

# Virtual Laboratory for Computer Networks Education

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**Abstract**— This paper presents skills development acquired in computer networks subject by using an interactive virtual laboratory and simulation program. The proposed virtual lab is useful for overcoming the difficulties facing the students in studying network courses and using the optimum of modern technology in education. The paper aims to provide the necessary information about the devices used in computer networks that are founded in the laboratory and simulate the different computer networks to help the student to build different experiments and correctly deal with the devices

**Index Terms**—A virtual Lab, computer networks, simulations, skills

## I. INTRODUCTION

A computer network is a group of computers that use a set of common communication protocols over digital interconnections to share resources located on or provided by the network nodes.

the interconnections between nodes are formed from a broad spectrum of telecommunication network technologies, based on physically wired, optical, and wireless radio-frequency methods that may be arranged in a variety of network topologies. [1]

Computer networking today has become one of the ways to share information where the systems are wirelessly linked together using a common network. I am sure you must be aware of what computer networks One of the major advantages is that it enhances communication and also provides better information by making use of instant messaging which allows users to send files in a real-time environment which is beneficial for business, Another major advantage of using computer networks lies in convenient resource sharing where major companies do not want to waste their resources and make sure that they are properly utilized among a shared group of people whereas it lacks independence i.e. the users would become idle if the system or the main file server breaks down, one of the other advantages of computer networks lies in its cost of joining the systems together as a single entity which is going down whereas in case of no computer networks the cost of combining systems as a single entity goes up as there are individual systems that need to be monitored and installed, and the storage capacity. [2]

The nodes of a computer network may be classified by many means as personal computers, servers, networking hardware, or general-purpose hosts. They are identified by hostnames and network addresses. Hostnames serve as memorable labels for the nodes, rarely changed after initial

assignment. Network addresses serve for locating and identifying the nodes by communication protocols such as the internet protocol (IP). [3]

Shaw built a computer simulation program to use in science teaching and the results showed statistical differences in favor of the group studying computer simulation.[4]

Walker (OMAR - PETEC - Ilker) Make a study to reveal the effect of computer simulation and problem-solving effects on students' achievement in chemistry and the results indicated the effectiveness and efficiency of simulation in academic achievement and scientific thinking skills.[5]

Everest and Andrea conducted a study to detect the extent of the impact of computers on students and adults and the tasks performance, and the study found the effectiveness and efficiency of students. [6]

The study of Singapore aimed to develop a C- vision program to creating a virtual environment based on the methods of interaction and engagement, this program becomes effective in understanding science and practical activities. [7]

Karl made a vision for the use of simulation applications in education, entertainment, and industry, the study found the effectiveness' of computer simulation. [8]

Borne conducted a study with the aimed to measure the effectiveness of using virtual reality technology to acquire scientific knowledge, the study concluded the effectiveness of simulation in that field. [9]

Shaan designed a training program to help teachers to perform practical skills that are deficient, the results showed the effectiveness of this program.[10]

Abu Saud created a virtual laboratory in the science subject, and the results showed the effectiveness and efficiency of the proposed program for teaching science.[11]

The University of Texas in America has created a project of a virtual microbiology laboratory and is excellence by its ability to reduce costs.[12]

Charles Stuart University in Australia has been created a chemistry laboratory in which teaching remotely, this virtual lab advantage by the three dimensions and the actual locations of all the devices and tools used.[13]

The University of Hanover in Germany where a group of researchers developed a visualization and simulation environment in natural and engineering sciences, and a virtual laboratory in the field of meteorology.[14]

Johns Hopkins University in America, the university team created this virtual laboratory that contains a wide range of experiments on logical circuits, drilling for oil extraction, heat transfer in pipes, bridge design, sound transmission and heat conduction.[15]

The virtual lab produced by Crocodile Clips used in more than 70% of British schools, the company has produced virtual laboratories for chemistry, physics and mathematics.[16]

From the above, virtual labs are an interactive multimedia program that provides a virtual learning environment that simulates real laboratories and enables learners to use devices and conduct experiments easily, despite the importance of real reality in education, but virtual reality has many advantages and possibilities including simplifying reality and providing security, availability, environmental control, and virtualization.[17]

2 - Many programs use computers in simulations such as the Packet tracer- GNS3- OPnet.

2.1 - A packet tracer is a software designed by Cisco Systems that is used for accent courses and ccna and it can build a virtual-networks by drag and drop.

