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Open Web-Based Virtual Lab for Experimental Enhanced Educational Environment

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1. Introduction

Nowadays, there exists a common problem that science and engineering students lack professional knowledge and skills. Students lack the ability that can guide them to practice with the theory and research methods. These problems are becoming more prominent among some poor condition schools.

Adams, Raymond K. introduced the virtual oscilloscope which was built aiming at the students who were majored in electrical and computer engineering in the University of Tennessee in the summer of 1988 (Adams & Raymond, 1989).

In 1990, Mercer, Lynn etc. from Canada University of Regina proposed the concept of the Virtual Lab and built a simple one (Mercer et al., 1990). During the next 20 years, a lot of researchers further built and enriched the concept of Virtual Lab (Hai Lin & Lin, 2005).

Educational environment means all the environments, places and conditions that can carry out learning and training activities, such as schools and training institutions. Learning environment means all the environments for learning. Chu-Ting Zhang considered that learning environment is composed of the factors that can affect people, which include the natural environment, the physical environment, the interpersonal environment and the educational concept environment (Zhang, 1999).

From the geographical point of view, the learning or educational environment can be divided into the classroom environment, the lab environment, the campus environment and the social environment. The specific learning environments correspond to the virtual learning environments. As shown in Fig. 1.

The most common modern classroom environment is the multimedia classroom which includes: projectors and large screens, object display platform, DVD player and computers. Among them, computer is increasingly becoming the centre of multimedia classrooms. Due to the lively features of having the image of specific and providing activities that students can personally involved in, modern curriculum resources provide students with a wide range of information stimulation and arouse students' sense and interests to participate in activities which seems like a real scene so that students can increase their knowledge pleasantly and develop their own capacity, which cannot be replaced by the traditional teaching.
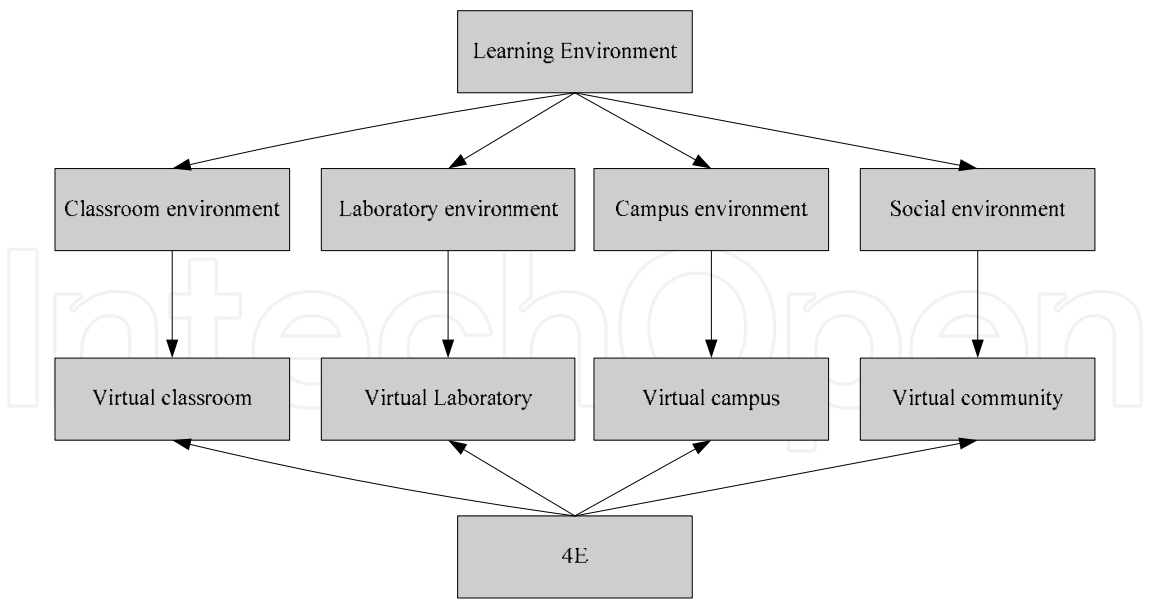
Fig. 1. The Learning Environment and Virtual Learning Environment

Laboratory environment refers to the laboratory which schools and training institutions build for teaching students. School laboratory is an essential part of teaching and learning environment. It provides students with convenient, safe and intuitive place to do scientific experiments. The experiment can stimulate interest in learning, experience the fun of exploration, improve the existing structure of knowledge and enhance the abilities of operating, diagnosis, analysis, design and innovation.

Campus environment refers to all the inside school learning environment except the classrooms and laboratories which includes the educational environment provided by the library, lecture hall, offices, communication rooms and other facilities.

Social environment refers to the learning environment except classrooms, laboratories and the campus environment that offered by the community such as science museum and internship department.

With the rapid development of information technology, the digitization and virtualization of the learning environment has become the future development trend. People construct virtualized learning environment through web technology and computer communication technology. This environment is widely used in distance education and Television University in China.

The virtual classroom is also called live classroom, which can provide real-time teaching function through web technology. Teachers can use texts, images, handwritings, voices, videos and other forms of media to teach students with theoretical knowledge. Students can use texts, voices and other forms of media to ask questions at anytime. The learning process is similar to the traditional classroom environment.

Virtual lab is an online virtual experiment system which is based on web technology and virtual reality technology. It is the digitization and virtualization of laboratories on campus. Virtual lab consists of a virtual laboratory bench, a virtual equipment cabinet and the web-based software for laboratory management. Virtual lab provides a bran-new learning and

training environment for experimental courses. The virtual laboratory bench is similar with the real laboratory bench. Students can configure, connect, debug and operate the virtual experimental equipment by themselves. Teachers can use the equipment in the virtual equipment cabinets to set up any reasonable typical experiment or experiment cases. This is an important feature that is different from general experimental courseware.

It is indicated in the psychology research, the closer between content in the study with the life background for student, the stronger the awareness in the study become. On the contrary, it is difficult for the student to accept the very abstract content. For Analogue Circuit Curriculum in the field of electronic, for instance, the theoretical arithmetic is over emphasized in the current teaching material while such theoretical arithmetic model cannot reflect the real circuit system exactly in many cases. As the students get confused and bored easily the course has been nicknamed the "devil course" among many students in China. Even though they strive to acquire the calculation methods from the course, these given methods rarely play a role in the science and production practice. Circuit simulation system could get the circuit parameter faster and more precisely than manual calculation, in addition, it is economic and feasible. The virtual experiments provide the teachers and students a more direct and convenient simulation experiment environment. We can get rid of the constraint of complex and inefficient theoretical arithmetic in teaching process by using simulation technology.

Virtual campus presents the campus environment to students in term of web technology and virtual reality technology. The official website of school shows all the detailed information to the visitors. The content of website includes department introduction, service organization, specialized subjects, curriculum, scientific research, social service, recruitment, employment and so on. Students can browse on it and join the virtual library, the lecture hall, Q&A room or online BBS.

"Virtual communities are social aggregations that emerge from the Net when enough people carry on those public discussions long enough, with sufficient human feeling, to form webs of personal relationships in cyberspace." Virtual community was defined by Howard Rheingold (Rheingold, 1993). Types of virtual communities include Internet message boards, online chat rooms, virtual worlds and social network services. Here, we take virtual community as virtual educational environment corresponding to the social educational environment.

