

Experimentation in Physics on Virtual Labs Using Smart Phones in Schools

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Abstract: *The study carried out on Students and Post Graduate Teachers in Physics from various schools strongly suggests and recommends the use of virtual labs and smart phone as the smartest technological tool to access the physics labs at home, seeing its effectiveness in both conceptual understanding and problem solving well beyond that achieved by conventional methods. Virtual labs offer advantages in education and can supplement physical labs. A combination of virtual lab experience before and after the conventional hands on lab may provide more learning gains. Students can navigate the website at their own pace, speeding through familiar material and more carefully exploring difficult or interesting parts of the experiment. Virtual labs reduce equipment needs, and thus cost, by providing "virtual access" to equipment and accompanying materials and can act as a boon especially for remote area and economically weaker schools/institutes.*

Keywords: Virtual lab, Smart Phone, Conventional labs

1. Introduction

In Twenty First century of Science and Technology, one hardly witnesses any invention or Innovation without the Use of ICT. It is a term which includes the set of technologies that facilitate us to generate access, evaluate and share the information with each other. Our life is influenced dramatically as Mobile phones have replaced TV, computer, calculator etc.[1] The Internet has brought in revolution in Information and communication such as all sorts of business transactions(e-commerce), banking transactions (e-banking), learning material in the form of lectures/presentation/video and research papers (e-learning) etc.[2,3]. All these functions are achieved by Smart Phones.

The Mobile Phones could also be used to assist students learn and perform Physics Experiments through virtual Labs in their own time without recreating the experiments in the Physics laboratory. It in fact allows the students to visually ascertain the relationship between the experiment in the form of simulation and recording the associated data in real time.

2. Virtual Labs

A common problem in many schools is that they do not have the necessary equipment in their laboratories due to space and a limited budget for maintenance and equipment.

Working in a Physics Lab includes the creation of interactive content that provides practical knowledge and stimulates development. [4]

Virtual labs are intended to enhance the learning of science and engineering subjects through performing experiments. Virtual labs are also known as Simulation based labs. In these labs there is no real equipment at the back end, instead there is a simulation engine that provides as the approximate version of the real world experiment [5].

But these labs have some major benefits as students can repeat experiments many times, step by step wizard to guide, solve complex problems, and available 24X7 to work as per own schedule. [6,7]

Accordingly, the objectives of Virtual Labs (VL) are to provide access to labs in physics to enthuse students and to share costly equipment. In fact, these labs enable a student to find a link between the practical aspect with theoretical one without using Pens and Papers. It can be defined as the virtual studying and learning environment that stimulates the real lab. [8-10] It provides the students with tools, materials and lab sets on smart phones to perform physics experiments anywhere any time. The Online Labs are based on the idea that lab experiments can be taught using the Internet, more efficiently and less expensively. The labs can also be made available to students with no access to physical labs or where equipment is not available. This helps them compete with students of better equipped schools and bridges the digital divide [11-14]. The experiments can be accessed anytime and anywhere, using a smart phone overcoming the constraints of the physical lab. Since I wanted to bring the idea of using virtual labs in the class rooms I tried many options but there were many constraints like internet speed, less number of computers, short supply of electricity etc. decided to work with smart phones as Technology can be a powerful tool for learning physics concepts and developing skills of measurement, analysis, and processing information'

3. Methodology

Equipments required to perform experiments by students are as follows:

- A smart phone/computer with internet connectivity of 64 kbps speed.
- Web Browser, Internet explorer 7.0, Mozilla fire fox 4.0, Google chrome
- Google ID or an open ID
- <http://amrita.co.in> or www.vlabs.co.in and others

The study was carried out on a group of 30 students of KV, Halwara and High Grounds and a faculty sample comprising of 52 PGT Physics of various Kendriya Vidyalayas’.

All students were given instructions on Conventional Lab applications and Virtual Lab applications and there after Students were divided in three groups each consisting of 10 students.

- First group(Gr-I) performed experiments on conventional lab(CL) applications
- Second group(Gr-II) performed experiments only on Virtual lab(VL)/smart Phone applications
- Third group (Gr-III) performed experiments on conventional lab(CL) + Virtual Lab(VL)/Smart Phones applications both

After experimentation each group collected data and asked to write report. The lab report of each group was graded objectively using a Rubric designed to assess the performance.

