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Designing A Virtual Electronic Program Based on Modeling and Simulation for Sixth Grade Physics Experiments

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Abstract

Objective: This work proposes the use of computer simulation and Javascript programming language to design a low-cost virtual laboratory within an interactive learning environment. The objective is to provide learners with a realistic and immersive platform to understand scientific principles in various fields of science. Theoretical framework: The research methodology involves a step-by-step approach to designing a computerized learning program. The process emphasizes defining goals, selecting content, and organizing frames in a sequence from easy to difficult. Method: Qadisiyah University in Iraq designed and implemented the virtual laboratory at the Faculty of Education. It supports the physics curriculum for sixth-grade learners and offers two practical activities accessible on internet-enabled devices. Results and conclusion: The virtual laboratory implementation enhance the physics curriculum for sixth-grade learners. Its interactive and immersive nature engages students in scientific exploration and understanding. Through computer simulations and virtual activities, learners actively participate in scientific phenomena and develop a deeper comprehension of scientific principles. Implications of the research: Virtual laboratories open new horizons for sustainable education, training learners in scientific principles across multiple fields. Integrating virtual laboratories into the learning environment provides a cost-effective way to enhance science education. The research highlights the benefits of computer simulations and virtual activities in fostering scientific learning. Originality/value: This work contributes to education by demonstrating a practical application of computer simulation and programming language in designing a low-cost virtual laboratory. The findings inform educators, curriculum developers, and educational technology practitioners on utilizing virtual laboratories to enhance science education.

Keywords :*Designing ،electronic program، modeling ، simulation*

Introduction

Learning science is essential for today's learners. This helps them to participate as informed and active members of society, and scientific thinking and skills help them in making decisions based on evidence [3] and also in improving their ability to solve problems [4]. (LiangLi et al., 2022)

The world requires skilled and keen learners who consider science as a career field in the future [1-2] in order to achieve the goals of sustainable development.

In fact, the value of laboratory experiments for science learning is generally recognized [6], and science laboratories can help learners gain a positive attitude towards science if they enable learners to participate in active and successful laboratory activities [9]. Because it is an important component of the educational process [8,7] and science cannot be meaningfully taught to learners without practical laboratory experience.

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More specifically, the application of science to our daily lives needs both theoretical and practical fields. While theory lends itself to classroom learning, practical training can only be learned and practiced in a physical or virtual laboratory [5]. (Poma et al., 2022)

Indeed, investigations provide opportunities for learners to interact directly with the physical world using scientific tools, models, and theories [10]. Similarly, activities in the science lab provide learners with opportunities to build their knowledge through experiment [11], allowing them to combine their perception of theory with laboratory practice [12], and enabling them to develop their skills [13]. Science education depends on the learner's experience in scientific laboratories, where theoretical principles are verified, and teaching is given practical direction [15].

The impact of information technologies and the Internet on education has radically changed the landscape of science education in laboratories [17]. A new form of laboratory has emerged that recreates the real experience. It is a broad concept that includes many online experimentation tools, such as virtual and remote labs, virtual reality, augmented reality, interactive videos, and serious games [18]. Moreover, it is generally accepted that digital tools such as interactive simulations or online labs can positively influence a learner's knowledge, skills, and attitudes [19, 20]. (Tabernero-Sala et al., 2022)

Research Objectives

Designing a virtual electronic program based on modeling and simulation.

Search Problem

In our research work, we have an interest in integrating and using virtual laboratories in the physics curriculum for secondary school education for many reasons including Virtual laboratories help overcome the limitations of a face-to-face physical laboratory, such as access to equipment, location, and other economic issues. In particular, virtual labs are a convenient tool that can afford massive access. In fact, virtual labs are computer simulations that offer similar perspectives and working methods to traditional face-to-face practical laboratories [21] and are environments in which learners can perform learning activities [22]. Also, virtual labs help learners to engage in the proactive learning process and improve their academic performance [23]. Nowadays, virtual laboratories have evolved into online interactive graphical user interfaces through which simulated experiments can be performed and where learners can perform the experiment and explore its development [24]. The trials are entirely web-based and provide online access [25]. (Widia et al., 2023)

Relevant Work

Online experimentation is a great concept that covers many methods and tools such as remote laboratories (28,27) and virtual labs (29) and virtual and augmented reality (31 _ 30) and games (32) and items technological other. To meet our need for an alternative solution to eliminate traditional laboratory activities, we have chosen to develop a virtual laboratory, The reasons given below justify this choice. The implementation of a virtual lab is a low-cost solution, there is no equipment for conducting tests,

Conducting practical activities through the virtual laboratory is a cheap and sustainable solution, Increase learners' motivation and ability to self-study. (Baig et al., 2022)

Learners are allowed to access the virtual laboratory at all times and places.