The program is characterized by being simple and easy to deal with, and officially certified certificates (CCENET - CCNA), does not need to download an operating system, great support for Cisco networks, speed of network construction and ease of testing and experience of sending and receiving data from the devices of those networks.[18]

Despite the many advantages of this program, it has some drawbacks, namely that it is limited to Cisco network devices and the inability to deal with other network products, the inability to deal with encryption protocols, the limitations that it can handle send and receive real Data but all that is a virtual simulation and it's also complex for most of the users[19]

GNS3 Graphical network simulator the most popular in the world for simulating networks, building a professional design for many different network devices. it includes all networks from Cisco, Microsoft, Intel and it supports security protocols and encryption. This program is characterized by its generality and ability to expand to include all network devices, as well as great full support for all types of the network device operating systems and updates and constantly evolving technologies. However, it does not fully support Cisco Switches, and the consumption of a large number of CPU capabilities for the computer it occupies, the need to download and install the operating system of any device before using it, takes a long time to build networks even if they are simple.[20]

OPNet It offers GUI for the design of the simulation and the visualization of captured data; it simulates computer and telecommunication networks. it has two versions which one is free and the other is priceless. Good support for Portable models, Good combination of a graphical and programmable interface, Models can be shared between different platforms, Powerful tool. Full control of models, its widely popular and preferred for many learners and researchers [21]. Despite the many advantages, it has some drawbacks, Expensive, Latest version (5.0) only works on Solaris platforms, demanding to model, Memory consuming models.

The current paper seeks to identify the effectiveness of the design of a virtual laboratory based on the simulation method to develop the skills of establishing computer networks in the students of the industrial high school's computer division three-year system and can summarize

the main reasons that led the researcher to carry out this current study in the following points. Students do not understand the content of computer networks, Students are unable to deal with network devices, there is a clear deficiency in the Contents of computer networks courses, most of the programs are expensive and not available to students, the possibility of building virtual labs for the content of computer networks, Supporting the student's abilities by actually using a virtual lab. [22].

The current research aims to Prepare a list of basic skills needed to create computer networks to be available to second-grade students, Designing and producing a simulation program to develop the skills needed to create a computer network and identify the components of this program, Study the effectiveness of the proposed program in developing the skills needed to create computer networks among the students of the Computer Division. [23] In this paper we discuss in the first part an introduction about the importance of computer networks, their material, and components, then we discuss in the second part the most important studies on the virtual laboratories in general, the third part discusses the most important programs that use a computer in simulation, in the fourth part we summarize the main reasons that led the researcher to carry out this study, the fifth part explains the research program to emphasize the points of research Then we move on to the most important conclusions reached by the researcher through the subject of the research, and then conclude the most important references that are reviewed.[24]

## II. PROCEDURE FOR PAPER SUBMISSION

It is a simulation program for computer networks and allows the network designer to implement it on the computer and verify the integrity of the wiring and the level of mastery of the network's work, and then implement it on the ground as it was designed on the computer. The program was implemented in Java script. Figure (1) shows, the main interface of the program [25]. When you click on the program icon, the following window appears, which contains both ' the title of the program is Computer Networks - Instructions for the program - The most important goals related to the content of computer networks - Lessons for the practical content of the subject - then the practical application of the material. It is a simulation program for computer networks and allows the network designer to implement it on the computer and verify the integrity of the wiring and the level of mastery of the network's work, and then implement it on the ground as it was designed on the computer. The program was implemented in Java script ' the main interface of the program 'when you click on the program icon, the following window appears, which contains both, the title of the program is Computer Networks - Instructions for the program - The most important goals related to the content of computer networks - Lessons for the practical content of the subject - then the practical application of the material.