3.1 Parameters of Experiment

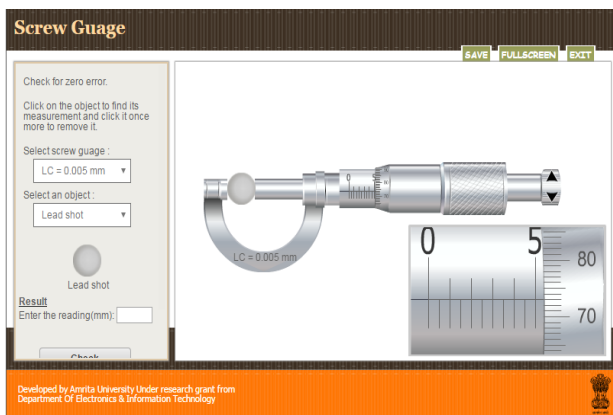
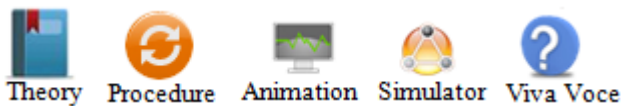


Figure 3.1: Illustration of the use of screw gauge to measure the diameter of the given lead shot



Figure 3.2: Illustration of the use of a simple pendulum To plot a L-T² graph

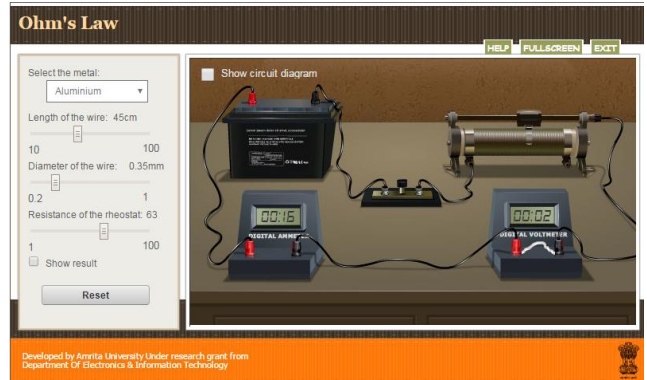


Figure 3.3: Illustration of the use of Ohm’s law apparatus to determine the resistance per cm of a given wire by plotting a graph of potential difference versus current

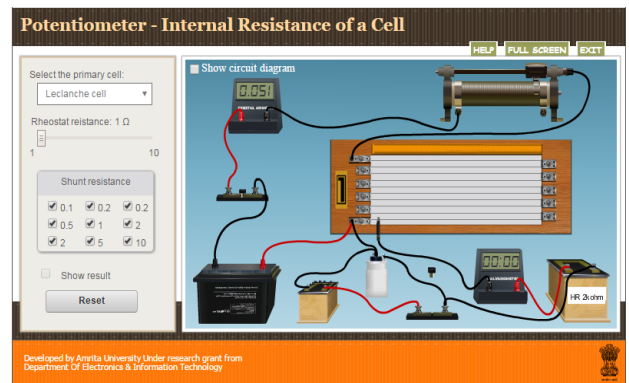


Figure 3.4: Illustration of the use of potentiometer to measure the internal resistance of a given primary cell

3.2 Rubric for experiments in conventional lab and virtual labs

Table 1: Rubric for Experiments

Score	0	1	2	3
Ability	Missing	Inadequate	Needs improvement	Adequate
Experiment Procedure	Step by step experimental procedure missing more than two key details / Not labeled dig / apparatus used is not described.	Step by step experimental procedure missing two key details / Not labeled dig / apparatus used is described.	Step by step experimental procedure missing one key detail / Not labeled dig / apparatus used is described.	Clear step by step experimental procedure/ labeled dig / apparatus used is described.
Data	Data is inaccurate or not shown	Accurate representation of data in tables without mentioning units and tables are titled	Accurate representation of data in tables with properly mentioned units but tables are not titled	Accurate representation of data in tables with units and tables are titled properly

Source: a comparative analysis of Virtual lab with Smart Phone (VIRTUAL LAB/ SMART PHONE) only, Conventional Lab(CL) Only, and Virtual Lab combined with Conventional Lab (VIRTUAL LAB/ SMART PHONE +CL) were undertaken and the following results were found.

Table 2: Mean Score and Standard Deviation

Group	Lab	Mean Score (MS)	Standard Deviation(SD)	Number(N)
Gr-I	Conventional Lab	8.4	2.92	10
Gr-II	Virtual Lab Using Smart Phone	9.7	2.0	10
Gr-III	Conventional Lab+Virtual Lab/ Smart Phone	10	2.34	10

Source: a comparative analysis of Virtual lab with Smart Phone (VIRTUAL LAB/ SMART PHONE) only, Conventional Lab(CL) Only, and Virtual Lab combined with Conventional Lab (VIRTUAL LAB/ SMART PHONE +CL) were undertaken and the following results were found.