The virtual classrooms, virtual labs, virtual campus and virtual communities play an essential role in building the virtual educational environment. However, the progress of such technology does not fundamentally change the effect of teaching and learning. The main reason is that they are only a mapping for real educational environment. Therefore, it is difficult to go beyond and completely change the existing educational environment. However, it is already under ripe condition for the integration and innovation on this basis, so we can expect a courageous challenge for education innovation caused by information technology.

2. Experimental enhanced educational environment

Experimental Enhanced Educational Environment (4E) refers to a virtual learning environment focused on experiment simulation that is built by information technology. The

4E centres on virtual lab and supplements related functions of the virtual classroom, virtual campus and virtual community. Breaking the natural barrier among the classroom, the laboratory, school, and the outside community, the 4E puts theoretical study, experimental operation, collaboration, communication and social practice together as a whole. It allows education open to real application at a lower cost and enables students to adapt to future development in a more efficient way.

In the opinion of constructivists, if learners want to complete the construction of the meaning of the knowledge, in other words, to understand the nature and laws of the reflected things and to appreciate the links between things and others, the best way is to let learners feel and experience the real-world rather than just listening to people who introduce and explain this experience. Within the 4E, it will be quick and convenient to create an environment similar with the real teaching situation. The 4E is more suitable for the learning mode such as Self-learning - remedial learning, Inquiry-based instruction, Anchored instruction, Analyze the phenomena of learning, Discovery learning and other learning model, even effective to Transfer–to accept learning and Butler's self learning mode.

Using different educational environment and facilities to carry out teaching, students' knowledge acquisition, active participation, practical ability and intuitive feeling is different, see Table 1.

Educational Environment	Classroom	4E	Laboratory	Society
Knowledge Acquisition	Easy	Easy	Difficult	Most difficult
Active participation	Negative	Positive	Positive	Positive
Practical ability	Bad	Good	Better	Best
Intuitive feeling	Bad	Good	Better	Best
Cost	Lower	Low	High	Superior

Table 1. Comparison of the 4E and the traditional educational environment

By means of simulating the cognitive objects in the real world, the 4E provides a vivid operating environment, which makes the students be willing to approach, understand, like and thus be motivated to learn and explore actively. The 4E can arouse the students' happiness of exploring and creating, and stimulate their cognitive interest and learning motivation. The students will have a more perfect understanding of the knowledge structure and their abilities will improve more effectively.

The students perform an experiment provided by the virtual environment. In that the experimental models are created by the students, and the experimental data is also collected by the students, they will become more interested in the experimental model, design and results. They can acquire more knowledge than that got from books and multimedia CD for learns. This method will also improve student's hands-on training, observation, analysis, diagnosis, design and innovation capability. The interest is the best teacher and the strong driving force for students to learn actively, think positively and explore bravely. So using the 4E in learning tasks will promote the students to throw themselves to learning activities, and play a multiplier role.

The 4E is a new kind of educational environment, but it is not a mature of the pedagogy. Along with the establishment of the 4E, a new pedagogy will appear in the future. The characteristics of the new pedagogy is predicted as following

1. Attach importance to the construction of virtual environment and information resources, and provide more intuitive knowledge
2. Virtual labs are the most important learning environment for students, especially for students of science and technology
3. Cultivation of students' creative potential to enable students to explore on a large scale;
4. Stimulate the students' motivation
5. Create the environment to share knowledge and experience, and let student study collaboratively
6. Enhance the guidance to students by means of automation and intelligent
7. Every student can create their own knowledge structure and design their cognitive objects
8. Restore every student's learning process and result
9. More precise individualized teaching, all students have their own private roles and learning space
10. Maximize the student-centred teaching philosophy

3. Demands on the environment building

3.1 A variety of learning resources

Digital resources are the information resources available for education which are released, accessed and used in digital form. Rich resources are helpful to build a good learning environment. The resources required in the construction of the 4E are mainly included:

1. Providing virtual instruments, devices and other equipment in virtual experimental platform;
2. The learning objectives and the experiment instructions which created in the 4E by the instructional designing experts;
3. Learning guidance document;
4. Knowledge database;
5. Question& Answer database;

Rich digital resources provide a strong guarantee for designs in the learning process. They are presented to the learner in a variety of forms at anytime. The construction work of digital resources should start earlier and keep improving and supplementing constantly according to the feedback during the teaching process.

3.2 Completely and orderly learning process

The learning activity should be a process which is lively, active and full of personality. The proper design for the learning process can ensure that learners not only have an order which can be followed in the learning activities, but also are free and independent enough to perform themselves. The learning process includes instructional design and events which are completed by the teacher; the background study, test, experimental observation, explore & design, discussion and experience summary which are the student centred; the evaluation, display, statistical analysis of study files, archive report which is teacher-led.

3.3 Timely and effective instruction

Guidance for students should reflect the concept of student-centred. Instruction should be accurate, timely and effective. The teacher acts as an organiser, director, guider and partner, whose position in the instruction should not be doubted. But because of the constraints of some factors, such as time, energy and memory, teachers need help from the guidance system which is based on artificial intelligence, information retrieval and multimedia knowledge base (Wang, 2010). It is possible to guarantee the timely and effective instruction by the system.

Firstly the guidance system should have a strong ability to understand and perceive students, on this basis, which can provide learners with a variety of guidance and help. In terms of the perspective of the subjective will of the students, learning guide can be divided into two types: Searching for Help and the Director. The Searching for Help means that the students take the initiative to request system to give tips, guidance and help when they are confused. The Director means that the guidance system prompts and guides students without the students' requests according to the status and situation of the students. From the view of feedback time, learning guide is divided into two kinds: real-time guidance and non-real-time guidance. The real-time guidance means that the system immediately responds when the students seek help or some kind of system considers that in the case should be prompted, no matter where the response comes, which also is known as synchronous real-time guidance. Conversely, non-real-time guidance means that the system can not immediately respond after the student seek help or some kind of system considers that the prompt should be put forward in the case, then the students need to wait a long time to get feedback, so it also known as asynchronous guidance. In general, the cost of real-time guidance is relatively high, so the intelligent guidance and answering system based on expert system and knowledge database will greatly reduce the repeated work of teachers.

Like a virtual teacher, instruction system is the most humane part of the 4E.The instruction should be accurate, timely and enlightening, and also should be designed user-friendly to establish a strong feeling with students in the learning process.

3.4 Learning environment in harmony

The reform and development of learning environment is primarily the combination between real learning environment and virtual technology environment. There exits real environment, physical environment, interpersonal environment and ideal environment in the natural environment (Zhang, 1999). Learning environment is a real atmosphere, and the school has its own tacit culture which is difficult to create by any technology environment. Therefore, the virtual technology environment must be consistent with the existing learning philosophy and learning order. With the smooth transition and improving, we should gradually expand the proportion of virtual technology environment in the existing of learning environment in practice. Any attempt to completely replace the traditional learning environment may be counter-productive.

The learner is the centre of whole service of the system. Experience of learners should be concerned, including learners' study experiences, learning effect, enthusiasm of participation and initiative, the upgrading of skills, evaluation to the learning environment and teacher. Only those can truly make a positive or negative answer to a learning environment.

