

Virtual Class Rooms for Distance Education in Engineering and Technology

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ABSTRACT

Virtual Class Room is currently the subject of academic researchers in distance education and virtual environments. However the conceptualization of virtual class room is not well documented or thoroughly researched. In this paper, the basic information and tools relating to virtual class room design are briefly discussed prior to the presentation of a possible design methodology for virtual class rooms. The paper then reviews the important features/characteristics and the problems encountered at various stages in the methodology. It also presents a sample application of robot movements, demonstrating the use of Virtual Reality Modeling Language (VRML) for virtual class rooms.

Keywords: Virtual Class Room, Virtual Teaching, Distance education, E-learning

1. INTRODUCTION

Today's teaching and learning is changing in a number of ways along with the altering global outlook. First, the world has moved from an industrial-based economy to an information-based economy. The knowledge of understanding and visualization is considered more profitable and a key resource than capital services in information based economy. Second, is the need to transmit high volumes of information and knowledge that is being generated in today's information-based economy. This has led to the phenomenal development that is being witnessed in the area of Information and Communication Technologies (ICTs). As a result, a variety of technologies became available for transmitting information. Recent developments in communications have transformed how, where and what is communicated today at a speed is many folds faster than what was imagined and dreamed of a few years ago. This has brought the information to every doorstep world over, even the remotest farmer. So, the role of distance learning institutions has become increasingly difficult and more responsible in today's modern age of ICTs. The challenges are formidable for many institutions especially in the developing world. Most of the institutions/universities are continually faced with lack of resources, dwindling volumes of books/printed materials and shrinking space with progressive increase in student enrolment.

Recent technological developments mark major impact from two facets: teaching and learning. During the late 80's, the world has witnessed emergence of portable personal computers with multimedia capabilities as a convenient and cost effective solution for numerous applications. Also the availability of networking allowed global contact and communications asynchronously or synchronously. This has unleashed a tide of unlimited growth of the Internet that has given the access to the World Wide Web (WWW) in open & distance learning and made teaching possible to a greater level. It now means that all the institutions must devise a means of virtual

teaching in a way that should be effective in meeting the needs of continuous education. These technologies produce not so much of an incremental change of today's routine use of personal computers (PCs) and local area networks (LANs) in laboratory environments, but rather introduce a new paradigm more akin to virtual reality. The vision of today's learning for a student or trainee who stays a few hundreds/thousands of miles away is to get the same (or much better) sense of presence and control as if he/she is at the experiment in a site or laboratory. The rest of the paper is organized as follows: the concept of virtual class room and its essentials are discussed in the next section. In Section 3, a brief introduction has been given to VRML. In Section 4, the necessity of virtual class room is elaborated with an example in robotics domain. The paper is concluded with a summary of the key findings in Section 5.

2. THE ESSENTIALS OF VIRTUAL CLASS ROOMS

The foremost requirements for a virtual laboratory are the necessary software tools. In these days most of such software tools are readily available and therefore it is possible to develop such laboratories. The requirements vary for each virtual laboratory depending on the application. Apart from this, the other requirements are in the terms of content, approach, methodology as well as the procedures that need to be adopted for such development. The major objective for developing a virtual laboratory is to make it highly interactive and user friendly. With such virtual laboratories, the students would be able to learn various aspects of science and engineering, and also 'design' and 'build' a few artefacts out of their intuitions. To meet such needs, a virtual laboratory should provide high-level CAD tools, which would aid students in creating and analyzing their designs. For example, a virtual laboratory for manufacturing facility should have different types of machines, components, material handling equipment, simulation capability, and some supporting equipment if required. The student/trainee would be interested in designing a shop floor by placing the different machines on shop floor, and assign jobs/parts/components to different machines according to their operational requirements and then associate material handling equipment to the machines for the transportation of the jobs. Then, record the production performance of the proposed design by simulating the layout for given time, which is known as simulation run. To add further, the student might even be interested in changing the position of machines or the parameters of material handling equipment, or components' attributes and evaluate the new design to see the effect. The ultimate interest of student would be to compare all the different design configurations and select the best design among them. The developed / used software in virtual laboratory must articulate and provide explanations for its results, and coach students on improving their designs. Self-explanatory simulators should be developed to provide the manufacturing facility outlook to the learners.