The following observations were recorded in:

- Gr-I, students had the lowest value of mean score (8.4+2.92)

- Gr-II, students had the mean value of mean score (9.7+2.0)
- Gr-III, students had the highest value of mean score (10+2.34)

3.3 Data Representation in terms of Mean Score, Standard Deviation and Number of Students

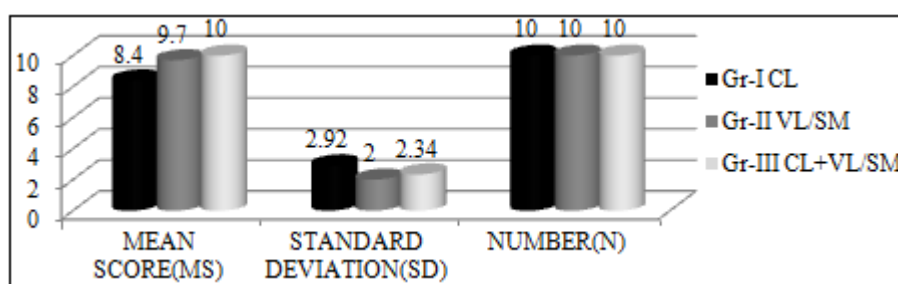


Figure 4.1: Graphical representation of the mean score, standard deviation & number

Here the SD was found to be the least for the group which had done the experiments with Virtual lab using smart Phone. All students were given Survey/Feedback Questionnaire to assess about the attitude & arousing of interest and their performance.

3.4 Data collection in performing physics experiments on virtual lab using smart phone by students

Table 3: The survey questionnaire used for challenges faced by students

The challenges that you face in a Real/conventional lab	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Shortage of apparatus	1	2	7	19	1
Time constraints	2	1	7	17	3
Errors in apparatus	3	2	11	10	4
Lack of interest in students to perform experiments	5	4	11	9	1
New experiment that you have not learnt earlier	3	2	5	18	2
Difficulty to handle apparatus individually in a large group of students	2	3	7	16	2

Table 4: The Survey Questionnaire used by Students for virtual Labs

Experience of using virtual labs in physics using a smart phone	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Using Virtual Labs in physics will improve the quality of my studies	2	1	5	19	3
Virtual Labs in physics will make it easier to do experiments at home	0	2	3	21	4
Virtual Labs provides higher level of engagement in studies in physics	4	3	5	12	6
Virtual Labs helps remember the concepts in physics better.	1	2	4	19	4
Using Virtual Labs will fit into my learning style.	3	2	9	11	5
I think that using Virtual Labs will fit well with the way I like to study.	2	3	9	11	5
My interaction with Virtual Labs is clear and understandable.	2	3	9	11	5
Using Virtual Labs I will get accurate results	1	1	7	15	6
I believe that it is easy to get Virtual Labs to do what I want it to do using my smart phone	1	1	8	16	4
I want to try out various experiments under the Virtual Labs using my smart phone	1	2	6	5	16
I am committed to supporting my efforts in using Virtual Labs using my smart phone	4	3	6	11	6
Overall, I would find using Virtual Labs to be advantageous in my learning	5	6	1	11	7
Overall, I believe that Virtual Labs will be easy for me.	2	2	9	11	6
I strongly encourage the use of Virtual Labs using smart phone	0	3	5	14	8

3.5 Physics Virtual Lab Workshop- Faculty Survey

Table 5: The Survey Questionnaire used for Faculty

The challenges that you face in a conventional lab as a Faculty?	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Shortage of apparatus	33	8	2	6	3
Time constraints	17	9	5	14	7
Errors in apparatus	19	8	6	12	7
Lack of interest in students to perform experiments	11	6	5	18	12
Unmotivated Students	16	7	4	15	10
New experiment that you have not learnt as a student	18	13	3	12	6
Difficulty to handle apparatus individually in a large group of students	26	19	3	4	0

