Evaluation of Researches Related to Virtual Physics Laboratory Applications

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Evaluation of Researches Related to Virtual Physics Laboratory Applications

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Abstract. It has been seen in the studies conducted particularly for the last 30 years that different types of virtual labs were applied to different study groups using very different methods and techniques. The aim of this study is to evaluate the virtual labs used in teaching physics in terms of the purpose of use, working groups, methods and techniques using the content analysis method based on literature review conducted. The results of the application, which is aimed at the selection, and use of the virtual physics lab programs that offer very different designs, scopes and means of application, and at the adaptation of such programs to the target audience by educators, as well as at provision of a means for measurement and evaluation, will be analyzed. By examining the data thus obtained in terms of the subject matter, method and outcome, it will be possible to assist the parties, who will utilize the virtual physics laboratory programs in teaching physics, to use such programs with expected efficiency.

1. Introduction

The laboratory applications which are considered as one of the most important and indispensable components and complementary of the physics courses enable the students to acquire some practical capabilities and skills and to increase their academic successes properly. However, the fundamental problems which are encountered by the lecturers and the students in the traditional laboratories are stated and specified in the following headings briefly [1]:

- That there is not sufficient experiment equipment for each student in the laboratory and the laboratory works which are carried out and performed with the groups which are composed of mostly 3-4 persons are not satisfactory about many aspects,
- The complicated experiment sets which contain advanced technology could not be left in the hands of the students (because the set is one, considering the possibility of deformation, there is not assistant who knows the equipment enough and preventing also the desire of working of the others, similar worries, etc.),
- The students are missing some of the experiments carried out and performed or these students feel detached and disconnected from the courses or they may lose their motivations in the end,
- The pressure and timidity which may be formed on the student by the possible and potential difficulties of the experiment carried out,
- That the entire testing and experiment system could become inoperable because of the reasons that the settings and adjustments of a sensitive equipment could not be made properly, and it may become useless,
- The negative competition or the communication problems in and between the experiment groups may detract the student from the laboratory works and studies,
- The mechanisms are fulfilled and realized by means of the careful and patient steps in the experiments carried out and performed, abundant quantities in the measurements made, the difficulty of making comparisons of the previously made measurements, will to resist the loss of time because of returning to the starting point in cases of errors, and similar other difficulties,
- The formation and occurrence of the information losses or doubts about the experiment studies and works after a while following the performance of the experiment,
- A test carried out may not be understood and comprehended by the students due to the mostly single trial or they may be perceived by them differently,
- In general, there is an opportunity of compensation only one of 6-8 experiments carried out and performed in the laboratory.

For finding a solution for the problems specified and determined, as the technology progresses, the requirement of using the virtual laboratory programs has become more and more important. The virtual laboratories which are defined as the computer environment which gives the opportunity to make and perform real-time simulations in the tests and experiments which are required to be carried out and performed to acquire...
a practical experience are called as modeling the reality in computer environment as a simulation based multi
environment [2, 3]. The students who work with these programs take more pleasure in the courses taken, their
motivation levels and interest levels increase and enhance and further their participation in the courses/lessons
become much higher [4, 5]. In addition to this, it is emphasized that it increases the conceptual learning process
[5, 6, 7]. On the other hand, because the virtual laboratories are being used for the students to convert the
alternative concepts into scientific concepts [8], it is stated and specified that they increase the academic
successes of the students and they affect the problem-solving skills and capabilities of the students positively [5,
9, 10, 11].

2. Aim

The purpose of this study is to evaluate the virtual laboratories which are used in the education of physics
based on the application purpose, working group, method and related techniques dependant on the literature
scanning process performed. Thus, it is targeted at making contributions for choosing and using these programs
which present the opportunity of application and versatile designs and scopes by the educators, adapting for the
target audience and providing an appropriate method and an effective measurement-assessment opportunity.

3. Method

In the study carried out, the studies which are performed by means of using the virtual laboratory programs
in the education of physics beginning from the primary school level up to the university level based on the
literature scanning process fulfilled and the data which are obtained within the dimensions of the content
analysis method and the application purpose, working group, method and result dimensions. In this context, the
studies in the literature is examined with using the content analysis. Because, content analysis is a quantitative
research technique provides to the researches a systematic, objective, quantitative information about studies [12].
However, it is implemented in a way that the studies in the literature used the virtual laboratory programs in the
physics education is collected and categorized according to a few dimensions. This dimensions contains; the
purpose of the study put into practice, the study group used in the study from the primary school level up to the
university level, the research method that is taken into consideration and the kind of results reached in the
studies.

