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## THE STUDY OF METHODS AND CHALLENGES FACED BY SCIENCE TEACHERS WHILE CONDUCTING PRACTICAL (LAB) ONLINE IN MUMBAI REGION DUE TO COVID 19

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**Abstract:** The aim of the study is to analyse the methods and challenges of online laboratory practicum teaching by science teachers in Mumbai region, based on experiences of the COVID-19 emergency. For this a survey method was undertaken and the data of two aspects was analysed. First the analysis of methods used to conduct science practical was analysed and secondly the challenges faced by the teachers during online conduct of science practical were analysed. The results of methods revealed that most teachers were not equipped with the knowledge, skill and technology to conduct experiments by simulations. Some used online labs. Majority of teachers showed live demonstrations of experiments and videos of experiments from You tube, while some showed recorded experiments. The challenges faced were mainly due to lack of face to face interaction, stable internet streaming by students, inability to create a laboratory atmosphere online and difficulty in assessing learning outcomes.

**Aim/purpose** The aim of the study is to analyse the methods and challenges of online laboratory practicum teaching by science teachers in Mumbai region, based on experiences of the COVID-19 emergency.

- Background** To day the world is facing the highest risk on health due to the outbreak of Covid 19 which started around March 2020 and continuing till now. This resulted in the closure of over 90% of schools, colleges, universities all over the world and resulted in the sudden transition of online mode of teaching from the traditional class room teaching. The ongoing pandemic has given an opportunity to re-think the deep rooted class room mode to online of learning of all the subjects including the ones which require physical laboratories.
- Methodology** For this, a survey method was undertaken and the data pertaining to the methods used to conduct of practicum in the science subjects during normal time (before the outbreak of the pandemic) and the methods used to conduct practicum during the lockdown due to covid-19, the challenges faced by the teachers in the process, the perception of the teachers about online labs with respect to its effectiveness compared to physical lab, opinion regarding whether it can be used for understanding of the students in addition to the physical lab, whether they would recommend online platform to their institution in future was collected through google form from the teachers teaching in schools colleges in Mumbai region. The data was analysed using SPSS.
- Contribution** The study results are expected to contribute to considering the technology enhanced methods like on line lab, virtual lab, simulation to supplement the physical lab and to create interest, self-learning, experimenting, exiting experiences for the learners by accessing various resources available crossing the geographical boundaries.
- Findings** The results of methods revealed that most teachers were not equipped with the knowledge, skill and technology to conduct experiments by simulations. Some used online labs. Majority of teachers showed live demonstrations of experiments and videos of experiments from You tube, while some showed recorded experiments. The challenges faced were mainly due to lack of face to face interaction, instability in internet connection, inability to create a laboratory atmosphere online and difficulty in assessing learning outcomes. Even though the teachers feel online laboratories cannot be considered as effectively as the physical ones they are positive about considering the option for better understanding and practice beyond the campus.

**Recommendation:** To provide Systematic training for teachers in the technology enhanced methods like online labs, virtual labs, simulation. Steps need to be taken by government to minimize the challenges faced due to unreliable internet connection. Efforts to be taken by policy makers, institutions and educational technology providers to come together to make the technologies available at an affordable cost to all the students so as to create 21st century requirement of STEM skilled work

**Further Research** The current study has focussed only on teachers. A separate study is required to be undertaken for the students to know their perspectives, experiences, challenges and learning outcomes.