Table 6: The survey questionnaire used for faculty

Please rate your agreement with the following statements by using (√)	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Using Virtual Labs will improve the quality of understanding Physics/Science.	0	0	0	28	24
virtual Labs will make it easier to do experiments.	0	3	1	32	16
Virtual Labs provides higher level of engagement in studies.	0	5	4	29	14
Virtual Labs helps remember the concepts better.	0	3	9	25	15
I will prefer to use Physical Labs before using Virtual Labs.	6	12	3	19	12
Overall, I would find using Virtual Labs to be advantageous in my teaching	0	1	2	31	18
Using Virtual Labs will fit into my teaching style.	0	5	3	35	9
I think that using Virtual Labs will fit well with the way I like to study.	0	2	4	35	11
Virtual Labs requires more of my preparation time.	6	21	8	14	3
My interaction with Virtual Labs is clear and understandable.	0	3	2	37	10
Using Virtual Labs will require a lot of training.	6	27	9	8	2
I believe that it is easy to get Virtual Labs to do what I want it to do with my students	0	4	7	32	9
Overall, I believe that Virtual Labs will be easy for me.	0	1	3	36	12
I want to be able to perform experiments under Virtual Labs on a trial basis to see what it can do.	0	1	6	33	12
I want to try out various experiments under the Virtual Labs.	0	0	1	36	15
I am committed to implementing Virtual Labs.	0	3	9	32	8
I am committed to supporting my efforts in using Virtual Labs.	0	4	3	35	10
I strongly encourage the use of Virtual Labs by students.	0	1	3	32	16

4. Results

4.1 Data Analysis –Students

In the student’s sample the challenges faced in a real/ conventional lab showed that

- 63% faced Shortage of apparatus,

- About 56% students faced Time constraints and
- About 60% faced the problem of New experiment that they had not learnt earlier.

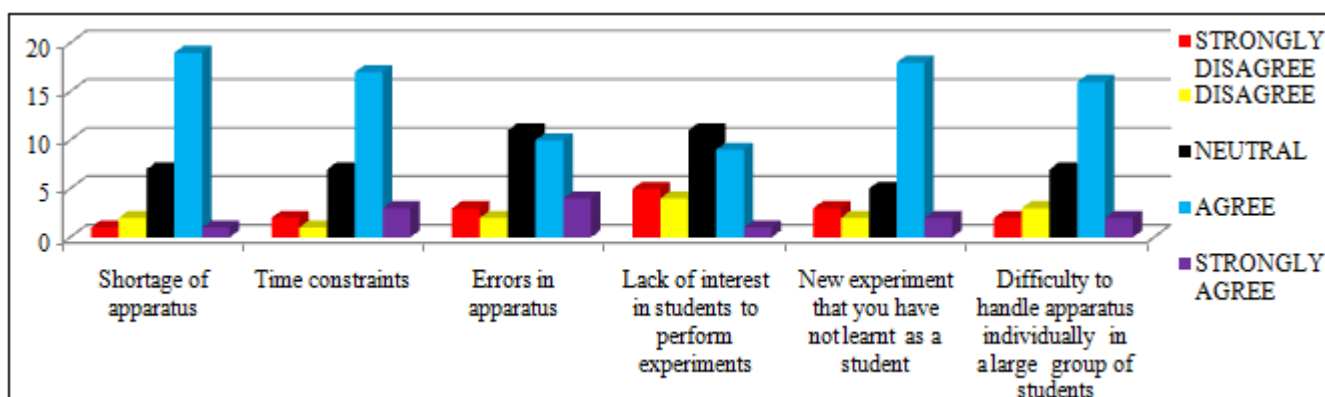


Figure 7.1: Graphical representation of the challenges faced

4.2 Experience of Students in virtual labs in physics using a smart phone

- About 57% of the students agree 10 % strongly agree that Using Virtual Labs in physics will improve the quality of studies.

- About 70% of the students agree and 13% strongly agree that Virtual Labs in physics will make it easier to do experiments at home.
- About 40% of the student (12) agree and about 20 % (6 – students) strongly agree that Virtual Labs provides higher level of engagement in studies in physics

- About 53% of the students (16) agree and 13%(4-students) strongly agree it is easy to get Virtual Labs to do what I want to do using Smart Phone
- About 77% of the students (23) agree Virtual Labs helps remember the concepts in physics better.
- About 37% agree (11) and 23% strongly agree (7) but 20% disagree (6) that I would find using Virtual Labs to be advantageous in my learning.
- About 53% of students strongly agree that I want to try out various experiments under the Virtual Labs using my smart phone.