4. Technology solution

The 4E can be built on campus network. The technology of the 4E is based on the educational technology. The virtual classroom environment can be built on the basis of the electronic classroom, the examination system (including the student's psychological test system) and Course On Demand (COD). Virtual lab environment can be built on the basis of virtual laboratory, educational games and academic tools. Virtual campus environment can build on the basis of question and answer system (including instant messaging systems), electronic reading room, educational administration (including the enrollment application, course scheduling, teaching quality assessment and performance management, Office Automation (OA) of school). Virtual communities environment can be built on the basis of open forum, chat rooms, Social Networking Sites (SNS).
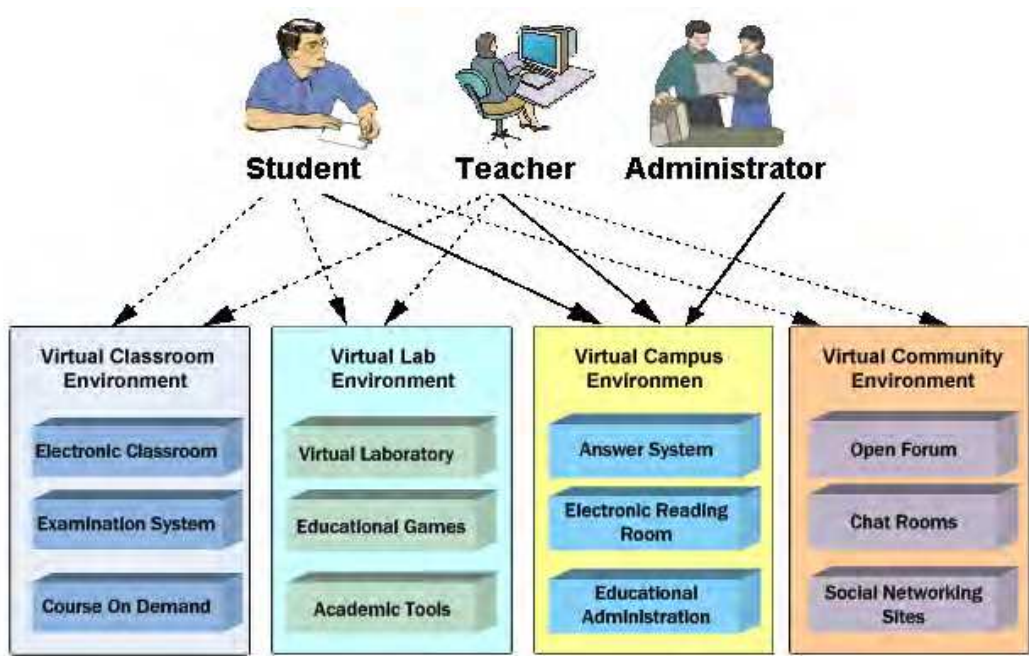

Fig. 2. Software functions included in the 4E

We will supplement related functions and strengthen the connections between systems based on the 4E idea. These systems get integrated through Web Service and realize single sign on that the user only need log on once during the process.

4.1 System architecture

The 4E software system uses three-tier system architecture: Client Tier, Server Tier and Data Tier. Client Tier is mainly about the user's Web Browser and Smart Client. Server Tier is mainly composed of Web Server and Application Server. The common Web Server has Apache, Nginx and Lighttpd. The main function is receiving the requests of the user, handling the request of static file download and forward dynamic process, it also can provide load balancing. There are some common application servers, such as Tomcat, Jetty and Weblogic, etc. It mainly used to handle the dynamic forwards request of Web Server. Data Tier mainly is the Database Server, File System Server and other external systems, Database Server is mainly used to store relational data. File System Server is mainly used to

store pictures, documents and other non-relational data. Other external systems is a kind of system which exchange and transmit data with the 4E. Application Server could access to hardware which is connected to the server, so the experiment device could be controlled remotely.
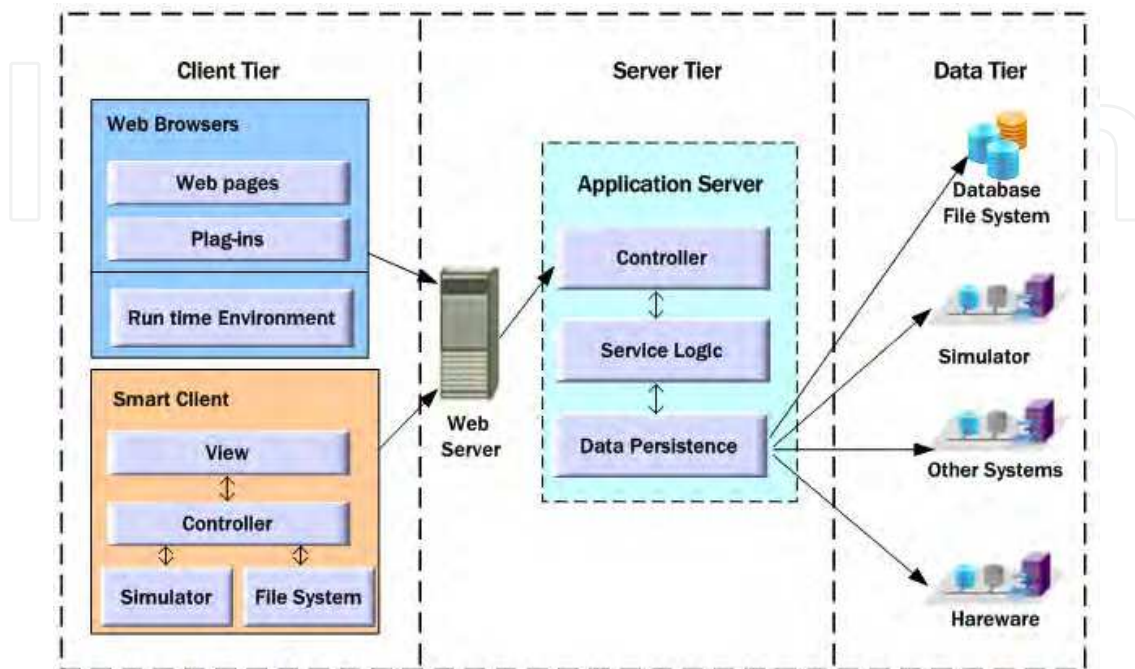

Fig. 3. System Architecture of the 4E

4.2 Development technology of information system

To build the 4E information system, there are an army of technological options to choose.

C/S is referred to Client/Server architecture which is called Rich Client (also called heavy, fat, or thick client). C/S is often characterised by the ability to perform many functions without connection to the network or the central server in order to reduce the pressure on the server. This architecture allows the user to work offline at most of the time, but it's complicated to deploy and update the client software and corresponding infrastructure software.

B/S is referred to Browser/Server architecture which is called Thin Client. The clients of B/S generally run application software in a browser. This architecture is easy to deploy, update and maintain. In addition, the server could take advantage of the cluster technology to improve its performance. B/S is a widely adopting architecture now, but it needs the real-time network connection when it is applied.

Smart Client combines the function and flexibility of Rich Client and deployment easily and stability which is belongs to Thin Client organically. It abandons the shortcomings of Thin Client and Rich Client, so it has certain advantages for developing the 4E.

There are many alternative technologies for B/S and C/S, such as Java, PHP, Python, Ruby and so on. Popular programming languages being adopted released on the form named TIOBE programming Community Index for October 2011. The rating of Java is 17.913%, in

comparison, PHP is 6.818% and C# is 6.723%. The ratings are calculated by counting hits of the most popular search engines (TIOBE Software, 2011). These figures illustrate that the three language or namely called platform, such as JEE/Java, PHP, .NET, account for most of share in the field of web nowadays.