4. Findings

Because of the literature review process performed, the intended usage purposes of the virtual laboratory
programs in the physics courses have been taken up mainly in two groups as follows:
1. Preparation for the real laboratory tests and experiments and providing support and assistance [11, 13, 14,
15, 16].
2. Replacing the real laboratory applications totally [5, 17, 18]. In the study which is carried out by Christian
(2001), the software package titled “Physlet” which is prepared by means of Java is introduced to be used in
the education of physics. It is further stated and specified that it could be used as a tool by the students to
develop the similar softwares. Thus, it is particularly emphasized that some even more effective virtual
laboratory environments could be formed in accordance with the specific needs of the users.
Whenever the presently available studies are examined properly, it is suggested in the researches to use the
virtual laboratory programs in ensuring the appropriate application environment for the students before the real
physics laboratory applications [9, 13, 15, 19, 20].

The methodologies of the works and studies which are carried out and performed as directed at using the
virtual laboratory programs in the physics courses could be taken up in three groups as follows:
1. The characteristics which should be present in the virtual laboratory programs which shall be used in the
learning and education processes and for developing the methods of formation [19].
2. Using a virtual laboratory program which is developed by the others in the educational processes [7, 13, 21,
22, 23].
3. Developing the virtual laboratory program by the researchers and then implementing and trying the same in
the education [5, 8, 9, 16, 17, 18, 19, 20]. The difference of this type from the others is not only preparing
the virtual laboratory software used by the researchers in the studies by the researchers in accordance with the
appropriate contents and targets but also examining their potential influences on the students concerned.
The data which are obtained because of the literature scanning process performed concerning the work groups of the virtual laboratory programs which are used in the physics courses, the methods used, and the techniques and the results obtained have been shown in the Table 1.

**Table 1. Important notes from the virtual laboratory researches which are used in the physics courses**

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<th>Studies indicated with reference number</th>
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| [24] Afra, Osta & Zoubeir (2007)       | • In the study which is carried out with 12 students the ages of whom range between 14-15 and who pursue the education at the 9th class in an American school which is situated and located in Beirut, it is tried to determine the concepts which the students have relating to the electricity subject. For this purpose, a module which is based on the questionnaire which contains the fundamental principles relating to electricity has been implemented. By means of using a program called DIRECT, it is tried to implement a final test and educative test which measure the comprehension levels of the students concerned.  
• As a result of the study carried out, the alternative concepts which the students have are determined and specified properly. It is seen and observed that it obviously increased and enhanced the conceptual perceptions of the mentioned participants in the end. |
| [21] Baser (2006)                     | • The virtual laboratories which are required to be used for the purpose of correcting the conceptual mistakes of the students should be a program with source codes and which provide the opportunity of working freely for the user in question.  
• The programs which present some restricted opportunities to the users and which make it possible to work only in some certain rules remain quite insufficient in correcting the conceptual mistakes. |
| [19] Biel, Vento & Costa-Castelló (2010) | • It is already shown that the virtual laboratory programs could be used as a support for the real laboratory environments and they could assist the developments of the mental models by the students by means of forming a structuralist learning environment. |
| [9] Bozkurt & Sarıkoç (2008)          | • It is further determined that the usage of the virtual laboratory programs in the education of the electricity subject in physics courses in the secondary school not only increased the academic success, interest levels and conceptual learning of the students but also their recognition of the experimental materials in real physics laboratory environment and their performances. |
| [25] Bull, Gardner, Jackson, Lancaster & Geban (2007) | • It is emphasized that the software with the open learning models should be used in eliminating the conceptual mistakes of the university students. Thus, the students could take and obtain some graphical and writing feedbacks by means of having the unlimited experiment performance environment through using the software developed and could facilitate the learning process.  
• The software titled OLMlets (Open Learner Models) gives to the student the opportunity to carry out and perform tests and experiments just independently. In addition to this, some links are provided in the program relating to the conceptual mistakes and the students are ensured to face them thoroughly. |
| [26] Erdoğan (2011)                   | • While a significant difference is found in the success tests in favor of the experiment group as a result of the studies carried out and performed on the subject of the brightness of the bulbs and the electricity currents in the 11th class by means of using the 5E education model, no difference is seen and observed towards the attitude. |
| [15] Jaakkola & Nurmi (2008)          | • In the study which is carried out and performed with 66 primary school students the ages of whom vary between 10-11, three different experiment groups have been used: 1) Those that use the online simulation, 2) Those who use the simulation and real laboratory, 3) Those who use only real laboratory environment.  
• As a result of the research carried out and performed, it is seen, determined and observed that the experiment groups that use the simulation and that use the simulation together with the real laboratory became more successful in comparison with the traditional groups. In addition to this, it is seen and determined that the incorrect concepts relating to the distribution of the current in the DC (Direct Current) circuit are corrected most in the group which uses the simulation together with the real laboratory environment.  
• In addition, it is stated and specified that the simulation helps the students in comprehending the theoretical electricity rules and distribution of the current and explaining the correct current circuit analysis.  
• The academic successes of the students that use the simulation and the real laboratory environments together are more effective only in comparison with those that use the simulation and the real laboratory environment only.  
• The joint usage of the simulation and the real laboratory environment ensures the understanding
of the theory and the practice by the students in a better way.