**Keywords:** online labs, virtual labs, simulation, STEM

## Introduction

World Health Organization (WHO) declared Covid 19 as pandemic on 11 th March 2020. Covid 19 has affected more than 4.5 billion people all over the world. In India the first case of Covid 19 was detected on 30<sup>th</sup> January 2020 in the state of Kerala who had the travel history from Wuhan, China. To contain the spread of Virus the first phase of Lockdown was announced by the Prime Minister on 25<sup>th</sup> of March 2020 followed by extension of Lockdowns up to 5. Up to 30<sup>th</sup> June 2020. Thus the pandemic covid 19 has impacted all the sectors including the Education Sector. According to the report of All India Survey on Higher education (AISHE 2019-20) India has 1043 Universities, 42343 Colleges, 11779 standalone institutions which contribute to the higher education. 420 universities are located in rural area, 60.56% of colleges are located in rural area. As reported by UNESCO, while Covid 19 has affected almost 68% of total world's population, the student population affected was 1.2 billion across the Globe due to the closure of educational Institutions. In India more the 32 crores of students have been affected by nationwide lockdown (Wikipedia) Governments around the world are making efforts to decrease or minimize the impact of closure of educational institutions particularly the disadvantaged lot by providing various digital modes of learning. However, technology has emerged as a lifesaver in the face of a crippling pandemic. What started as a unique experience of no physically going to school, college, University, no classes, no Exam and study sitting at home, is now making the students frustrated and what seemed to be a stop gap arrangement due to pandemic is continuing even now with uncertainty of time limit for it ending. Alternatively, the government and educational institutions have done a fantastic job of "keeping things going." Covid-induced online education, it is widely agreed, arose out of need and, at best, serves as a stop gap measure. Thrown into this mess, science teachers were challenged with a daunting task of conducting practical and experimentation online. They had to reconsider the deeply ingrained laboratory form of practical and create a 'laboratory environment' online. This research investigates the various forms science teachers resorted to the conduct of practical online. Further the challenges faced by these teachers were also investigated.

## Literature Review

Teaching practices were completely thrown off gear due to the overnight shift from face to face classroom teaching to online teaching practice with the outbreak of the pandemic. The virtual model of education posed largely a new experience with a new set of challenges for the school and college teachers' teaching norms, their professional role, the teaching strategies and likewise. Experimenting with an array of methods on different online learning platforms was the norm of the day.

Noor S. et al (2020) in their study of challenges faced due to online teaching practices in Pakistan, highlighted the issues and challenges confronted by school teachers in delivering online lessons via Google Classroom, Zoom, and Microsoft Teams such as high-cost Internet packages, uncooperative learners, low attendance of learners, teachers' technology confidence, limited availability of educational resources, lack of ICT knowledge, and poor network infrastructure. Moreover, science teachers were faced with a daunting task to structure the teaching- learning process inclusive of practical which are integrated in the curriculum. A.S. Sidhiq et al (2020) in their investigation on the response of chemistry teachers from West Java to online learning in the COVID-19 pandemic, found that chemistry teachers though tried to utilize various technology platforms in conducting learning, most of them faced difficulty to arrange the lab-work activities and did nothing. Some teachers resorting to lab-work multimedia instead of real activities. The efforts and difficulties experienced by science teachers during online learning were also reflected in a study conducted in Indonesia during the Covid-19 pandemic Wisanti R. et al (2020). The results showed that the majority of science teachers faced difficulty with difficulties identified in three main factors namely technology, students, and teachers. Though internet access was a technological factor that caused the greatest difficulty, teachers made an effort to carry out online learning optimally by presenting the material and providing slide presentation and discussions. With the challenges thrown at them teachers no doubt started equipping themselves with the technological skills (ICT) required to align with this new system. Science teachers were strongly encouraged to use of LMS (Learning Management System) filled with learning activities such as discussions, presentation materials, and evaluation R D Hardianti\*(2020). In yet another study by Karen L. et al (2020), where ecology lecturers had not only to rush lectures and tutorials online but also laboratory and field classes, it was found that most of the field and laboratory classes had to be cancelled. 17% (5 individuals) cancelled them outright, 13% (4 people) shifted to tutorial-style sessions, 13% recorded themselves undertaking the laboratory for students, 13% provided video links of the techniques to students, 7% (two people) provided "do it at home" options for students, and 7% live-streamed themselves undertaking the laboratory so students could join the session online. That challenges could be classified into technological, pedagogical and social was reflected in the study by Fernanda F. et al (2020). They listed technological challenges as mainly relating to the unreliability of Internet connections and many students' lack of necessary electronic devices. The pedagogical challenges were principally associated with teachers' and learners' lack of digital skills, the lack of structured content versus the abundance of online resources, learners' lack of interactivity and motivation and teachers' lack of social and cognitive presence (the ability to construct meaning through sustained communication within a community of inquiry). The social challenges were mainly related to the lack of human interaction between teachers and students as well as among the latter, the lack of physical spaces at

home to receive lessons and the lack of support of parents who were frequently working remotely in the same spaces.