JEE/Java source file should be compiled to .class byte-code file firstly, and then the byte-code file would be interpreted and executed in the java virtual machine. Java has abundant functions and great resource utilization in server, so it's widely used in enterprise or large system though it has a great resource overhead. Java platform is open and stable enough. It has a great number of high-quality open-source frameworks and libraries, so it is also suitable for small or medium-sized applications.

PHP is a scripting language interpreted in the server. It's easy to learn. The grammar of PHP is similar with C. PHP is more widely used in small and medium applications on the Internet. Thinkphp or CakePHP MVC framework is widely used. However, PHP's prospects are not promising, because its design is too simple. There shows a downward trend of usage in the future.

Microsoft's C# combines the advantages of the Visual Basic, Java and PHP and other languages with the power of Java, the briefness of Visual Basic, and the easy-to-start of PHP. Consider that it is relatively closed platform only for Windows, not opened for other platforms, with the high licensing fees for the supporting software. It is worried about the prospects in the education industry.

There are also ROR, Python, Node, JavaScript and other Web development technologies, but these techniques are generally applied to specific areas, not the mainstream of the software technology for information systems.

In comparison, JEE/Java is more preferred because the Java platform is more open, and there are lots of open source frameworks such as Struts2, Spring, Hibernate, Wicket, Spring MVC, JSF, Guice, Ibatis. There are several combinations of the framework to develop B/S application. It is recommended to use the combination of the most common framework SSH, which is Struts2, Spring and Hibernate.

4.3 Simulator platform technology

Simulator platform is an essential part of the 4E, which provides the main interface for experimental operation. The human-machine interface is generally coded by the form of plug-ins within a browser. The simulator can be realized in the plug-ins, also can be implemented as an application programme in a client or servers. There are several common technologies to implementing the platform:

ActiveX has been used for a long time because of its flexibility and strong function, such as operating on the local file system; accessing the external network connection and so on. But the security problem is also appeared at the same time. Besides that, the compatibility between the browser and the platform based on ActiveX is poor. ActiveX can just run in the browser of Internet Explorer based on the Windows platform. Because of its security problem, ActiveX has been used less.

Flash has a variety of platform version, high installed rate and better browser compatibility. In addition to these, it is safer than ActiveX, and has a strong function include connecting

the network and playing audio and video, so Flash has a strong expression for education. Flash mainly uses Action Script language and has a powerful Integrated Development Environment (IDE). Currently as a common element in the web page, it is widely used to increase the dynamic effects of the web page and even to be the main expressive form of the application system report and user interface. Its principal flaw is not open as a standard.

Applet/JavaFx use Java language as the language of development. It needs to download and install a relatively large Java Runtime Environment (JRE) to be able to run. It runs in the default sand box, so that the security is better. The Applet has an advantage of cross-platforms which means that it can run in all kinds of operating system and browsers.

JavaScript language is mainly used in the development of HTML5, which adds the "canvas" element and integrates SVG content. Besides that, it has powerful drawing functions and a part of the Rich Client functions. But its standard has not yet fully formed, and its function is not in full. On the other hand, it has not supported for old versions of the browser.

Comparing with the above four techniques, ActiveX has trouble in security and cross-platform supporting. The standard for HTML5 is not yet mature. Considering the fact that a large number of instruments' internal logic needs to be programming in the simulation platform, rigorous static language is more suitable than the script language. So Applet is preferred for the simulation platform.

5. An Open Web-based Virtual Lab

With the effort to design, realize and apply on educational environment based on the virtual experiments, this paper reports an Open Web-based Virtual Lab (OWVLab) for colleges on engineering experiment. The OWVLab is a real digital lab, which can be used by students, teachers and lab technician through Internet anywhere at any time. The service capability of the lab could be enlarged infinitely by Cloud Computing Service or Computer Cluster technology. It is the simulation of a real lab. Surrounding with the virtual entrance, information desk, the classroom, chat room, the instructor and the evaluator, the virtual devices, instruments and elements can be moved from the equipment cabinet to compose various trial and errors for the experiments in different disciplines and explore on the virtual laboratory bench just like in a real lab. An experimental enhanced educational environment with open web-based virtual lab has been set up for colleges [Fuan Wen, 2010].

5.1 Experiment enhanced learning management

For the requirement of learning in schools, OWVLab provides an integrated management solution. There are an army of useful functions such as curriculum management, academic programs management, course selection management, laboratory management, learning resources, learning activities management, knowledge learning, attendance management, virtual laboratory management, intelligent guidance, automatic correcting experimental records, laboratory reports management, the learning process monitoring, evaluation of the learning effectiveness, file management and etc.

System is divided into five roles such as system administrators, teachers and students and faculties for school governor, laboratory staff, different roles have their own permissions. The system is built by modules to make sure that the functions are easy to expand. With the

ongoing of the application of experimental learning, the system can be customized to the actual requirement for different types of schools.

With the application of the system, we can promote that the laboratory will be more and more informationized and regulated. The threshold of the laboratory will be lower for students. The pedagogy of experimental learning will be improved greatly. Achievements of experimental learning will be accumulated.
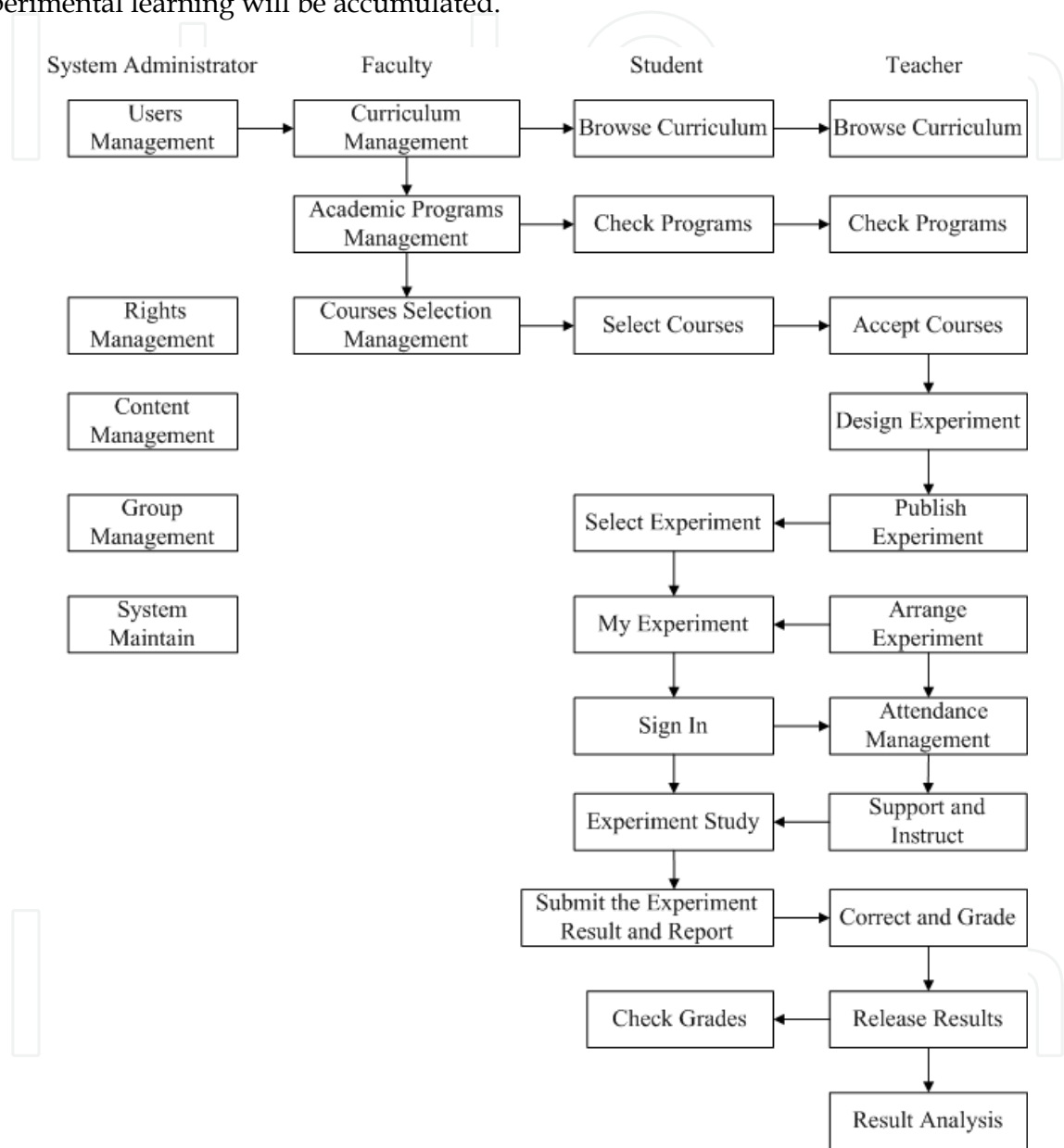