[27] Jimoiyannis & Komis (2001)

- In the study, it is aimed at forming the conceptual knowledge with the students in the physics course. The possible and potential influences of the computer simulations on the students the ages of whom vary between 15-16 are examined and then it has been finally concluded that there is a significant difference in favor of the experiment group.
- As a result of the research carried out and performed, the computer simulations are considered as an educational tool which eliminate the problems which are directed at comprehending the physics subjects by the students and which makes it possible the functional understanding.


- An increase is observed and determined in the number of the students who install the correct circuits as a result of forming a simple electricity circuit not only in simulation but also in real laboratory environment in the form of groups which are composed of 4-5 persons.
- The simulation has been used as a tool of learning and measurement.
- As the simulation which is used in the education process is quite easy for the student level, because of the fact that the student installs and operates the mechanism in a rapid manner and could not understand and comprehend the event fully, the simulation should not be excessively easy or difficult and should be in compliance with the level of that student concerned.


- A virtual laboratory program which is formed in web environment has been used in the study which is carried out and performed with the students who took the Science and Statistics course in Utah University. A research focused area has been formed by the experts and thus the students are given and provided the opportunity to simulate the subjects related with the course in a realistic manner and to work in an online environment.
- In this environment, the students had the opportunities to reach a library, to review the theoretical subjects again, to get access to the scientific puzzles and the laboratory environment, to design a study, to gather and analyze the data and information properly and then to write a report relating to them.
- In this study environment, the results of the designs and data analyses which are carried out and performed by the student are graded and then recorded in a database. The data obtained could be recalled and used whenever required and requested by the trainers or students and these are opened for the sharing for the purpose of examination of the other students.
- As a result of such entire study, it is observed and determined that the interests of the students towards the research increased and they had even more information than could be provided in a face-to-face education by a teacher.


- The simulations and the learning scenarios are more effective in correcting the conceptual mistakes of the students.
- The scenarios and the didactic variables are considerably useful in forming the model relating to the subject in the minds of the students and in giving a meaning for them.
- The discussion which is carried out and performed by the students is considerably effective in determining the mental models of the students as well.


- It is stated that this kind of interactive environments could be leading for the students in learning the complicated events and concepts in the real world and could help and assist the students in developing correct mental models.


- It is also stated that the virtual laboratory applications increased the academic successes of the student at every level, they developed some positive attitudes towards the course in question and it also causes certain positive developments in learning the concepts.
- The students could materialize the concepts which belong to the real world which they have formed in their own minds by means of using the virtual laboratory programs and the teachers could also use the virtual laboratory programs as an assistant tool in the process of evaluation and assessment of their own students.
- It is stated in the study that the virtual laboratory programs are supported to be used in the education strategies based on the structuralist and collaborative approaches and thus considered appropriate.


- Such programs not only could present to the student the opportunity of working in accordance with the knowledge and under the control of the teacher but also could provide the student with the opportunity of learning with a trial-and-error approach.


- In the study which is carried out and performed relating to the diode tests and experiments with the physics teacher candidates, it is determined that the virtual laboratory supported experiment group showed a significant difference in the academic successes in comparison with the group that uses only the virtual laboratory program and that never uses it.
- The students who use the virtual laboratory program could have preliminary knowledge and could also have the opportunity of collecting data on the tests and experiments before entering into the virtual laboratory environment.
The combination of the virtual laboratory and real physics laboratory methods could make positive influence with regard to not only experiment performance in the laboratory but also success of the participants.