Use of VRML and Internet facilitates the students with possibility of handling a model in a virtual way to the applications similar to the above discussed scenario. In an indirect way the students are motivated to make the alternative designs based on their intuitions to their exercises/assignments. This method equips the students with basic skills for cooperative engineering and problem solving capabilities. Apart from several benefits in learning, this method also provides a vital reward to the teaching in terms of supervised distant learning. The supervised learning technique allows the teaching instructions to reach all the students online (even the remotest student). This is feasible for every single subject/domain. It will be very difficult for easy and clear understanding in virtual teaching and learning without the facility of supervised distant learning.

3. THE VRML LANGUAGE

VRML is an acronym for 'Virtual Reality Modeling Language', and usually pronounced as 'vermal'. VRML is an idea for three-dimensional (3D) compositional graphics on the Web, proposed by Dave Raggett as "Virtual Reality Markup Language". The VRML language is proposed in 1994 and was recognized as an international standard (ISO/IEC-14772-1:1997) by the International Organization for Standardization (ISO). It is a scene description language that works with 3D models over the Internet. VRML is not a general purpose programming language like C++, a script language like JavaScript or a page specification language like HTML. It is a scene description language that describes the geometry and behavior of a 3D scene or "world". VRML is a standard file format for representing 3D interactive vector graphics, designed particularly with the WWW in mind.

VRML FORMAT AND ACCESSIBILITY

VRML files are commonly called worlds and have the .wrl extension (for example island.wrl). VRML is a text file format where, e.g., vertices and edges for a 3D polygon can be specified along with the surface color, image-mapped textures, shininess, transparency, and so on. Thus, the VRML can be seen as a 3D visual extension of the WWW. The WWW is the set of all information accessible using computers and networking. Each unit of information is identified by a Universal Resource Identifier (URI). URI is the string (often starting with http:) that is used to identify anything on the Web. The user will access an URL (Unique Resource Locator) containing a VRML document, from which the information is downloaded into the Internet browser. URL is a term used sometimes for certain URIs to indicate that they might change. Although VRML worlds use a text format they may often be compressed using gzip so that they transfer over the internet more quickly. Many 3D modeling programs can save objects and scenes in VRML format.

The VRML language allows adding other information into the 3D model, such as links to other Internet documents. URLs can be associated with graphical components so that a web browser might fetch a web-page or a new VRML file from the Internet when the user clicks on the specific graphical component. Animations, sounds, lighting, and other aspects of the virtual world can interact with the user or may be triggered by external events such as timers. A special Script Node allows the addition of program code (e.g., written in Java or JavaScript) to a VRML file. As the browser detects the type of file, a VRML visualizer is initiated. This visualizer allows to move the scene (and/or the observers) in a 3D virtual world. The files containing the 'VRML Worlds' have a ".wrl" suffix, in opposition to the ".html" suffix in traditional WWW pages. At present, browsers allow visualizing the VRML models either directly or through the use of 'plug-ins'. The WWW had two fundamental dimensions: connectivity (the http protocol) and interface (i.e. the rendering of content, especially HTML and embedded URL's). VRML inserts itself seamlessly in the Web's connectivity. The VRML language works in a large variety of platforms, from personal computers to powerful workstations. VRML browsers can access other VRML files via URL. They can access any other format that then is passed to another application (e.g. an HTML browser or a HTML window). On the other hand HTML browsers can be configured to fire up VRML helper applications (or plug-ins). HTTP servers, finally, can be configured to tell the client that a VRML (*.wrl) document is transferred. Another important feature of VRML is that it is compact, allowing a reasonable response time over the Internet. Complex 3D models can be described in files with sizes that are comparable with the size of common HTML documents.

A large number of tools are readily available to create the 'worlds' by using simple commands and geometric primitives. Construction of models using these tools is relatively simple but time consuming. The last decade witnessed many converter programs in the market. These converter programs allow content developers/designers to convert the files of 3D drawings stored in the '.dxf' (Drawing Interchange Format) or '.max' (3D-Studio MAX) formats directly into VRML models. All VRML coordinates are specified in terms of x, y, and z axes. The X-axis can be thought of as moving from right to left on the screen; i.e. horizontal. The Y-axis is up and down, i.e. vertical. Finally, the Z-axis is in and out. This convention is known as the right hand rule. All distances in VRML are measured in metres. Again, the rotations in VRML are by the right-hand rule only. If the developer imagines wrapping his hand around one of the axes, with thumb pointing in the positive direction, the direction of positive rotation is the same as the direction that fingers wrap around in, i.e. clockwise looking in a positive direction. This is true for rotations about any axis. This also applies to the rotations about arbitrary axes. All rotations are measured in radians, not degrees. In general to obtain the radians, it is equivalent to the multiplication of the number of degrees by $\pi/180$.