Fig. 4. The main working flow in OWVLab

5.2 Features of OWVLab

1. A set of effective virtual experiment management system has been provided and it is easy to integrate with other learning and instructional system.
2. Adopting multimedia technology, abundant experimental learning resources are offered for students.

3. Intellect and one-to-one real time guidance are provided on emphasis and difficult problems during the process of experiment for students.
4. Automatic correcting functions are provided to the experiment result thus to reduce teacher's duplicate work.
5. Adequate experiments models are designed by experts to enhance the abilities of operation, design and innovation to students.
6. The knowledge learning and operating ability cultivation are combined to form a complete experimental learning system.
7. The virtual instruments can present an experimental phenomenon that the real devices cannot reflect.
8. With direct and user-friendly interface all the virtual equipment is easy to operate and more similar to real equipment.
9. With strong extensibility and flexibility users can add experimental equipment and experiment model according to specific requirements which is individual customization service.
10. The standards such as SPICE (Simulation Program with Integrated Circuit Emphasis) are abided by the system.

6. Use case and simulation

6.1 Use case

There is a Use Case describing how the OWVLab is used by all kinds of users. When a student sit in front of a computer at home and log into a web site, a virtual lab will appear on the screen. She/he will find messages listed on the information desk, enter in a virtual classroom and listen to the teacher in class, and has a test on related knowledge. She/he may take a rest with music and beautiful pictures, go into a chat room has a talk with classmate, send message to teachers when they are absent. The virtual instructor may guide the student visit in a lab. A lab technician may show the intent of the experiment today. The student will drag the appropriate equipment to a laboratory bench, connect them together, manipulate the instruments, observe, ponder over and record the result. In case the study on the experiment has been finished, fill in report, save and submit all experiment record to his teacher. The teacher will retrieve and correct the experiments and grade the student at home. All the people active in virtual lab are monitored by the laboratory staff and school governors.

6.2 Simulator platform for the circuits, computers and communications

Simulator platform includes a virtual equipment cabinet in which there are about a hundred types of electronic component and popular instruments. It also include a virtual experimental platform for circuit design. Students can connect, configure and test the circuit.

6.2.1 Virtual components and Instrument

(1) Virtual Electronic Components

1. Resistor: 57 common value resistors, one custom value resistor and one sliding rheostat
2. Capacitor: 9 common value capacitors and one custom value capacitor

3. Inductor meter: 2 common value inductor meters and one custom value inductor meter
4. Transformer: Along the string transformer and Playing transformer, Parity four-terminal transformer, Ectopic four-terminal transformer
5. Diode: 6 general diode and 2 voltage regulator tubes
6. JFET: 2 JFET-NJF and 2 JFET-PJF
7. BJT: 7 BJT-PNP and 3 BJT-NPN
8. Integrated operational amplifier: µA741, OP37AJ, 741
9. Multiplier: Analog multiplier
10. Three terminal regulator: LM7805CT
11. Linear transformer: TS_PQ4_10
12. Bridge Rectifiers: 1B4B42
13. Quartz crystal oscillator: HC-49U_3MHZ
14. Source: AM signal, FM signal source
15. Three-phase Power: Star and triangular three-phase power
16. Switch: SPST switch, SPDT Switch
17. CC series: CC4001, CC4012, CC4071
18. 74series chips: 74LS00, 74LS03, 74LS04, 74LS08, 74LS20, 74LS21, 74LS32, 74LS48, 74LS74, 74LS85, 74LS86, 74LS90, 74LS112, 74LS125, 74LS138, 74LS148, 74LS151, 74LS153, 74LS160, 74LS161, 74LS164, 74LS169, 74LS175, 74LS183, 74LS192, 74LS194, 74LS244, 74LS283, 74LS373
19. Load: Lamp, fluorescent lamp, ballast
20. Others: Connectivity board, potentiometer

Note: The above parameters of the components can be edited as needed, types of component can be expanding

(2) Virtual Electronic Instruments:

Digital DC ammeter, digital DC voltmeter, digital AC ammeter, digital AC voltmeter, DC milliammeter, a multimeter, signal generator, oscilloscope, DC power supply, pulse pen, pulse signal, high and low end, cycle counter, logic analysis unit, power meter. Some new equipment or model may continue to be added.
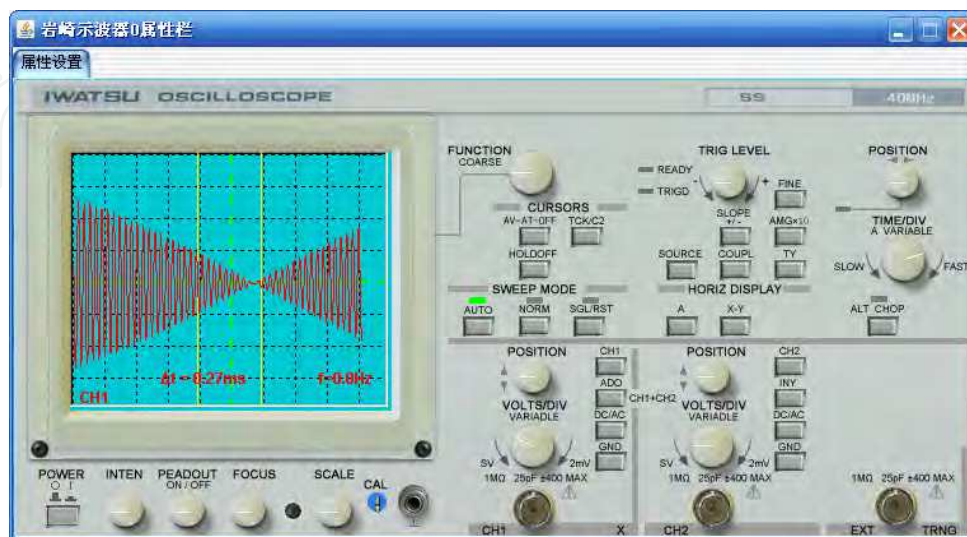