It also supports simultaneous communication of learners, which means that many learners can do the same experience at the same time. In this project, Virtual laboratories are considered as open educational resources (33, 14), It is one of the most interesting open educational resources that may be offered for science education .(Forrest et al., 2023)

Virtual laboratory is an interactive practical environment where learners can conduct scientific simulation experiments (34). in addition, they have the ability to enhance learners' skills and attitudes and understand the concepts of physics. Many different experimental studies have been shown in different fields of science education .The use of virtual laboratories provides educational results similar to traditional scientific laboratories (39_ 35_ 22).

Additionally, according to study (34 and salmeron _ manzano) (manzano agugliaro), They summarized that research on virtual laboratories It is implemented as a model for teaching and learning with a great future within the University worldwide.

Similarly, learning topics related to theoretical concepts in physics require.

Simulations to support learners' understanding, that's why we use virtual laboratories extensively in physics learning (16,1). Several pilot research projects have been implemented to develop examples of virtual laboratories. (Al Dulaimi et al., 2023)

which can be used for practical teaching of physics in higher education.

Study shows (De La Torre et al. 24)

Positive Impact of Virtual Laboratory Use and Dissemination on Learners' Learning

Bella's study confirmed and (Widiyatmoko 40) The contents of the virtual laboratory that provides theoretical material in photos, animations and videos.

Let learners learn independently That's because learners now tend to prefer things about computers (41).

IN study (Zhao et al. 42) A virtual laboratory is designed to support and enrich the laboratory experience of university learners in addition to the laboratory , Learners considered that the virtual laboratory was very useful and useful.

Study shows (44,43) Using virtual laboratory media can improve learners' conceptual understanding as well as their ability to solve problems (45)

It also promotes their creativity (46).

In addition, the huge gift of virtual laboratories was appreciated When educational activities were affected by the pandemic lockdown (COVID _ 19) (26). While conducting theoretical classes online, educational institutions found it difficult to complete the laboratory experimentation curriculum Due to the closure of universities as well as traditional laboratories.

KAPELAN and others (48) Offer to exploit virtual simulation laboratories during a pandemic COVID_19 To provide mechanical engineering education learners with the opportunity to complete planned laboratory experiments.

Indicate learners' feedback in this study Virtual labs helped them understand theoretical concepts, It was felt necessary to introduce virtual labs into the engineering curriculum. Simulation software has increasingly been used as an educational tool in recent decades (59). The continuous development of technology and programming languages to make simulation an advanced tool that reflects realistic situations with a high degree of accuracy [60].

Study recommended (Garcia Vela et al. 49) Maintain the use of virtual spaces developed during the pandemic as a resource to promote teaching and learning.

Virtual laboratories are online learning tools .Introduces a new dimension to science learning using

conceptual techniques Such as animation, simulation and graphic videos (50,23). It's a special method of scientific laboratory experiment Using computer-based simulations which focuses on presenting perspectives and working methods that resemble their physical counterparts.

(51). They are used to attract the attention of learners and maintain their motivation (52).

Moreover, it offers additional benefits Such as support for distance learning (53). It has become an essential component of e-learning environments, especially for scientific and technical education disciplines.

The use of computer interactive simulation in science education has undergone several studies (54, 38, 36). in science education, the use of computer simulations plays an important role in the richness of teaching.

Making lectures more attractive to learners and helping them achieve a deeper understanding of scientific topics (56,55) By providing the learner with a high level of active interaction to engage and participate, Immediate feedback, and recurring practice challenges (57).

Higher earnings were also shown to learners Who use computer simulations from those who use practical activitiesOnly in a study on the concepts of physics learning (54).

The use of carefully designed computer simulations is likely to lead to take more favourable attitudes towards science among learners (37).

Simulation is an educational approach to the design of teaching and e-learning activities (57).