- About 57% of the students agree that I am committed to supporting my efforts in using Virtual Labs using my smart phone

7.3 Response of 30 Student's

- **Virtual Labs provides higher level of engagement in studies in physics**

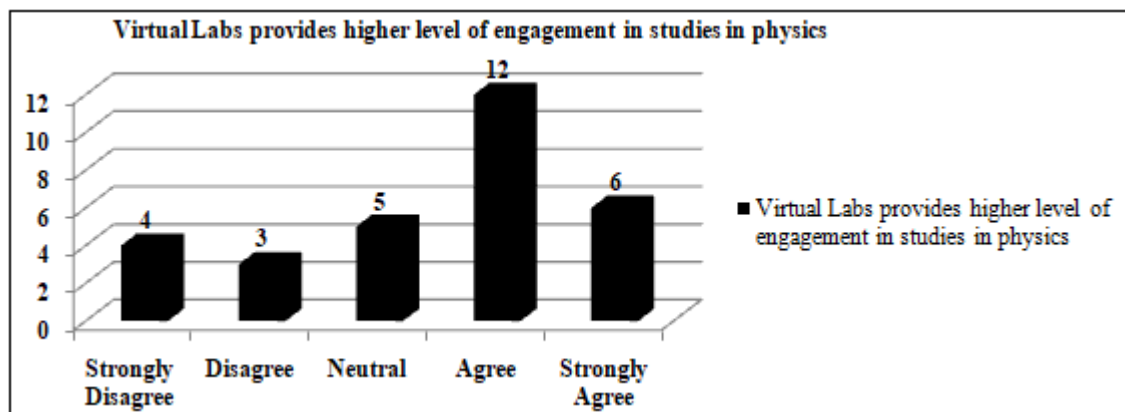


Figure 7.2: Virtual Labs provides higher level of engagement in studies in physics- Graphical representation

- **Virtual Labs helps remember the concepts in physics better**

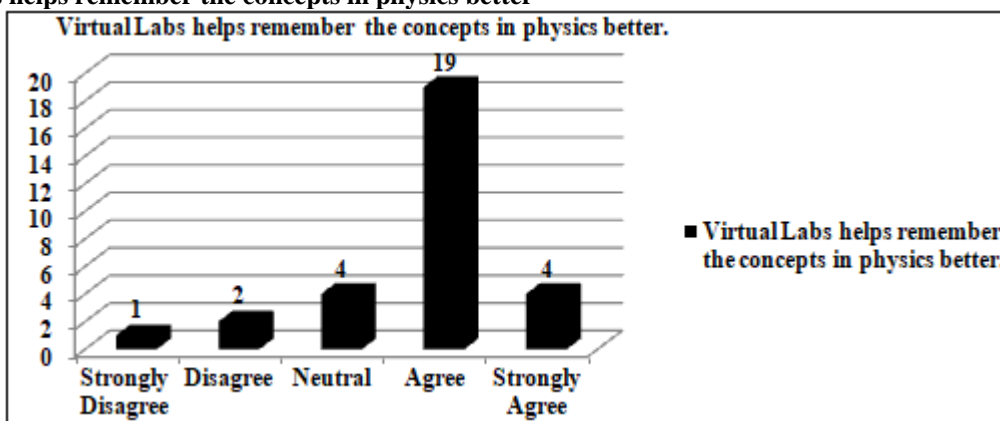


Figure 7.3: Virtual Labs helps remember the concepts in physics better- Graphical representation

- **I believe that it is easy to get Virtual Labs to do what I want it to do using my smart phone**

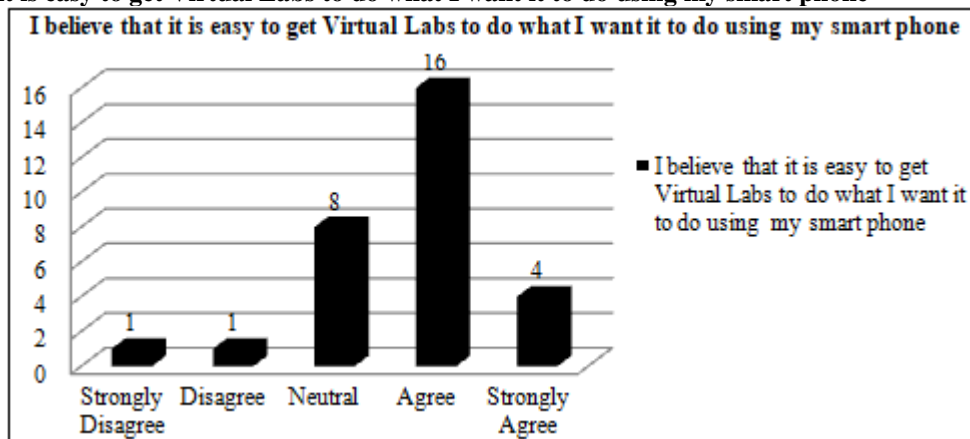


Figure 7.4: I believe that it is easy to get Virtual Labs to do what I want it to do using my smart phone- Graphical representation