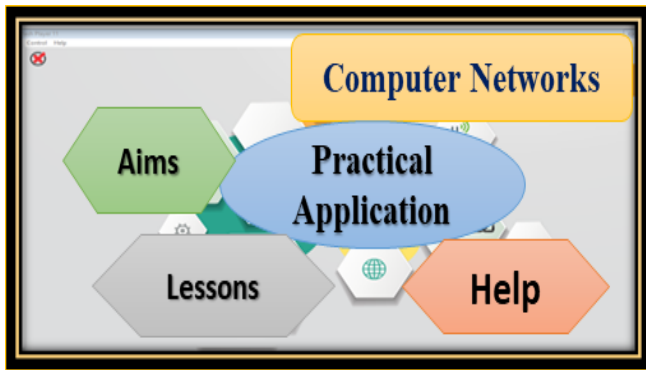


Figure (1) The interface of the program

**A. Aims Screen**

When you click on the Targets button as shown in figure (2), the Targets window appears, which contains the targets related to the content of computer networks. After the implementation of the program, the student is expected to be able to Learn about different networking devices - how different networking devices work - how to change the device name and add its IP How to connect two devices with each other. How to create a local network consisting of only two devices. How to create a local network consisting of three devices using the HUB. How to create a local network using the Switch. How to connect and make a linear network. How to connect and make a ring network. How to connect and operate the network. How to connect and operate the interconnected network. How to make and connect a peer-to-peer network, how to make and connect a client - server network.

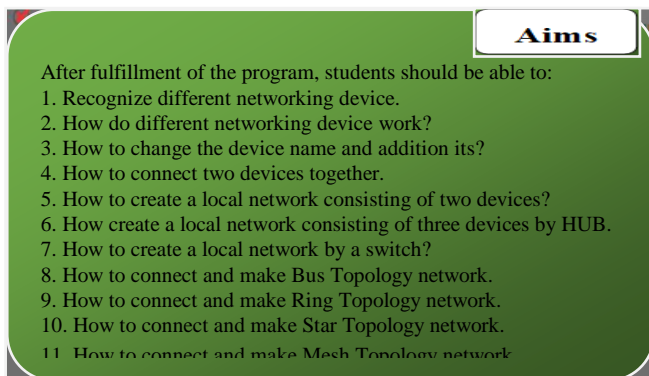


Figure (2) Aims Screen

**B. Help Menu (program instructions)**

When you click on the instructions window as shown in figure (3), instructions appear for the program, how to use the special tools in the program, how can a specific lesson be chosen, how to choose a specific task, and how to do it.

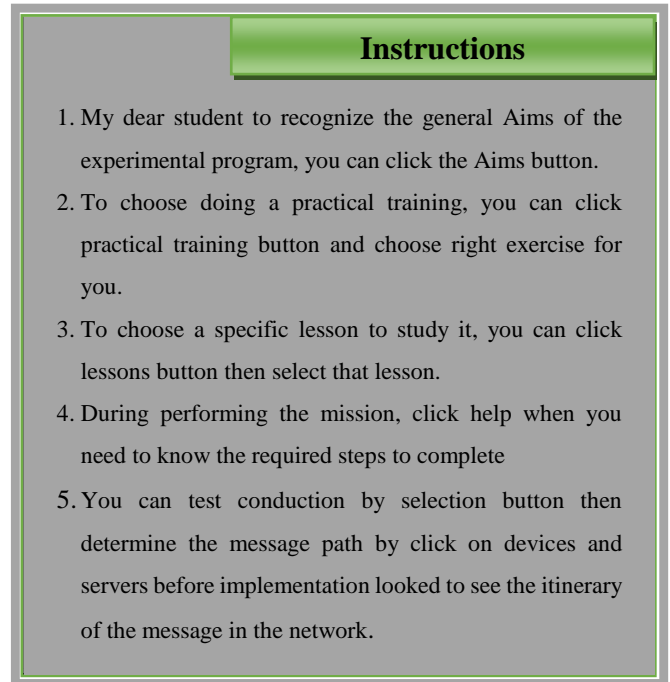


Figure (3) program instructions

**C. Lessons GUI**

Using Lessons Menu by Press on Any Items the Experiment of the Lesson will Appear as shown in figure (4) for Example. If the Student Press on the Fifth Items, The Experiment of the Bus Topology Network.