Computer simulation is software that represents aspects of real-world attitudes .Includes mathematical models, calculates specific input effects and selects results accordingly (58).

They provide quantitative and practical experience for each experience that complements real laboratory practices and skills (23).

Method

Virtual laboratories have emerged as an alternative to the weakness of real face-to-face physical laboratories [34], This has been demonstrated to be a powerful tool for achieving sustainability in education. Laboratory activities are an important educational strategy for acquiring competencies in science education. This makes learners understand through a pragmatic approach theoretical subjects taught in class. Yet, building a virtual teaching and learning laboratory is a very complex process. Because experiments are conducted in practical teaching laboratories Traditional face-to-face is not easy to transfer to the Internet environment, many technical aspects are needed to express the behavior of the phenomenon in computer form. Moreover, these experiments often use scientific tools and other specialized equipment. Their perception requires skills in areas as diverse as the design and production of texts, images, environments and interactions; Their production requires programming and animation [22]. Designing a virtual online lab is an educational project. To do this, we chose the steps of designing a computerized electronic software as the main design method. (del Barrio Aranda et al., 2022)

Steps to Design and Compute an Educational Program

Software preparation needs effort, And a great deal of time. A good programme requires great care in setting goals.and content , and method settings , Organizing them sequentially is easy to difficult. The software design process goes through multiple stages Until the program reaches its final picture, these stages are [16].

1_ Determine Educational Material: Course material for classes containing activities (experiments)

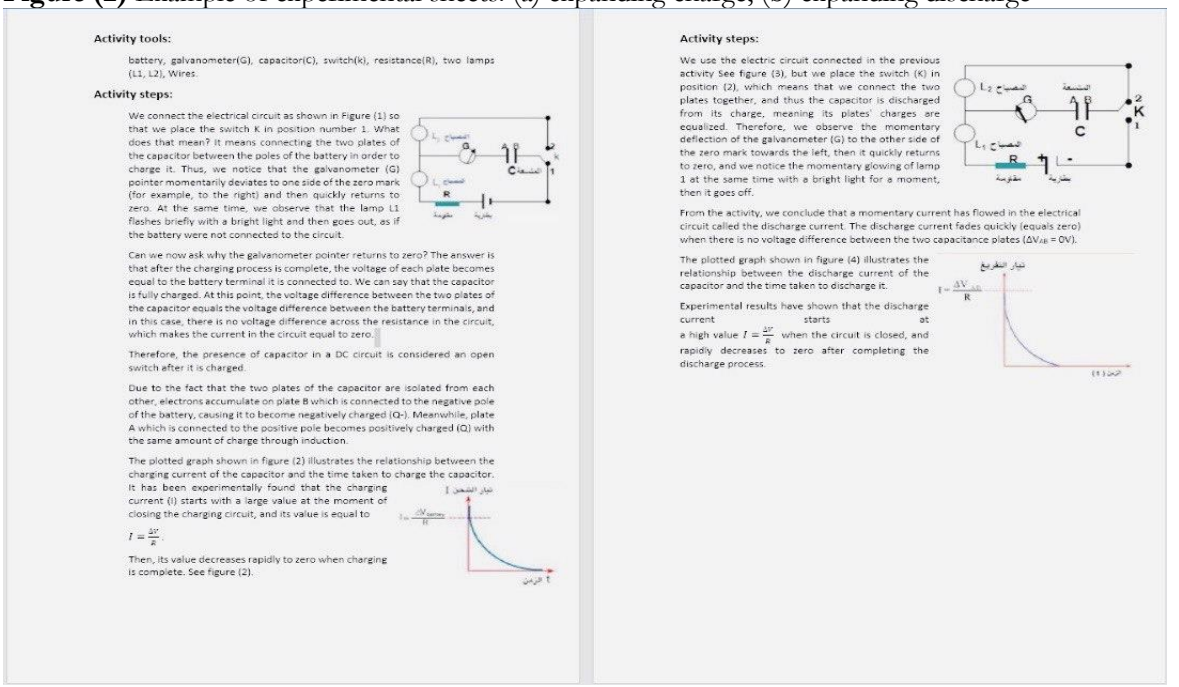
was identified of the physics book, which is 10 activities for the sixth grade for the academic year (2022-2023) 11 for 2021. As in the form of (1) below:

Form (1) Physics Experimentation Table for Grade VI Secondary

T	name for the experience.
1	Faraday
2	Connecting breadwinners respectively
3	Connecting exponents on (parallel)
4	Connecting expatriates on (mixed)
5	How to charge expanding
6	How to empty expanding
7	Effect of frequency change in induction radiator amount
8	Effect of the change of the self-induction coefficient in the amount of induction radiator
9	Impact of variability of voltage source frequency in capacity radiator amount
10	Impact of variability of voltage source frequency in capacity radiator amount

Two discharge charging experiments have been selected and their results presented The rest of the experiments will be presented in another paper. Form (2) is an example of extensive charging and unloading test sheets:

Figure (2) Example of experimental sheets: (a) expanding charge, (b) expanding discharge



A b

2_ Defining the programme's objectives in measurable behavioural terms: The most important step taken by the educational designer in the programme design process The design of education and educational materials and curricula is the definition of general educational objectives. [64]

The importance of defining general educational goals is that they help the educational designer

Starting to choose educational content,and organization and rank , in a manner consistent with the learner's readiness, motivation and abilities, It also helps him to learn about the appropriate educational methods to achieve these goals, And the calendar methods needed to measure them The designer then organizes them, arranging them to help achieve learning and education. Hence, there is a strong interrelationship that links each of the educational goals. educational content, teaching and evaluation methods together, [65] Consequently, the general objectives of physics teaching have been defined For the sixth grade of the General Directorate of Curricula, Adapted to research and allocated to sixth grade and classified into three areas (knowledge, skills and conscientiousness). (Garbellini & Ramallal, 2022)

3. Determining the starting point for learners: Previous Information Test (Past Experiences) for Physics, The test aims to determine the level of physical information Previous experience in 6th grade students To determine the starting point of the design of the e-program for activities (Experiments) Physics for the academic year (2022-2023).

4- Task analysis: The process of analyzing the educational task is all the procedures To divide educational tasks into their constituent components, Until he comes up with that part of the learner's knowledge, This process of analysis will be in lists containing elements of the content and summary of the educational material. This process shows how these elements are arranged and sequenced to lead to meaningful learning that achieves the desired goals. [64, 65] Mission analysis of activities (experiments) has been completed

The physics book of the sixth grade to comply with the design steps of the electronic program, Where the content of the experiments of the sixth scientific physics material was reviewed and analyzed To consist of key teaching tasks and subtopics about vocabulary and its content. As well as inventory of the main and secondary tasks in the activities (experiments) of the physics book for the sixth grade

5- Writing programme framework: The frameworks in the program are designed according to design steps Where a question has been developed that requires answering yes or no A multiple selection question has also been developed and the answer contains some hints to guide learners Towards the right answer to prevent him from getting wrong.

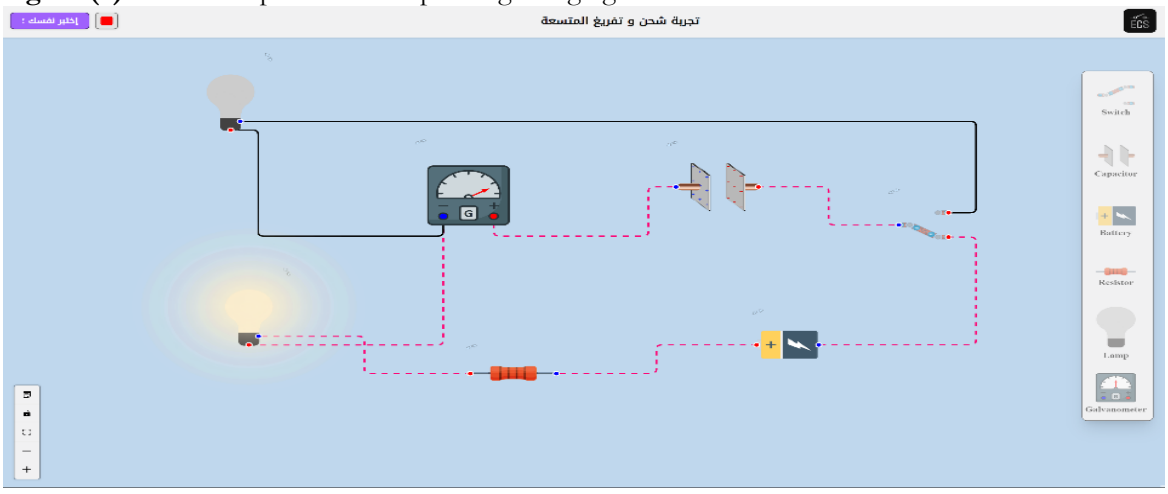
The design also contained a drawing extracting information from it. This diversification in the presentation of frameworks is crucial to avoid the boredom of learners from the program