- Overall, I would find using Virtual Labs to be advantageous in my learning

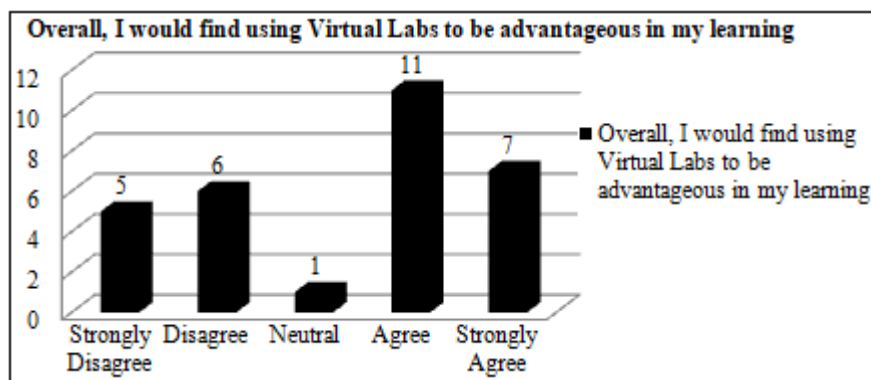


Figure 7.5: Overall, I would find using Virtual Labs to be advantageous in my learning- Graphical representation

7.4 Data Analysis –52 Physics Faculties

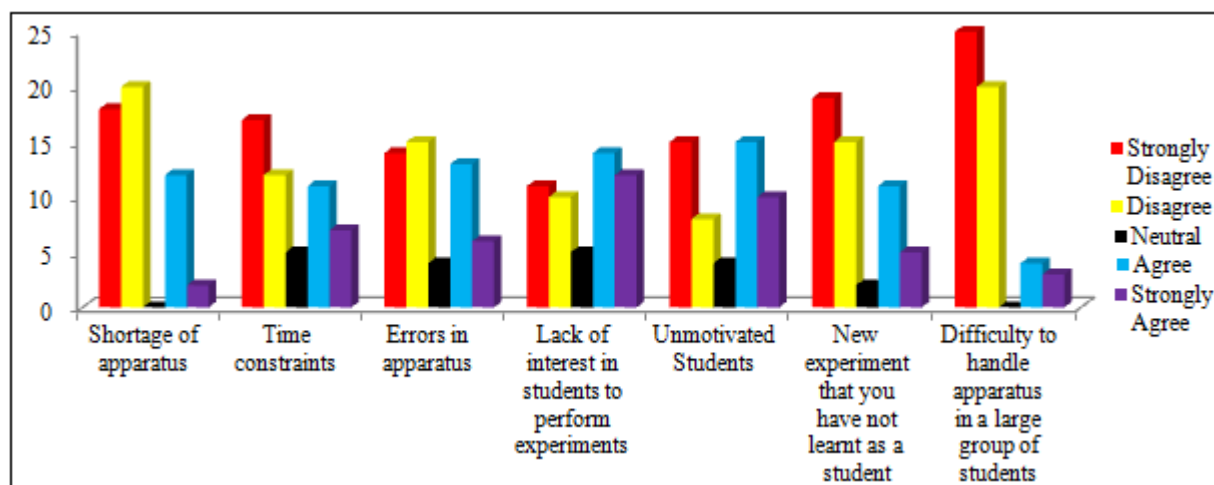


Figure 7.6: Views of 52 physics faculty members- Graphical representation

The following observations were recorded:

- About 12% Teachers agreed but 63% strongly disagreed about the shortage of apparatus
- About 27% agreed but 33% strongly disagreed about the time constraints
- About 35% agreed but 21% strongly disagreed about the lack of interest in students.
- About 23% of Teachers agreed about the New Experiments that they had not done earlier

7.5 Experience of Physics Faculty Using virtual labs in Physics.

- About 54% Physics teachers agree and 46% strongly agree that Using Virtual Labs will improve the quality of understanding Physics/Science.
- About 62% Physics teachers agree and about 31% strongly agree that virtual Labs will make it easier to do experiments.
- About 56% Physics teachers agree and about 27% strongly agree that Virtual Labs provides higher level of engagement in studies. About 27%
- About 48% Physics teachers agree and about 29% strongly agree that Virtual Labs helps remember the concepts better.