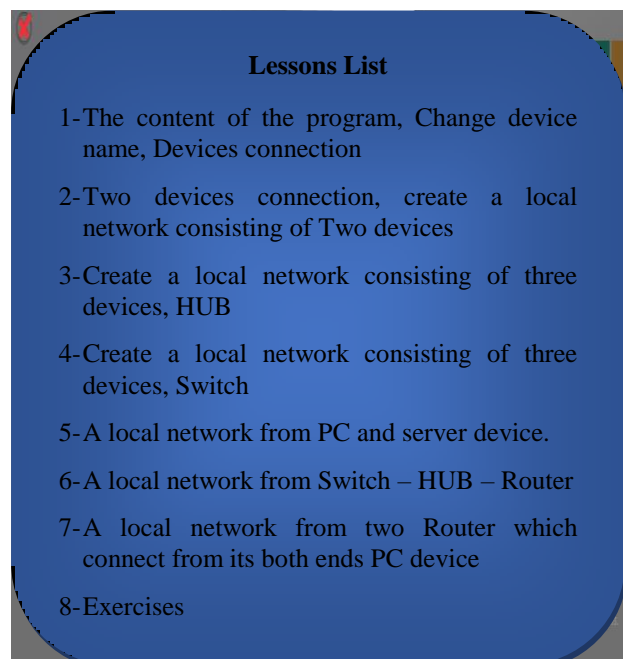


Figure (4) Lessons GUI

**D. The practical application menus**

When you click on the task list of the practical lessons for the course, this window appears as shown in figure (5), which contains a set of practical lessons that the student or user performs in practice.

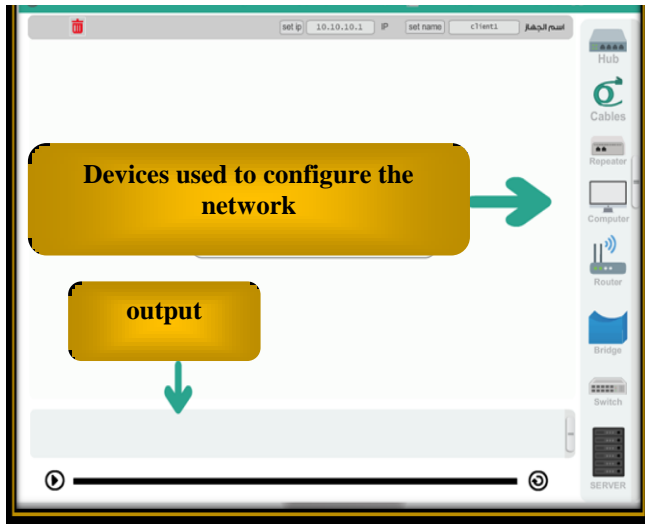


Figure (5) The practical application menus

**E. Networks Components.**

**Repeater:** Functioning at Physical Layer. A repeater is an electronic device that receives a signal and retransmits it at a higher level and/or higher power, or onto the other side of an obstruction so that the signal can cover longer distances. A repeater has two ports, so cannot be used to connect for more than two devices.

**Hub:** An Ethernet hub, active hub, network hub, repeater hub, hub or concentrator is a device for connecting multiple twisted pair or fiber optic Ethernet devices and making them act as a single network segment. Hubs work at the physical layer (layer 1) of the OSI model. A device is a form of multiport repeater. Repeater hubs also participate in collision detection, forwarding a jam signal to all ports if it detects a collision.

**Switch:** Network switch or switching hub is a computer networking device that connects network segments. The term commonly refers to a network bridge that processes and routes data at the data link layer (layer 2) of the OSI model. Switches that additionally process data at the network layer (layer 3 and above) are often referred to as Layer 3 switches or multilayer switches.

**Bridge:** A network bridge connects multiple network segments at the data link layer (Layer 2) of the OSI model. In Ethernet networks, the term bridge formally means a device that behaves according to the IEEE 802.1D standard. A bridge and switch are very much alike; a switch being a bridge with numerous ports. Switch or Layer 2 switch is often used interchangeably with a bridge. Bridges can analyze incoming data packets to determine if the bridge can send the given packet to another segment of the network.

**Router:** A router is an electronic device that interconnects two or more computer networks, and selectively interchanges packets of data between them. Each data packet contains address information that a router can use to determine if the source and destination are on the same network, or if the data packet must be transferred from one network to another. Where multiple routers are used in a large collection of interconnected networks, the routers exchange information about target system addresses as shown in figure (6).

