virtual World Using a Database System

The growing complexity of data information both on the web and in databases often push the limits of two dimensional representations. The Xerox PARC User Interface Research Group has conducted extensive research about information visualization. Several projects in this group are related to 3D visualization of generic information. Information Visualizer and the Butterfly browser are two leading
projects of Xerox on new interfaces that can be applied to the database visualization in 3D. The Information Visualizer is an experimental system to develop a new user interface paradigm for information retrieval, oriented toward the amplification of information based work. It is based on the Xerox analysis of several aspects of information use that have led them to simplify the information retrieval problem as an information workspace [125]. Xerox had some projects based on the Information Visualizer, specifically the Cone Tree and the perspective wall, which used 3D concepts to represent complex patterns of information in simplest way.

The Cone Tree [126] is one of the Information Visualization techniques which are used for visualizing hierarchical information structures. The hierarchy is presented in 3D to maximize effective use of available screen space and enable visualization of the whole structure. Interactive animation is used to shift some of the user’s cognitive load to the human perceptual system.

The technique called the Perspective Wall is used for visualizing linear information by smoothly integrating detailed and contextual views [127]. It uses 3D interactive animation to fold wide 2D layouts into intuitive 3D visualizations that have a center panel for detail and two perspective panels for context. The resulting visualization supports efficient use of space and time. The Perspective Wall works with any 2D layout that has been described as a list of 2D vectors and 2D positioned text. The placement of the 2D layout on the panels is determined by a single parameter that specifies what part of the layout should be in the center of the detail panel. The wall scrolls when this parameter is set to a new value.

Butterfly, developed by Inxight, is an application for accessing DIALOG's Science Citation databases over the Internet [128]. DIALOG is a service providing access to millions of document sources on very large set of fields. It is complex; online database document based, and can also contain multimedia documents. Network information often involves slow access that conflicts with the use of highly interactive information visualization. Butterfly addresses this problem, integrating search, browsing, and access management via four techniques:

- Visualization supports the assimilation of retrieved information and integrates search and browsing activity.
- Automatically-created "link-generating" queries assemble bibliographic records that contain reference information.
Asynchronous query processes explore the resulting graphs for the user.

Process controllers allow the user to manage these processes.

The most effective means of transferring knowledge to groups of people is through demonstration in seminars and lecture rooms. The level of understanding of the teaching material by the students can be enhanced through interactive Web3D where 3D information is presented on the table-top in conjunction with real objects. The virtual demonstration starts by launching a web browser. In the home page the user has the option to choose from. An interactive 3D model displayed in an embedded VRML browser. The demonstrator can describe the underlying theory of the concepts by interacting with the 3D model, e.g. rotating, translating or scaling the model. Users can interact with the 3D model using standard I/O devices like the keyboard and the mouse. The user can zoom, pan and rotate virtual information as naturally as if they were objects in the real world.