The frameworks are formulated in JavaScript programming language with accuracy of scientific information Science arranged logically and psychologically With the inclusiveness of frameworks for basic ideas of the educational content contained in the experiences A tool is designed within the software interface to explain the steps and conclusion of the studied experiences To prepare the learner before starting the experiment by default through the desktop software designed, These frameworks consist of three exciting sections, response and feedback Where experimental tools are designed in clear shapes and colors to attract the learner's attention, When the learner uses the tools within the software interface and complete the steps to get to execution, If there is an imbalance in the connection at execution, there is a notification that alerts the learner of an error. If there is an imbalance in the connection at execution, there is a notice alerting the learner There is an error if the error with the link appears the phrase "the connection with the error of the attempt) (Hua & Jiang, 2023)

If the imbalance is a lack of tools, the phrase "there is a lack of tools" appears. If the connection is correct, there is a response signal placed in the design of the directive.

So by simulating the Service's work. As in figure (3)

Figure (3) Simulation process for expanding charging



A tool is designed in the main experience interface When you click on it, we go to a multiple selection type test to find out the learner's information on the experience to be carried out. The learner can find out the correct answer after completing the test with the appearance of a phrase (Your answer is true in green) for the right answer, And the phrase (your answer is wrong in red) for the wrong answer with a sign on the correct answer.

6- availability feed back: Feedback is defined as information given to an individual after answering It provides the student with his actual performance level, Feedback is important in stirring learner's motivation By helping him to detect the right responses, he stabilizes them and deletes the wrong responses. Feedback strengthens the educational process.

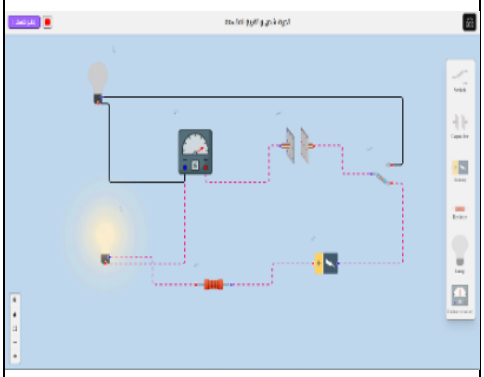
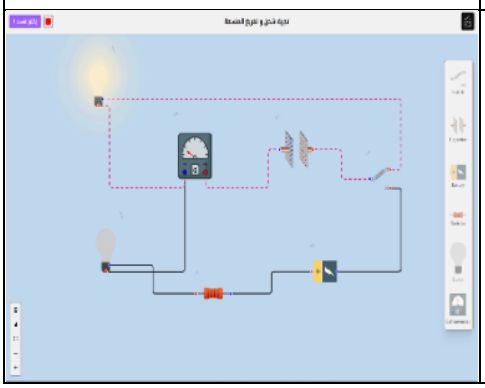
as well as correcting the wrong learner answer that would weaken the wrong associations which occurred in his memory and the replacement of valid associations,

This was implemented in the design When the learner finishes answering the given question, whether it's yes or no questions, Or the answer is a multiple choice through the appearance of the phrase "your answer is correct" for the correct answer. And the phrase (your answer is wrong) for the wrong answer with the sign. on the right answer. As in illustration (4)

Format (4) Test page and answer display

7- Piloting the program, modifying it: Before the program started, a group of 10 students was identified [16] Sixth grade in secondary and preparatory schools of Qadisiyah Education Directorate For the academic year (2022-2023), and tested on female students, By giving them a test before they studied the program and their level was determined by the test prepared Then enter the program the learner selects the required practical activity For example, extensive charging and unloading activity performed out of 10 practical activities. Once the activity is reached, from the list of activities in the interface as in figure (5)

Figure (5) Virtual working presentation produced for two widespread shipping and full-time operations