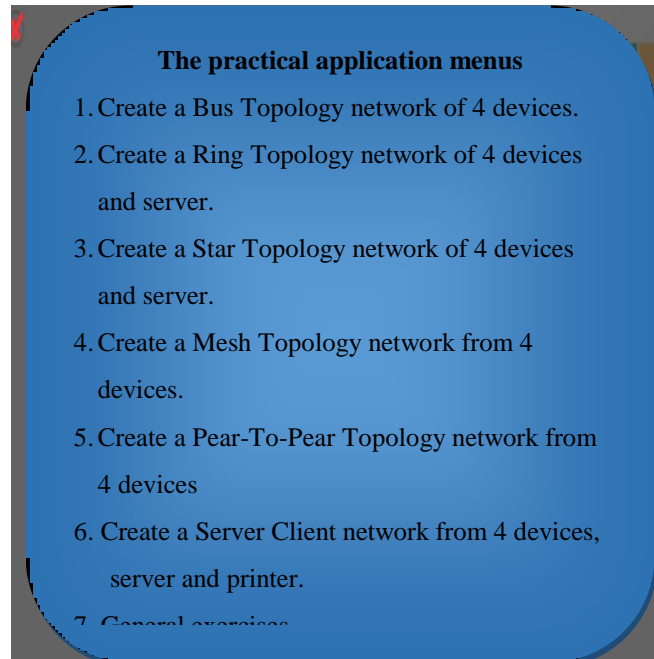


Figure (6) Devices used to configure the network

**F. Study of network IP**

Click on PC, change the name of PC, click to set name, change to set IP, click to set IP as shown in figure (7).

**G. Connect the computers in Local Area Network**

Add to Work Board 2 PC, connect to The Cable, click PC1 to PC2, click to Simulation, click to Executed as shown in figure (8).

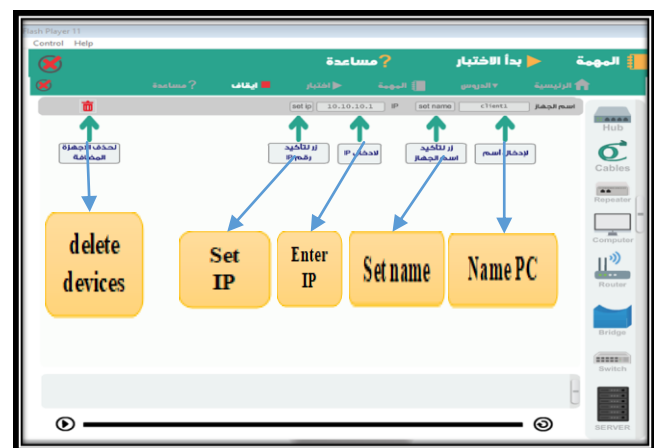


Figure (7) Adjust of network IP

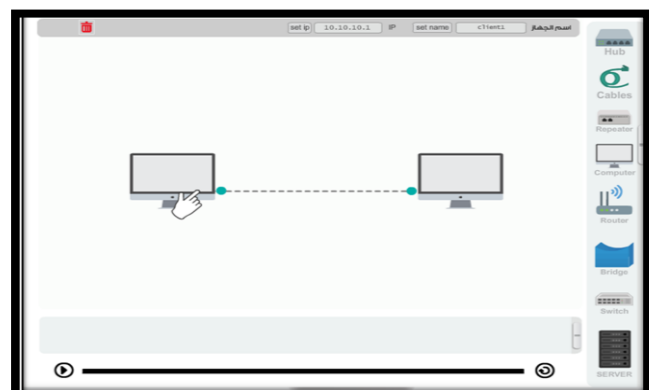
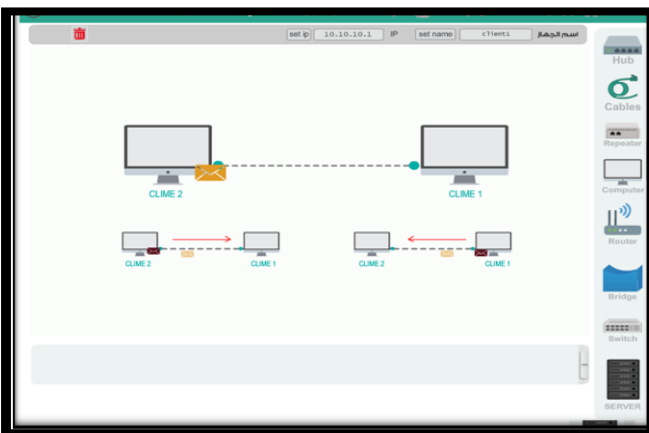


Figure (8) Connect the computers in Local Area Network

### III. APPLICATION OF THE PROPOSED VIRTUAL LAB

The researcher built the study tools which consisted of building the test also, the researcher built a notecard for the network in skills, where it consisted of (18 paragraph) and



the researcher divided it into (4 axes), where he prepared a list of skills to deal with networks, contained in the book computer networks for the second-grade specialized computers in the schools of technical education system three years.