Fig. 5. Virtual Oscilloscope SS7802A Iwasaki

(3) Virtual Network Equipments

1. **Computer:** Windows PC, Linux PC
2. **Routers:**
    Cisco: Seven kinds of 2500 Serials, Four kinds of 2600 Serials, Two kinds of 3600 Serials, 4500 Serials
    Ruijie: RSR20-40
    Digital China: DCR-2626
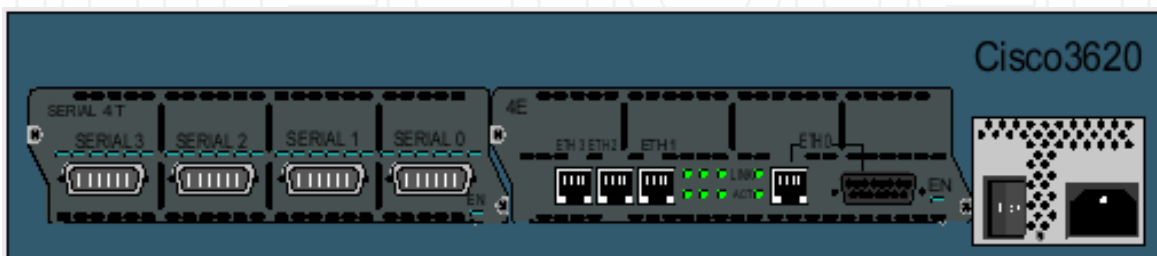   HuaWei: AR18-22-24, AR46-40

Fig. 6. A Virtual Cisco Router

3. **Switches:**
    Cisco: 2950, 3550, 1900
    Ruijie: RG-S3760-24
    Digital China: DCRS-5650-28
    HuaWei: S3928
4. **Hubs:** Hub of 8 ports , Hub of 12 ports

6.2.2 Typical experience cases

Experimental teaching experts build a large number of typical virtual experience cases on the virtual lab platform according to different learning goals. Most of the cases are similar with traditional physical case. Every typical case includes experimental name, goals, equipment, steps and report formats. The experiment platform build the initial system previously in some typical cases, and student could design and build on a virtual laboratory bench according to schematic diagram in some other cases.

(1) 16 typical experiments provided on Circuit Analysis (OWVLab CAS)

1. Use of the digital multimeter
2. Use of the signal generator and oscilloscope
3. Measurment volt-ampere characteristics
4. Validation of Kirchhoff's law
5. Validation of the principle of superposition
6. Validation of Several theorems of linear network
7. Validation and application of Thevenin's theorem
8. Study of resonant circuit
9. Performance of the PLC component in the Sinusoidal AC circuits
10. Response test of First-order RC circuit
11. Study of the transition process of first-order
12. Second-order circuit response and its state trajectory

13. The research of the controlled source's characteristics
14. Sine steady-state ac circuits phasor research
15. Voltage source, a current source and its power equivalent conversion
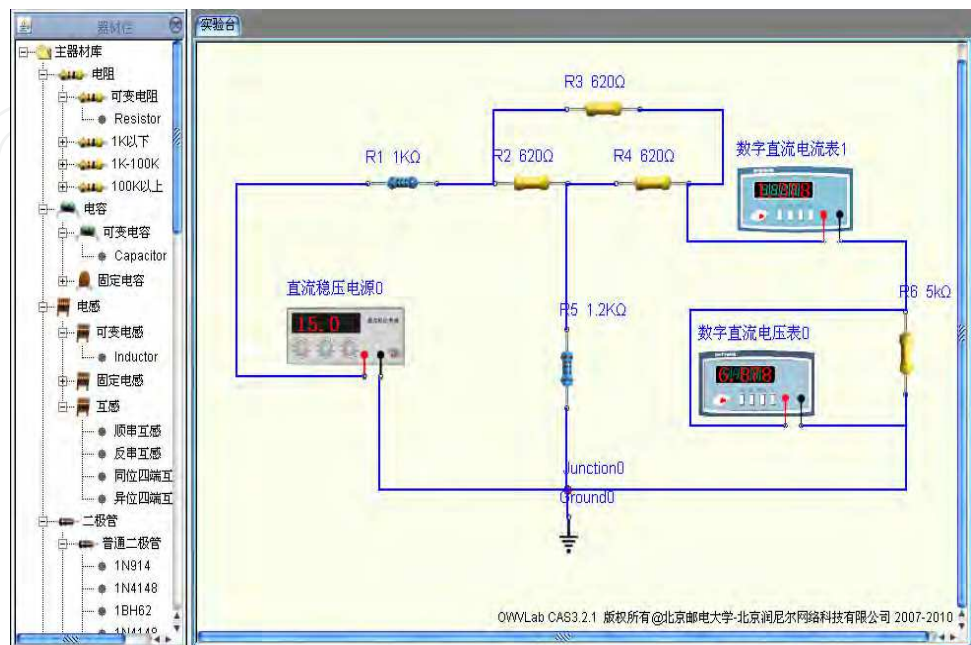16. The flow of current and voltage in three-phase AC circuit

Fig. 7. A Circuit Analysis Simulation Platform

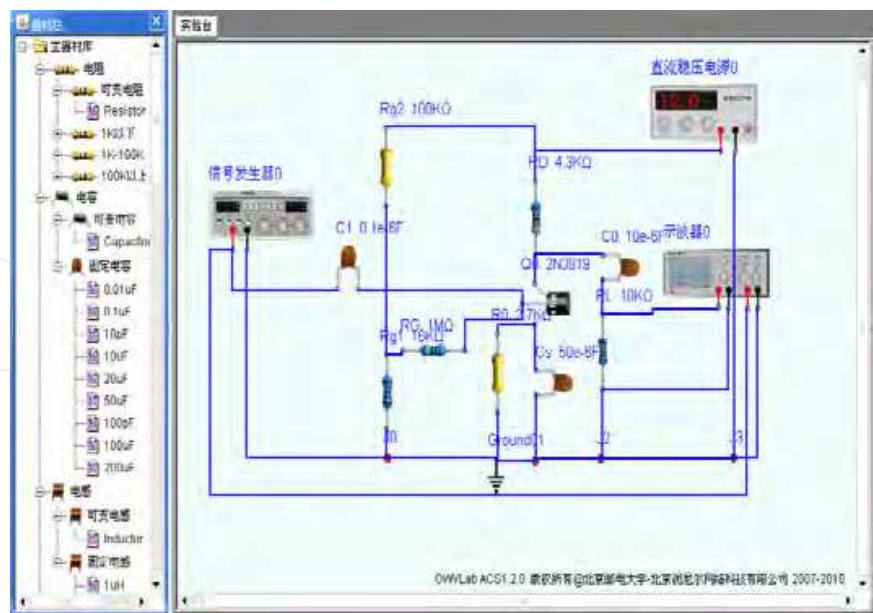**(2) 19 typical experiments provided on Analog Circuits (OWVLab ACS)**