- About 60% Physics teachers agree and about 35% strongly agree that Overall, I would find using Virtual Labs to be advantageous in my teaching
- About 71% Physics teachers agree and about 19% strongly agree that My interaction with Virtual Labs is clear and understandable.
- About 52% Physics teachers disagree and about 15% agree that Using Virtual Labs will require a lot of training.
- About 69% Physics teachers agree and about 23% strongly agree that Overall, I believe that Virtual Labs will be easy for me.
- About 69% Physics teachers agree and about 27% strongly agree that I want to try out various experiments under the Virtual Labs.
- About 58% Physics teachers agree and about 31% strongly agree that i strongly encourage the use of virtual lab

Response of 52 Post Graduate Faculties in Physics

Virtual Labs will make it easier to do experiments

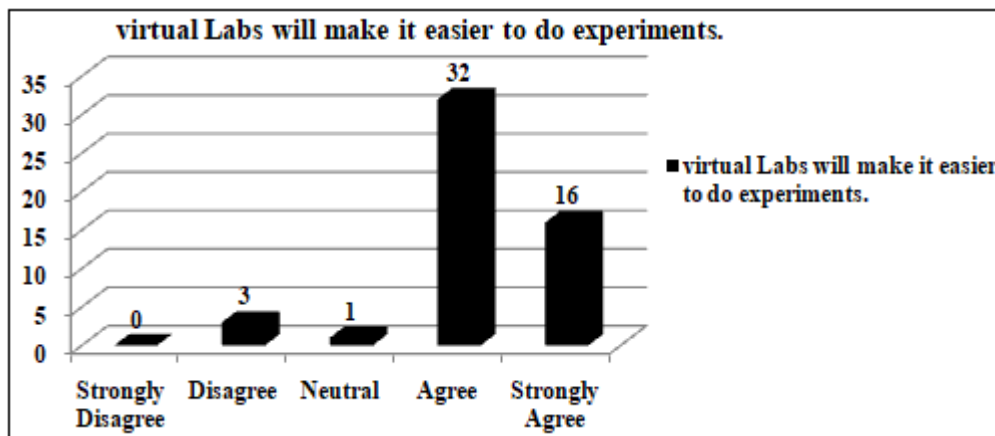


Figure 7.7: Virtual Labs will make it easier to do experiments. -Graphical representation

Virtual Labs helps remember the concepts better

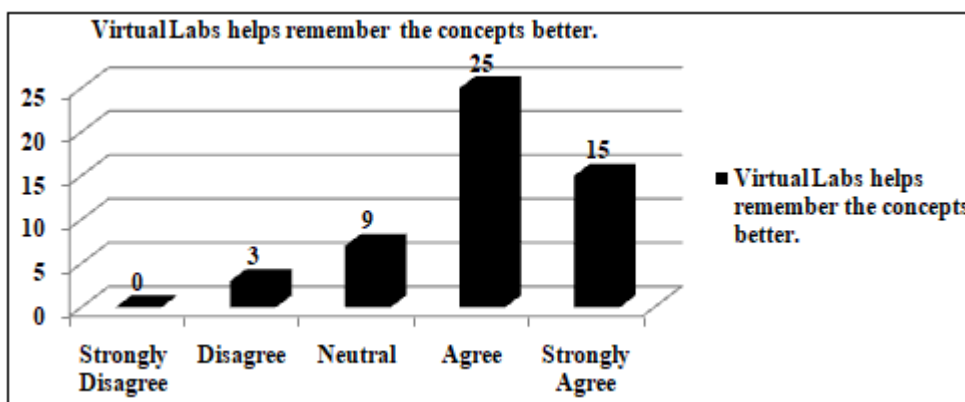


Figure 7.8: Virtual Labs helps remember the concepts better. -Graphical representation