To ensure the sincerity of the test and observation, the researcher presented the tools to a group of arbitrators, some of the experts in the curriculum and teaching methods, some of them experts in its materials and networks, and some of the experts in the field of Education technology has completed the proposed modifications. Also to complete this study the researcher built a computer program based on the simulation method to develop the skills of dealing with networks and present it to the arbitrators to ensure its safety, and suitability for an application.

The researcher chose a two-semester intended sample and applied the one-group system due to the small number of students per class. The number of (35) students of the computer department in the industrial high school girl's system three years, and the researcher used according to the nature of the study three approaches:

Descriptive analytical approach: to analyze the content of the computer network syllabus for students in the department of computers in the industrial school system three years, to extract a list of the skills to deal with the networks contained in the network syllabus.

Building method: To build a simulation-based computer program that aims to develop some network in skills among students in the computer department of technical education schools.

Experimental curriculum: To study the impact of the simulation-based computer program in the development of some network in skills in the network syllabus of the students of the computer department, where the group was exposed to the program prepared by the researcher.

SPSS program is used to conduct statistical treatments to analyze the grades obtained by the researcher to calculate the homogeneity of the two groups and the table (1) showing the parity of the two groups.

Dimension	Network communication skills		The test all	
	before	After	before	After
Application				
Number	35	35	35	35
Average	2.09	3.304	10.26	15.44
Standard deviation	1.16	1.105	2.767	3.203
Value "T"	3.48		6.106	
The value of the significance	0.002		0	
Pampering level	0.01		0.01	

Table (1)

#### A. Connecting a local network

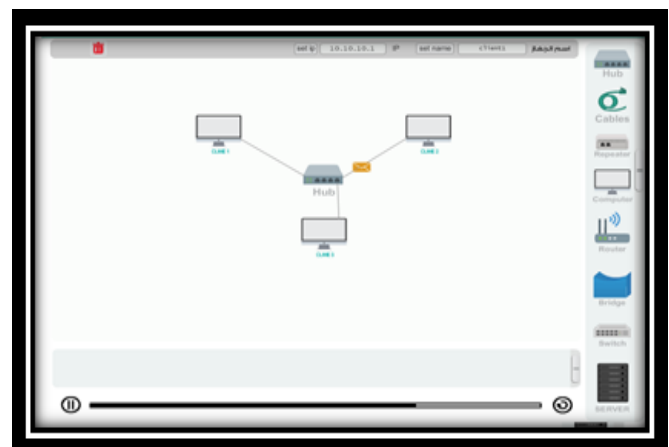
The network consisting of only two devices and indicating that the signal is sent together: Add to Work Board 2 PC, connect to The Cable, click PC1 to PC2, click to Simulation, click to Executed as shown in figure (9)

Figure (9) Connect two devices together

#### B. Connecting a local network consisting of 3 computers and HUB

Add to Work Board 3 PC and 1 HUB, connect to The Cable, click PC1 to PC2, click to Simulation, click to Executed as shown in figure (10)

Figure (10) Connecting a local network consisting of 3 computers and a Hub.



*C. Connecting a local network consisting of 3 computers and a Switch*

Add to Work Board 3 PC and 1 Switch, connect to The Cable, click PC1 to PC2, click to Simulation, click to Executed as shown in figure (11)

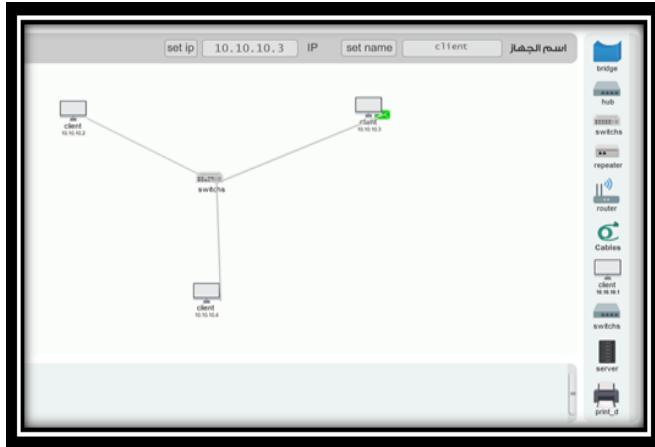


Figure (11) Connect 3 devices and switch

*D. Connecting a local network consisting of 1 PC and a Server*

Add to Work Board 1 PC and 1 Server, connect to The Cable, click PC1 to a Server, click to Simulation, click to Executed as shown in figure (12)