Fig. 8. An Analog Circuits Simulation Platform

1. Single-tube AC amplifier
2. Negative feedback amplifier

3. FET amplifier
4. Differential amplifier circuit
5. Two AC amplifier
6. Emitter follower
7. RC sinusoidal oscillator
8. LC and LC selected frequency sine wave oscillator circuit to enlarge
9. Low-frequency amplifier-OTL power amplifier
10. Integral and differential circuit
11. Testing integrated operational amplifier indicators
12. The basic application of integrated operational amplifier—Active filter
13. Oscillator controlling pressure
14. The basic application of integrated operational amplifier—Analog computing circuits
15. Waveform converting circuit
16. The basic application of integrated operational amplifier—Voltage comparator
17. Complementary symmetry power amplifier
18. The basic application of integrated operational amplifier—Waveform generator
19. Single-tube transistor common emitter amplifier circuit

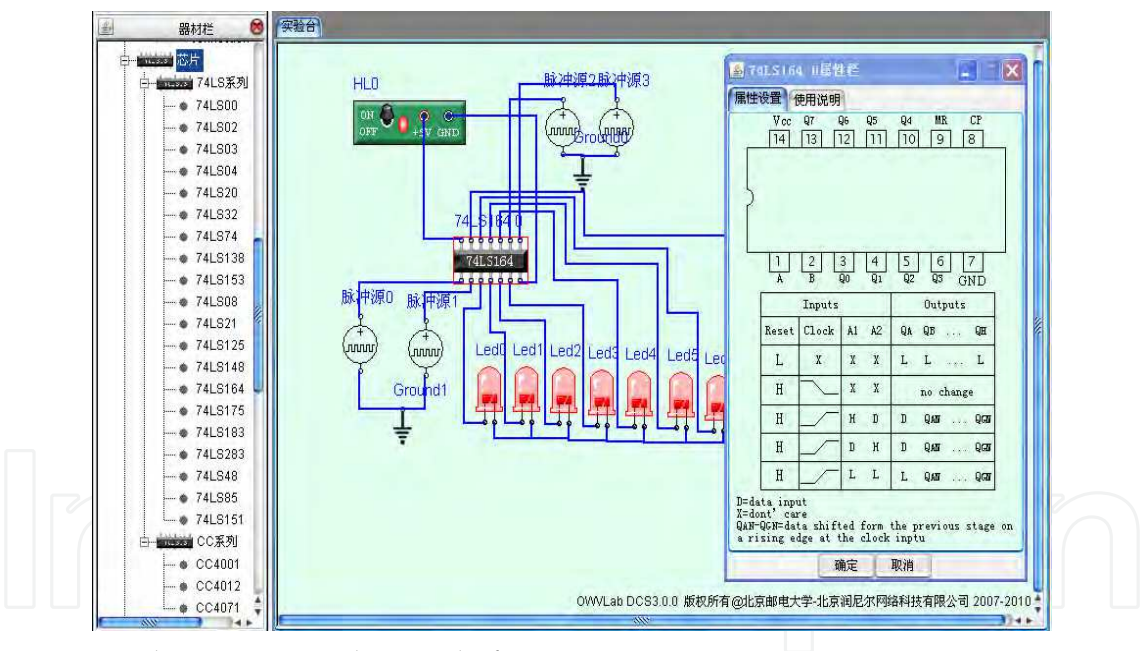**(3) 20 typical experiments provided on Digital Circuits (OWVLab DCS)**

Fig. 9. A Digital Circuits Simulation Platform

1. The test of the performance parameters of TTL integrated logic gate
2. The application test of TTL OC tri-state logic gate and door
3. Characteristics of CMOS integrated logic gates' performances
4. Constitute the counter by the JK flip-flop
5. Basic logic operations and circuits
6. The design of Serial Signal Generator
7. The basic logic function of the trigger
8. D flip-flop formed by the twisted ring counter

9.   The design of Pulse distributor
10.   Asynchronous Counter
11.   Small-scale combinational logic circuit experiments1: majority voting circuit
12.   Small-scale combinational logic circuit experiments 2: Water-level shown control circuit
13.   Mid-scale combinational logic circuit experiments 1: Comparator and its application
14.   Mid-scale combinational logic circuit experiments 2: Decoder and its application;
15.   Mid-scale combinational logic circuit experiment 3: Selection and its application
16.   Mid-scale combinational logic circuit experiments 4: Adder and its application
17.   Mid-scale timing integrated circuits - the second application of the counter
18.   Mid-scale timing integrated circuits -The application of the shift register
19.   Mid-scale timing integrated circuits - the first application of the counter
20.   Mid-scale timing integrated circuits -Cascaded counter

(4) 17 typical experiments provided on High-frequency Circuits (OWVLab HFCS)
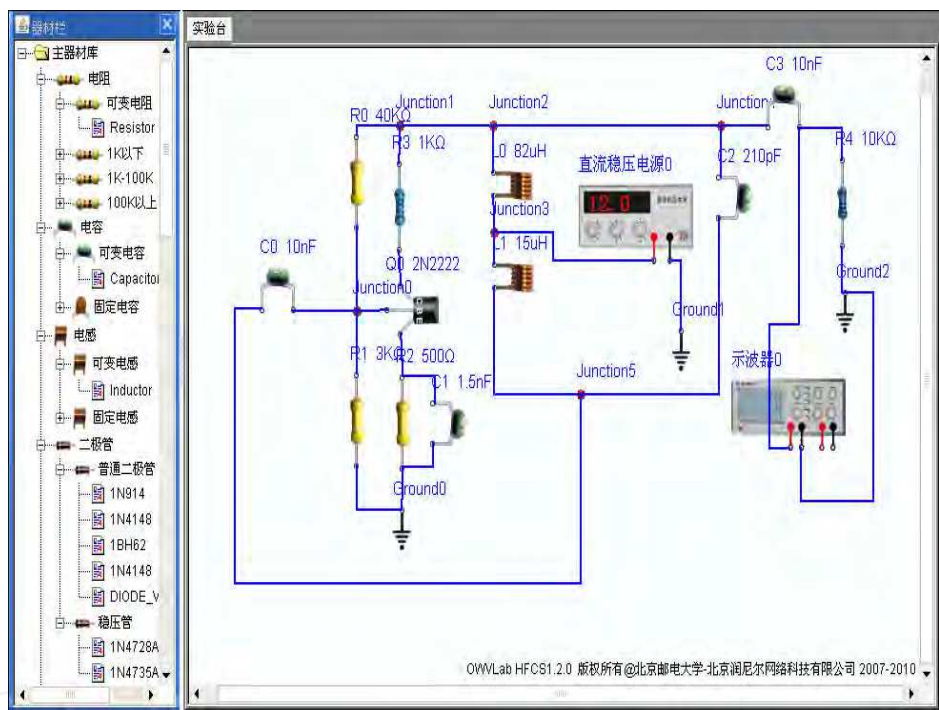

Fig. 10. A High-frequency Circuits Simulation Platform

1.   Single-tuned circuit small-signal frequency-selective amplifier
2.   Double-tuned circuit small-signal frequency-selective amplifier
3.   C-Class amplifier
4.   Inductance three-end oscillator
5.   Capacitance three-end oscillator
6.   Carat dial oscillation circuit
7.   Syracuse oscillation circuit
8.   RC sinusoidal oscillator
9.   Differential amplitude modulation circuit
10.   Multiplier AM circuit
11.   Differential transistor mixer circuit

12. Demodulation of AM signal- Multiplier demodulation circuit
13. Multiplier mixer circuit
14. VCO transistor circuit
15. FET mixer circuit
16. Demodulation of AM signal- Diode envelope detector circuit
17. Multiplier phase discriminator circuit