Overall, I would find using Virtual Labs to be advantageous in my teaching

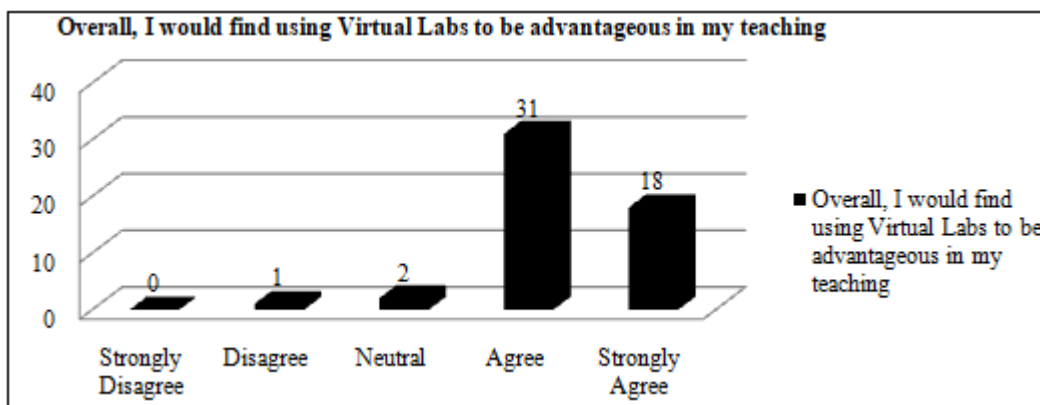


Figure 7.9: Overall, I would find using Virtual Labs to be advantageous in my teaching- Graphical representation

I want to try out various experiments under the Virtual Labs.

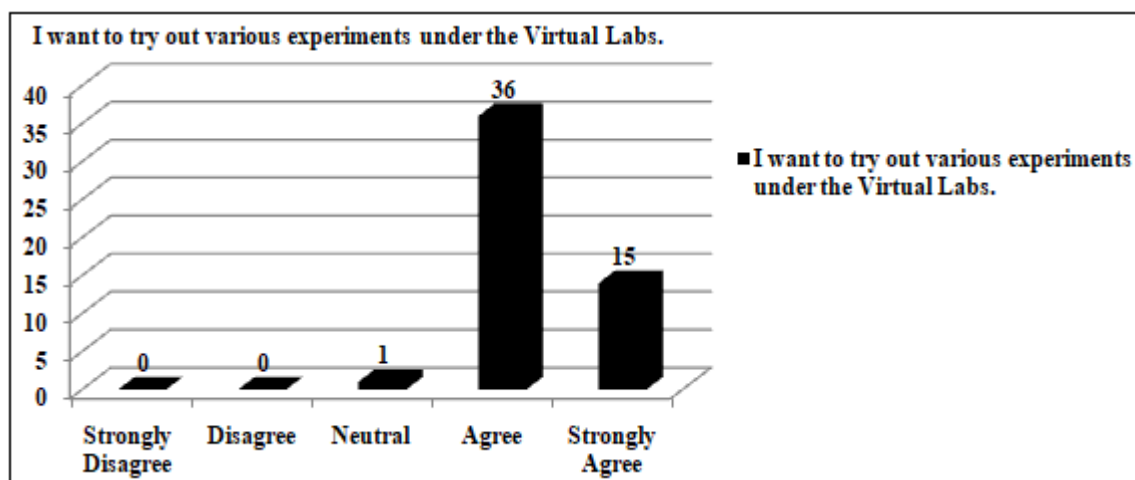


Figure 7.10: I want to try out various experiments under the Virtual Labs. -Graphical representation

5. Data Analysis and Discussion

According to the analysis of data acquired from students and the faculty at the end of the research

Except the differences in challenges faced in real /conventional labs by students and the faculty members as well which could be due to the differences in their perception and understanding level otherwise on the whole it was found that

- Virtual labs appear to be more effective than conventional labs in motivating the students.
- The students who did experiments in virtual labs were found to have advantage in learning and answering questions in viva-voce
- The students who had performed the experiments on conventional lab did not enjoy answering questions in viva-voce.

6. Conclusion

The following conclusions are drawn from the study carried out on students as well as on the recommendations of faculty members:

- 1) Virtual labs indicated that they act as supplementary education platforms in understanding concepts of Physics experiments.
- 2) The virtual lab /smart phone, can minimize the need of Equipments and thus cost by providing virtual access to equipment and the relevant material
- 3) The Virtual Lab/ Smartphone can act as boon to those schools/educational institutions where there is shortage of Equipments and are located in remote areas.
- 4) Virtual lab enhances the motivation and self-learning attitudes of school students.
- 5) It can also provide a new perspective to students which they never would have thought of. e.g. Simple Pendulum etc experiments students can do not only on earth but also on other planets using virtual lab.

7. Future Scope

- This study, indicative of encouraged usage of Smart Phones for Virtual Labs in Physics in Kendriya

Vidyalayas /CBSE schools could be extended to other schools /Boards

- Also broadening the present investigation for the best possible usage of real and virtual labs: Where there is a shortage of Equipments or Apparatus has developed faults

8. Acknowledgement

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