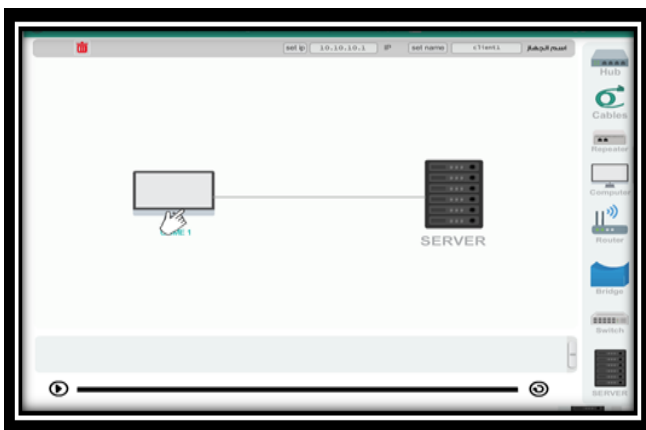


Figure (12) connect PC and Server

*E. Create a local network consisting of Switch - Hub - Router*

Add to Work Board 6 PC, Switch, Hub, and Router, connect to The Cable, click Switch to PC, click to Simulation, click to Executed as shown in figure (13)

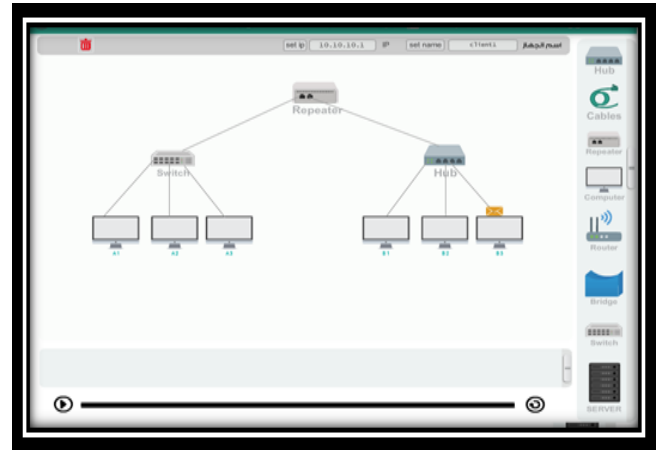


Figure (13) connect 6 PC, Switch - Hub - Router together

#### IV. CONCLUSIONS

Computer networks can be considered one of the most academic subjects related to technology, whether knowledge-based or in terms of integrating technology in education so that students can study many practical experiences that cannot be studied in the laboratory due to the high material cost or the lack of materials and tools necessary to conduct them or the limited time of application.

The study provides a list of the skills to be available to the students of industrial high schools and the computer division to establish computer networks, in light of the opinions of the expert specialist's mentors and teachers. The study provides an application on the use of computer simulation models in the methods of training in practical skills in general and the skills to create computer networks in particular.

The current research seeks to identify the effectiveness of the virtual lab design based on the simulation method to develop the skills of using computer networks has been identified the problem in terms of students not understanding the content of computer networks, as well as students are unable to deal with networks devices and identify them, most programs are expensive and not available to students, the possibility of design virtual labs for the content of computer networks. So the researcher built an easy and simple program with attractive screens based on simulations that enable the student to interact with them through windows that are easy to handle and equipped with explanations and various help instructions and Designing and producing a simulation program that simulates the actual reality in the development of computer networking skills for students and other specialists.

There are statistically significant differences at ( $\leq 0.05$ ) between the degrees' averages before and after the applying of the achievement test. There are statistically significant differences at ( $\leq 0.05$ ) between the experimental group degrees' averages before and after applying for the Network skills observation card.

At the end of the research and through the rapid global expansion of the uses of IT, especially in the field of education, Egypt education sector must benefit from this revolution of information and technology, and study how to use it to serve the objectives of education.

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