(5) Linux experiment simulation platform provides 11 experiments of 2 categories

Linux System Management Experiment:

Fig. 11. A Linux System Simulation Platform

1. Linux Commands Experiment
2. Linux Files Management Experiment
3. Linux Process Experiment
4. VI Text Editor Useage Experiment
5. Linux User Management Experiment

Linux Network Experiment:

1. Linux NIC Configuration Experiment
2. Linux DHCP Server Configuration Experiment
3. Linux HTTP Server Configuration Experiment
4. Linux FTP Server Configuration Experiment
5. Linux DNS Server Configuration Experiment
6. Linux Samba Server Configuration Experiment

(6) Computer Network provides 33 typical experiments as 3 categories

Fig. 12. A Computer Network Simulation Platform

(1 Windows Network Experiment:

1. Windows LAN Configuration
2. Windows WEB Server Configuration
3. Windows FTP Server Configuration
4. Windows DNS Server Configuration
5. Windows DHCP Server Configuration

(2 Routers Configuration Operation Experiment:

1. Routers Basic Configuration
2. Routers IP Configuration
3. Routers Static Routing Configuration
4. Routers Default Routing Configuration
5. Routers Configuration Copy Operation
6. Routers ARP Operation
7. Routers RIP Configuration I
8. Routers RIP Configuration II
9. Routers IGRP Configuration
10. Routers EIGRP Configuration
11. Routers OSPF Protocol
12. Create HOST Watches
13. Routers TELNET

(3 Switches Configuration Operation Experiment:

1. Switches IP Configuration
2. Switches Ports Configuration
3. Switches TRUNK Configuration
4. Switches VLAN Configuration I

5.   Switches VLAN Configuration II
6.   Switches VTP Configuration
7.   Switches VTP Client Model Configuration

(7) 15 typical experiments provided on Signal and System (OWVLab SSS)
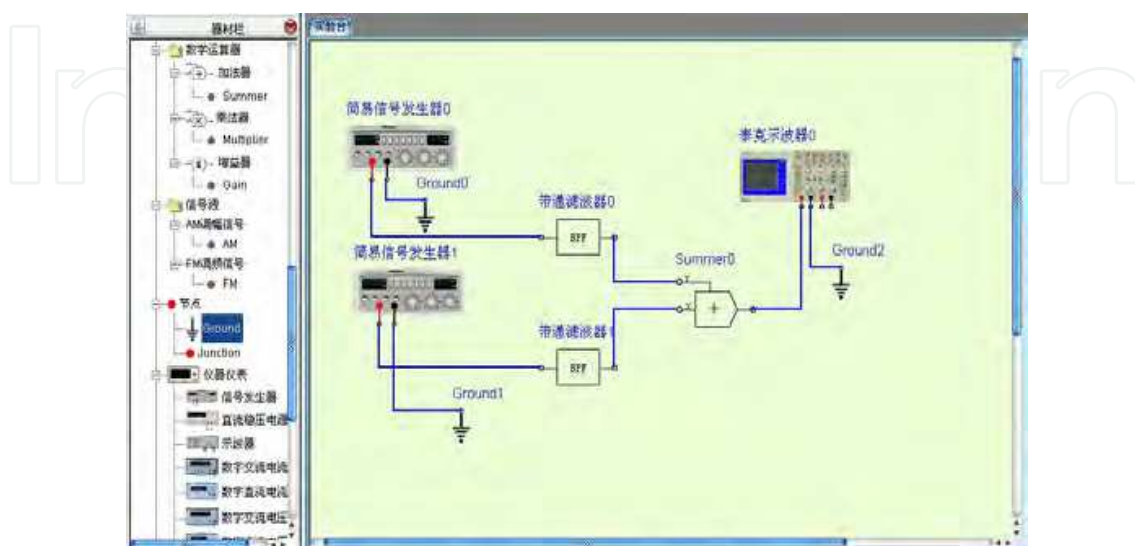

Fig. 13. A Signal and System Simulation Platform

1.   Zero input, zero state and the complete response
2.   Decomposition and synthesis of signal
3.   Lossless transmission system
4.   Analysis of analog filters
5.   Passive filters and active filters
6.   Transmission characteristics of second-order circuit
7.   Simulation of continuous-time systems
8.   Transient response of second-order circuit
9.   AM Amplitude's modulation and demodulation
10. The analog of Second-order function network
11. The test of RC frequency selection circuit
12. The realization of single-sideband modulation signal
13. Common signal's classification and observation
14. Linear time-invariant system
15. Signal frequency-domain analysis

In addition to these experiments, users can also use the equipment provided to design experiments on the platform.

7. Application practice in China

The research results have been used in Beijing University of Posts and Telecommunications, China University of Petroleum, Dalian University of Technology, PLA University of Science and Technology and other twenty universities. The system has won the praises from teachers who are responsible for guiding the experimental learning, college students,

national experts in the field of educational technology, experts on electronic electrical, computer science and communications.

8. Conclusion

Paving the way for carrying out large scale distance experimental learning, virtual lab is the future trend in the construction of laboratories and training rooms in all kinds of colleges and continuing education institutions. In terms of the change in the educational model, the system has filled the insurmountable gap between the lab and the classroom. Open virtual lab has broken boundaries of the labs and classrooms ever. Blending the knowledge study within an experiment, there shall be a historic opportunity for the real integration of experimental and theoretical learning. OWVLab will become an essential equipment of experimental learning in school, and it will stimulate the next wave of educational innovation.

OWVLab can promote the students to combine their study with application, plan the flexible experiments without the limit of time and space. Where the Internet is connected, the experiment can be conducted, so the open lab in the real sense is achieved. Virtual experiments can reduce the intensity of maintaining the experimental equipment and alleviate the current shortage of lab equipment. With the supporting of the abundant learning resources, the corresponding intelligent tutor for the experimental process and automatic correction for the virtual experiment results, virtual experiment can achieve the organic integration of the theoretical and practical learning, cultivate the students' ability to design, diagnose and innovate. The 4E blaze a promising way to solve the problem occurred in a classroom. It let us to avoid facing the embarrassed when we lack of audiovisual aids. The existing experimental learning system on computer science, electronics, telecommunication would be improved with the establishment of the virtual lab.

9. Acknowledgment

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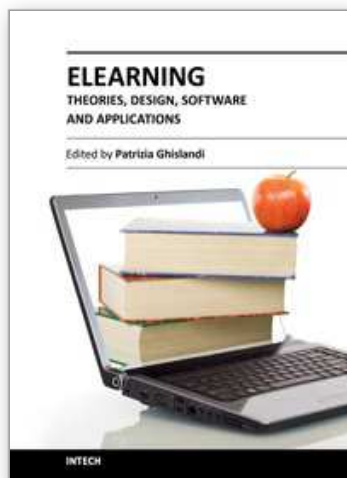
eLearning - Theories, Design, Software and Applications

Edited by Dr. Patrizia Ghislandi

The term was coined when electronics, with the personal computer, was very popular and internet was still at its dawn. It is a very successful term, by now firmly in schools, universities, and SMEs education and training. Just to give an example 3.5 millions of students were engaged in some online courses in higher education institutions in 2006 in the USA1.eLearning today refers to the use of the network technologies to design, deliver, select, manage and broaden learning and the possibilities made available by internet to offer to the users synchronous and asynchronous learning, so that they can access the courses content anytime and wherever there is an internet connection.

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