In the experimental study which is carried out and performed with 64 students from the 12th grade, the computer simulations have been examined with a different point of view. Three (3) different groups are formed in the experimental study performed and carried out as follows: 1) The group which uses the teacher oriented computer simulation, 2) The group which uses the student oriented computer simulation, 3) The group which uses the real experiment materials.

In the study, the test which is used for the DC circuit concepts, 19 questions of the multiple choice test which is composed of totally 29 questions which is developed by Engelhardt and Beichner.

As a result of the study carried out and performed, a higher success is seen and observed in the experiment groups which use the computer simulation in comparison with the student group which uses the traditional laboratory method and it is further observed that they could prepare the experiment mechanisms in a faster manner.

It is observed that the student groups which use the teacher and student oriented computer simulation became not only more successful in academic meaning in comparison with the group which uses the real physics laboratory but also they became much more effective in recognition and formation of the experiment materials in the real physics laboratories.

In physics education, it could be used as supportive and pioneering to the real physics laboratories which use the computer simulations.

As it could be obviously seen in the Table 1; it is stated that the virtual laboratory programs should be used for the preparatory purposes before the real laboratory activities and they become effective in understanding the concepts for the student in different age groups and it provides a structuralist learning environment. The literature reviews for the virtual labs used in physics teaching in terms of the purpose of use revealed some problems of the real physics laboratory applications. It is pointed out from the literature review of the virtual labs used in physics teaching in terms of the students at high school and university level. It is regarded as the virtual labs used in physics teaching based on the literature review with respect to using before the real physics laboratory applications and learning models. It could be indicated according to the literature review conducted about the virtual labs put into practice in physics teaching in terms of the effective learning environment can be provided with many subjects by choosing one of the available virtual laboratories for the student level. Especially, it is recommended to using it in subjects that are difficult to teach such as electricity. Also, as student level increases, functionality and remote access of virtual laboratories come into prominence.

5. Conclusions

Because of the literature studies carried out and performed, the results which are reached by means of taking into consideration the findings which are obtained in the studies carried out and performed using the virtual laboratory programs are stated and specified as follows;

- The virtual laboratory programs have some positive influences in the learning and teaching processes.
- They could be used for different age groups and purposes.
- Their effectiveness becomes even more and higher whenever it is used together with and in collaboration with the different educational methods and techniques.
- The virtual laboratory programs have become a requirement under the conditions of nowadays.
- The effectiveness of virtual laboratory programs increases when used in conjunction with teaching models such as 5E, 7E.
- Virtual laboratory programs reduce misconceptions, improve mental models and provide permanent learning.
- As a result of literature review, virtual laboratory programs take place to be used for all subjects in physics teaching process. Especially, the numbers of work done on electricity has attracted attention. This is because the subject of electric involves abstract concepts, the presence of dangerous experimental environments, daily life and frequent teaching since primary education.
- Whenever the researches and studies carried out and performed is examined properly; then it is specified and stated that they become more effective whenever these are used before the real physics laboratory applications.
• While the virtual laboratories are being used as they are composed of simulations mostly in the secondary school level, it is seen and observed that the remote controlled virtual laboratories are being used in the higher education level.
• While the virtual laboratory programs which are used at the level of secondary school are in the form as used in ready condition by the teacher after developed by the researchers; it is also seen and observed that the researchers at the level of higher education choose to develop and use such programs in general.
• This kind of programs enables the measurement of the knowledge and mental models of the students in question as well.
• It is also seen and observed that the virtual laboratory programs are needed, formed and implemented on the physics area and about electricity.

6. Suggestions

It is also required to take into consideration the following suggestions and recommendations while carrying out and performing the applications with the virtual laboratory programs in the physics courses by means of considering the above-stated results:
• Not only the virtual laboratories could be used before the real physics laboratory applications but also, they could be used as an alternative in the situations in which it is not possible to perform the laboratory applications.
• Virtual laboratory programs should be used by integrating into an instructional model to enhance their effectiveness.
• The follow-up process should be made and performed by the teachers by means of recording the files which are formed by means of using the virtual laboratory programs. Thus, the comprehension levels of the mentioned students could be monitored and followed properly.
• An additional period should be certainly recognized to the students who work with this kind of programs for performing trials and error methods and approaches.
• It is suggested and highly recommended that the simulation and graphics weighted programs should be chosen at the levels of primary school and secondary school and the virtual laboratories which present the opportunity of working with the web-based and online library working methods should be chosen for the higher education level.
• It is also necessary to develop this kind of programs on different subjects except for the subject of “Electricity” on physics area.

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