When a basic shape is drawn, it is drawn at the origin (0,0,0), and it has no colour. These are the attributes that must be defined in order to be used. Usually the shapes are hollow. This is useful when creating a "room". Also, the shapes are dark in die, unless the user specifies a light inside of the shape (Point Light). The four basic shape types in VRML are the cube, the sphere, the cylinder, and the cone. All of these are the typical shapes commonly thought of, except for the cube. The cube is a six-sided box that does not necessarily have width, length, and height all equivalent. These four basic shapes can be moved, coloured, lit, stretched, etc. to create a variety of different shapes.

4. DISTANCE EDUCATION – AN APPLICATION TO ROBOTICS

A major advantage of virtual class room is the amount of savings in space and capital. This is especially true in the case of technical universities/institutions. For example, a technical university with several campuses spread all over the country or world, need to have similar equipment in every laboratory in all the campuses according to their curriculum. With virtual class room approach, the institutions need not buy such an expensive robot (or a machine) and install them at every laboratory in all the campuses. All the applications pertaining to either a robot or machine (or several machines) are stored in the form of software in a PC. Thus, physical space required for a machine is saved. From technological perspective, the machine or robot which is ultra modern at the present times may become obsolete with time, say a couple of years. So, once again institutions may have to invest additional amounts to go for new machines or equipment to be in-line with cutting edge technology. This is very much necessary as the technology becomes obsolete, the machine might not be of no interest to the teachers as well as learners. With virtual class room approach, the universities need to spend only a fraction of investments to update the software tools, which is in contrast to the investments that are normally needed to acquire the machines physically. Not only, they need not invest huge amounts of investments on the machines, they could also save the space (which is normally limited) for some other important applications.

An application is developed to suit the above described methodology. It illustrates basic understanding about a robot and its movements. A robot can be defined as ‘an automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications’. In simple words, a robot is a mechanical or virtual, artificial agent. It is usually an electro-mechanical system, which, by its appearance or movements, conveys a sense that it has intent or agency of its own. For engineers, the physical appearance of a robot is less important than the way its actions are controlled. The student might like to learn the functioning of an articulated robot in a working environment. The basic character to classify a robot is with its degrees of freedom. The ‘*Degrees of Freedom*’ can be defined as the directions in which a robot can freely move or access the work envelope. To a learner who has not seen the actual robot and its movement, it would be highly difficult to visualize its movements, as well as number of degrees of freedom. Some robots have 6, 8, 12, or even 20 degrees of freedom. In general, a robot with six degrees of freedom is enough to perform jobs that require versatility and dexterity for most of the basic tasks. Figure 1 shows such a robot with six degrees of freedom. The joints are depicted with numbers 1 to 6 in figure.

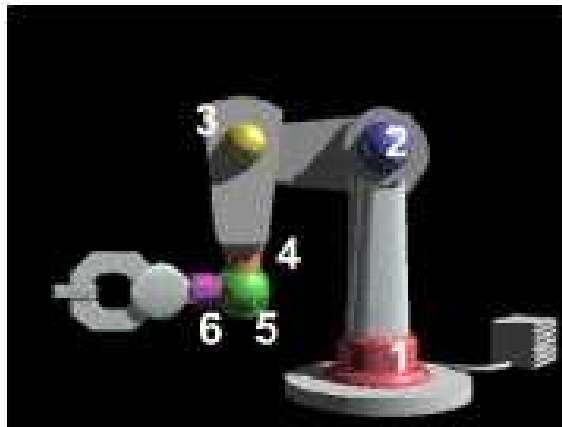


Figure 1: Robot with six degrees of freedom

In this paper, only two joints are elaborated with varied positions in rest of the discussion. It is just to demonstrate the relevance of virtual class room concept to the reader.

ROBOT BASE

The movement of ‘Joint-1’ is as illustrated in the figures 2(a) to 2(f). This movement resembles the rotational movement of the human hand at the shoulder. Figure 2(a) shows the starting position of the robot whereas figure 2(b) shows the position when it has reached the right most position. Figures 2(c), (d), (e) and (f) gives the further motion of the links to left side and back to original position.