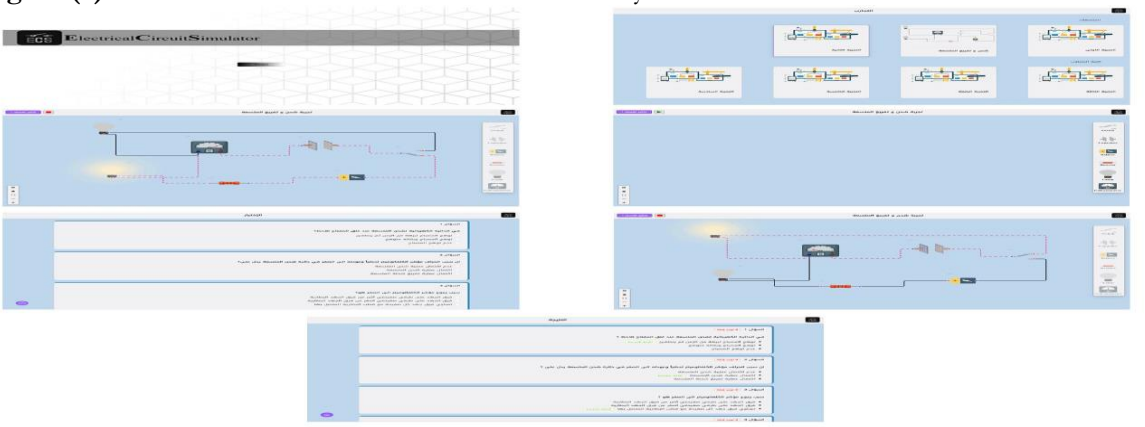
Experiment Simulation	Experiment Title	Process Explanation
	Capacitor Charging Process	When we press the button, it will move to the bottom position and then the charging process of the capacitor will begin. We notice the lamp glowing brightly and at the same time we also observe the galvanometer's needle moving to one side of zero, indicating the flow of current in the circuit and the start of the charging process. After a moment, we notice the lamp turning off and the galvanometer's needle returning to zero, indicating the end of the charging process.
	Capacitor Discharging Process	After completing the charging process, the discharge process can be carried out by pressing the circuit switch again. We observe the switch moving to the top position and then the discharge process begins. We notice the other lamp glowing and the galvanometer's needle deflecting to the opposite side, indicating the flow of electric current in the circuit and the start of the discharge process. After a moment, we notice the lamp turning off and the galvanometer's needle returning to zero, indicating the end of the discharge process.

Learners have been followed step by step as they progress in studying frameworks framework after framework, In the meantime, he recorded his observations on the difficulties faced by learners in reading the frameworks, and understanding or sequencing them in an affordable manner, Where these observations are valuable in making the programme clear, and an understanding of the learners, and after the learners have finished reading the frameworks, Give them a choice to determine their achievement in the program, Based on observations and test results, this process is repeated with each individual student, and each time we record the observations and make the necessary adjustments, Until at least 90% of learners are able to respond correctly to all of the program's steps These pilot steps take time not short to show the programme successfully Following the fulfilment of these requirements, the programme was presented to the arbitrators of professors specializing in computer science and introduction their feedback , and necessary adjustments were made in accordance with the observations recorded by the researcher and the specialists' observations.

8- Finalization of the programme: After the revision and modification of the software, the software

is final usable It can be taken out as seen by the programme's author. As in figure (6).

Figure (6) Different interfaces for virtual business activity.



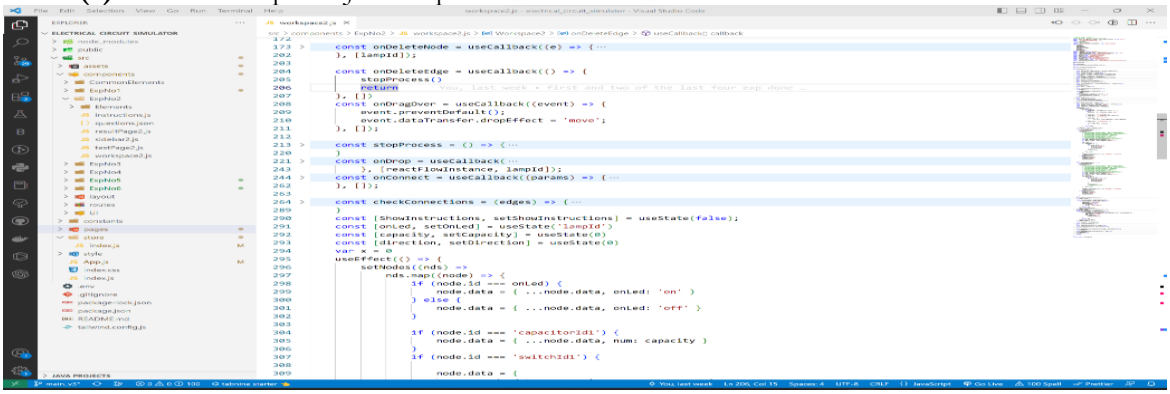
9. Preparation of tests accompanying the program: After the program became ready for final use, the researcher prepared two types of tests:

Tribal test: given to the student before starting to learn the program to determine the level of the subject; If the student receives a high degree of this choice, there is no need to study the program, If he gets low grades, he can actually study the program.

Remoteness test: This test is given after completion of the program study The comprehensiveness of the article's content and objectives should be emphasized. As in figure (4).

10- Software computing: using JavaScript as in figure (7) below High-level programming language is widely used in web development The development of forward applications is a key feature of JavaScript's simplicity. Unlike other programming languages such as C or Java, JavaScript is easy to learn and use. Their installation is intuitive and straightforward, This makes it a popular option for beginners.JavaScript is also versatile, This allows developers to create complex applications using a few lines of code. This diversity stems from JavaScript's ability to process HTML and CSS, They are the building blocks of the web, JavaScript is an excellent option to create web apps Virtual laboratories such as the one created for research. Their simplicity, versatility and portability An extensive library of tools and texts makes it a perfect language To create dynamic, interactive and attractive web apps at which point it has been piloted and circulated.

Form (7) with an example of JavaScript code



Results and Discussion

It is difficult to get an understanding of scientific theories without scientific laboratory activities. In order to provide an alternative to actual physics laboratory activities for learners in the sixth secondary grade, project ", an interactive online virtual laboratory was implemented in secondary schools in Iraq. The virtual laboratory provided the opportunity to implement the process By providing computer simulations that give designs and methods that resemble actual experiences. Ten virtual practical activities assigned to the 6th Secondary Physics Curriculum They have been created, designed, implemented and accessible via the Internet. Form (1) provides a summary of all practical things productive activities, which covered 10 activities taught in the 6th Secondary School Traditional laboratories provide physical infrastructure However, they may have limitations on location, scheduling and financial matters [61]. Virtual laboratories have become mainstream in higher education of science and engineering in many countries around the world [7]. Moreover, they are very effective learning environments High performance potential at low cost [62]. Also, technological progress in education allowed everyone to participate in the virtual world [63].

Conclusions

Laboratory learning is a requirement for science education, In particular, it also offers learners the possibility to gain practical experience. This research presented a proposed solution to overcome the lack of practical physics activities in secondary schools. A virtual lab that can run over the web and uses a computer. Simulation is designed to illustrate actual physics experiments to support the teaching of physics material in the sixth grade secondary. JavaScript language is certified in virtual lab design, simulation and online teaching content The lab includes ten virtual activities: (Fraday activity, breadwinner activity respectively), Activity of connecting expats on (parallel), Activity of binding amplifiers Mixed binding, Activity how to charge the wider, activity how to unload the wider, Current frequency change effect activity in induction radiator amount, activity of the effect of changing the self-induction coefficient in the amount of induction radiator, The effect activity of changing the voltage frequency of the source in the capacity radiator amount,) Taught in 6th Grade Secondary. Virtual activities were tested by high school learners, experiments can be conducted in schools or at home, The virtual lab increased flexibility and motivated the learner He offered similar education to the achievements of a physical laboratory. programme ", the effectiveness and usefulness of the virtual laboratory were positively assessed by teachers and learners; Learners also appreciated the virtual laboratory experience as it increased their motivation to learn physics. Plus feedback collected from learners and teachers He noted that the virtual laboratory designed to support learners' understanding of the scientific concept of physics. There is no doubt that not all real lab practices can be reproduced Simulation in virtual laboratory, But at the same time many studies have demonstrated the effectiveness of using virtual laboratories to teach science.

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