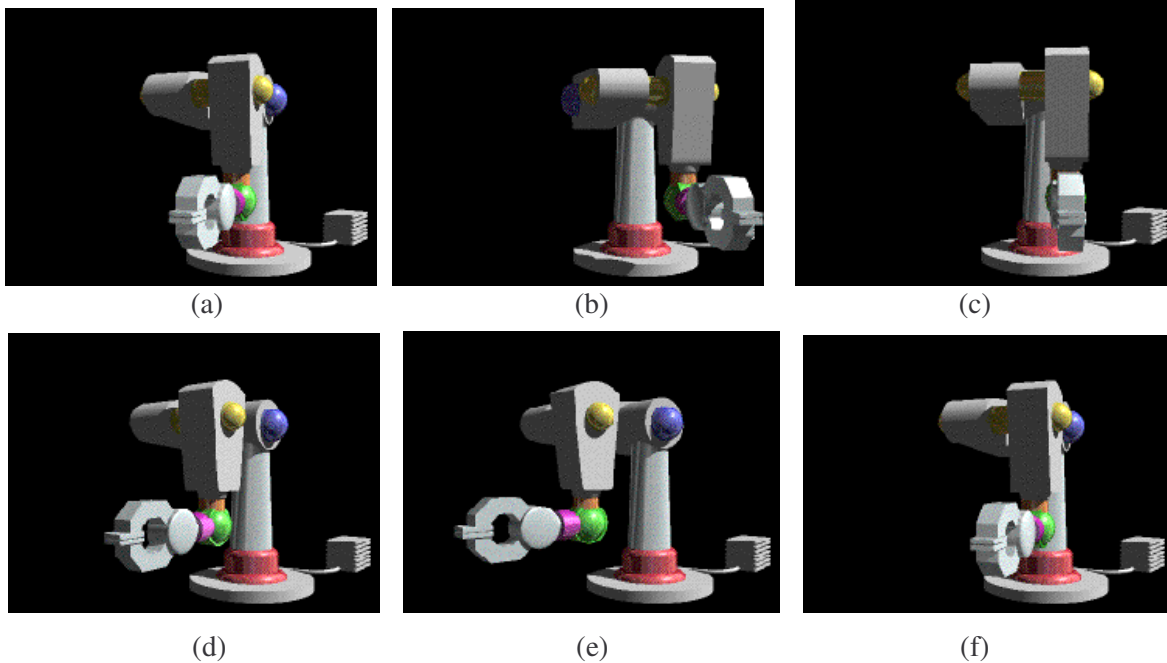


Figure 2: Different positions of Robot Arm Rotating Base

ROBOT ELBOW

The movement of 'Joint-3' is illustrated in following figures 3(a) to 3(f). This movement resembles the movement of the human hand at the elbow. Figure 3(a) shows the starting position of the robot whereas figure 3(b) shows the position of the elbow when it has reached the uppermost point. Figures 3(c), (d), (e) and (f) gives the further motion of the elbow downward and back to original position.

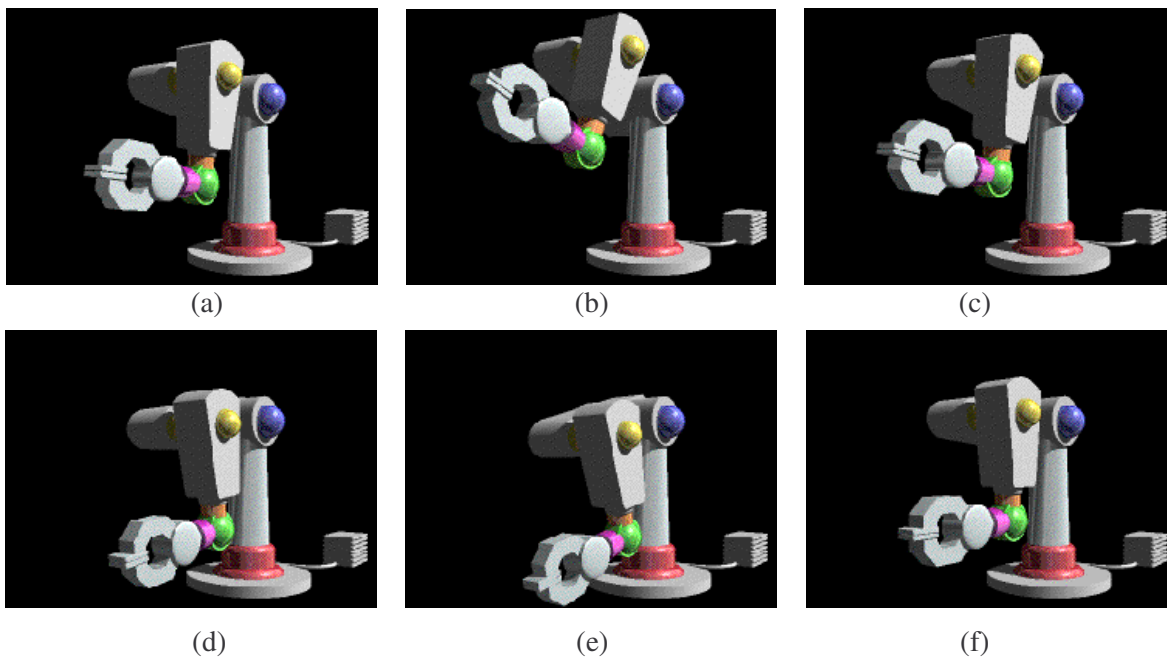


Figure 3: Different positions of Robot Arm Bending Elbow

5. REQUIREMENTS FOR VIRTUAL TEACHING

Any virtual classroom's goal is to empower, enable and connect learners around the world. Basically, it should create a participatory environment where students can learn essential skills. Most of the requirements for such an environment relate directly or indirectly to infrastructure and network capability. A few basic requirements normally needed for setting a virtual classroom is as discussed below.

MONITORING AND CONTROL

A web-based experiment is an experiment usually conducted over the internet. Web based experiments have become increasingly popular in recent years because of their ability to collect large amounts of data over internet from a wide range of locations. However, a few concerns have been raised about the weaker controls in web-based experiments as opposed to laboratory-based experiments. In case of engineering related laboratories, the experimentation should be closely monitored from a remote location and needs proper control at a given point of time and at different time intervals. With the availability of ICTs, cognitive scientists have been posting more complex and real-time studies using various software and technologies. For simple laboratory based measurements LabView software is a better tool and is also widely used in industries. LabView is a product of M/s.National Instruments, USA, commonly used in small to medium scale systems (with up to a few hundred monitoring and control points). Large-scale real time experiments could have thousands to tens of thousands of control and monitoring points. For these experiments the institutes can either use custom build control systems or Experimental Physics and Industrial Control System (EPICS). EPICS is a set of open source software tools, libraries and applications developed collaboratively and used worldwide to create distributed soft real-time control systems for scientific instruments such as a particle accelerators, telescopes and other large scientific experiments.

LABORATORY NOTEBOOK

A laboratory notebook is a primary record of experiments/research. The notebook serves as an organizational tool, a memory aid, and can also have a role in protecting any intellectual property that comes from the experiments/research. Researchers use a lab notebook to document their hypotheses, experiments and initial analysis or interpretation of these experiments. The lab notebook is usually written in as the experiments progress, rather than at a later date. The guidelines for lab notebooks vary widely between institutions and between individual labs, but some guidelines are fairly common. A lab notebook is often maintained to be a legal document and may be used in a court of law as evidence. Many say that lab notebook should be thought of as a diary of activities that are described in sufficient detail to allow another scientist to follow the same steps. An on-line laboratory notebook or electronic laboratory notebook (ELN) is a software program designed to replace paper laboratory notebooks. These are a fairly new technology and offer many benefits to the user as well as organizations. For example, electronic lab notebooks are easier to search upon, support collaboration amongst many users, and can be made more secure than their paper counterparts. These can be divided into two categories: Specific and Generic notebooks. "Specific ELNs" contain features designed to work with specific applications, scientific instrumentation or data types. "Generic ELNs" or "Cross-disciplinary ELNs" are designed to support access to all data and information that needs to be recorded in a lab notebook.

TELE-PRESENCE

Tele-presence refers to a set of technologies which allow a person to feel as if he were present at the experimentation site. It is to result an effect on the learner, though he is at a location other than his true location. Tele-presence requires that the senses of the user, or users, are provided with such stimuli as to give a feeling of their presence in that location. Additionally, the user(s) may be given the ability to affect the remote location. In this case, the user's position, movements, actions, voice, etc. may be sensed, transmitted and duplicated in the remote location to bring about this effect. Therefore information transmits both ways between the user and the remote location. Depending on the application, a specific set of capabilities could be identified. Some of these channels are low bandwidth and some are high, but all must be multicast. However, it appears that variations of these will be common to all such environments:

Video

- cameras at local and remote workstations
- robotic cameras for area monitoring (remotely controlled)
- data cameras monitoring sample chamber
- remotely controlled video switch

Audio

- wireless microphone/speaker sets
- audio mixer

Software tools

- vic, vat, wb, CU-SeeMe, nevot, ivs, etc..

SECURITY AND DATA CONFIDENTIALITY

In virtual environments, computer security and access control includes authentication, authorization and audit of a user. It also includes measures such as physical devices (including biometric scans and metal locks, hidden paths, digital signatures, encryption, social barriers) and monitoring by humans and automated systems. Access control systems provide the essential services of identification and authentication (I&A), authorization, and accountability where:

- identification and authentication determine who can log on to a system;
- authorization determines what a user can do;
- accountability identifies what a user did.

COLLABORATION BETWEEN MULTIPLE USERS AT MULTIPLE SITES

Given a scenario, several users might be accessing a remote experiment/service from different sites. There is a modest possibility that the users can control a few aspects of that experiment in collaboration with each other or in an isolated manner. To have such an advanced control over the experimentation, there should be a robust mechanism for implementing a policy whatever is established to permit multiple user access to the experiment. The system should be able to monitor (status of resources), arbitrate (current controller), and negotiate (pending requests). It must be scalable to any environment which should accommodate many resources and collaborators.

CROSS-PLATFORM COMPATIBILITY

Most operating systems are equipped with an application that provides an interface to the operating system (OS) managed resources. These applications have been command line interpreter as a basic user interface, but more recently they are available with a graphical user interface (GUI) for ease of operation. The operating system forms a platform for other system software and for application software. Microsoft Windows NT, XP, VISTA, Linux, Unix, Sun, and Mac OS are some of the most popular operating systems. The tremendous benefits of cross-platform compatibility come from a package's interface being exactly the same on every system. Generally, the software chosen for a specific application would determine the operating system compatibility. After determining the basic compatibility, one has to check software vendor's web site for implementation notes and software patches (updates). For any questions regarding the compatibility between a specific OS version and the backup application, one should contact the software vendor.

MAINTAINABILITY

As new systems are deployed or migrated, the key to reducing operational costs is to eliminate duplication wherever possible. Fewer the hardware and software combinations in an environment would be better. At the same time, a PC's "personality" is critical to end-user productivity and understanding. This personality will consist of user data (e.g., Microsoft Word and Excel files), customized application settings (e.g., Microsoft Word dictionary), and Windows configuration settings (e.g., toolbar settings and shortcuts). If these customizations and data are lost, the result can be an increase in helpdesk calls, significant end-user frustration, and downtime - all of which can cost an institute considerable time and money.

INTERFACE AND COMMUNICATION

The bandwidth required for communications to support virtual laboratories is fairly laboratory-specific in terms of the data that has to be transferred. But the multimedia streams for human collaboration and monitoring has a fair bit of commonality across different types of labs. The data flows are higher than current production networks could sustain (5 - 15 Mbits/s of application data, 7-21 Mbits/sec of network-level bandwidth. there are real-time (though as yet uncharacterized) requirements in the control system; multiple coordinated data and multimedia streams must be multicast (using several different models) to several users and sites that are widely spread across the country; and a versatile, strong, and widely distributed security infrastructure must be in place. From the point of view of the virtual laboratory there are several different types or uses for communication:

- Multimedia collaboration
- Experiment parameters
- Experiment results
- Collaborator control information
- Security information.

6. CONCLUSIONS

The institutions offering online education have to be particularly conscious of this fact since virtual education is often thought of as a technical solution to distance, and generally tends to forget the learning needs of the students and their satisfaction with the learning experience. This paper presents a possible methodology for distance education in engineering and technology, viewing virtual class room as in invaluable aid. To most of the universities, the proposed methodology/concept represents advancement not only to the discussed application, as well as in the use of new productivity tools in all other domains/subjects. It adds the value matching with similar to what we get through conventional on-campus programmes. Ideally, the learning should be always student driven rather than system driven.

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