Laboratories are an important part of the study of physics and other natural science disciplines. It aids students in grasping topics and developing hands-on skills as well as illustrating theory (Johnstone & Al-Shuaili, 2001). The practical laboratory sessions, according to (Bretz et al., 2013), boost students' curiosity and good attitudes toward science. Simulations, animation, films, and visualisations, for example, are particularly promising when used in conjunction with real-world activity, according to evidence in the literature (Hofstein & Kind, 2012). Combining a virtual lab with a real practical lab is one way to use Information and Communication Technology (ICT) in learning physics lab (Darrah et al., 2014). Online Labs (OLabs) pedagogy is designed as a complete learning environment with tutorials, theory, procedure, animations, videos and simulations while the assessment includes conceptual, experimental, procedural and reporting skills. Research shows the traditional lab students showed better performance in reporting and experimental skills on the other hand students using online labs revealed improved conceptual skills. (Campos, N *et al.* 2020)

A virtual lab is a computer based activity giving interactive learning experience to students using animations, simulations and to observe, manipulate system generated objects and data giving the experience of a traditional lab. As reported by the research on survey of virtual labs observes that virtual labs are innovative solution to enhance lab practice for distant learners (Soni .S et al 2014)

### **Objectives of the study**

The purpose of this study was to explore the challenges faced by Science while teaching science practical in online mode. The study attempts to answer following research questions:

1. What are the Methods used by science Teachers to conduct practical (laboratory) sessions during off line Lectures (on campus) before Covid 19 ?
2. What are the methods used by Science teachers to conduct Science practical (Laboratory) during online lectures during lockdown due to Covid 19?
3. What are the challenges faced while conducting Science practical (Laboratory) during online lectures during lockdown due to Covid 19?
4. What is the opinion of the teachers about considering online labs beyond campus?

### **Scope of the study**

The research focuses on studying the responses of science teachers in schools and colleges in Mumbai. The responses in this study are from teachers teaching Physics, Chemistry, Botany and Zoology teaching at various levels such as High School, Junior College, Diploma Courses and Degree College with varied number of years of experience.

## Methodology

This is a survey research focused on finding the methods used by science teachers to conduct lab practical before the outbreak of Covid 19 and during the Lockdown due to Covid 19 in online mode and the challenges faced by them in Mumbai Region with the intention to arrive at a feasible suggestion or methods to overcome the difficulties and reach the desired learning outcome.

A Google form was created with Section 1 giving the background of the study, Section 2 containing demographic information including the subjects taught, number of years of teaching experience, the methods used to tech science lab session before Covid 19, Section 3 listing out various methods that could be used to help with teaching science practical on line, Section 4 consisting of the challenges faced by them based on the literature available.

## Research Statements:

The study was based on the following Statements:

1. Methods used by science Teachers to conduct practical (laboratory) sessions during off- line Lectures (on campus)
2. Methods used to conduct Science practical (Laboratory) during online lectures during lockdown due to Covid 19
3. Challenges faced while conducting Science practical (Laboratory) during online lectures?
4. Opinion of the teachers about considering online labs beyond campus?

## Research Hypothesis:

1. To test the teachers' perception about whether online labs can be used with the same effectiveness as physical lab.
2. To test impact of online labs for understanding of students as perceived by the teachers in addition to the physical lab.

## Data Collection:

A Google form was created with Section 1 giving the background of the study, Section 2 containing demographic information including the subjects taught, number of years of teaching experience, the methods used to tech science lab session before Covid 19, Section 3 listing out various methods that could be used to help with teaching science practical on line, Section 4 consisting of the challenges faced by them based on the literature available. The link of the Google form was sent to the teachers teaching Science subjects in High School, Junior College, Diploma Courses and Degree College in Mumbai.

**Data Analysis:**

Data was analysed using SPSS and Z test was used to test the hypothesis.

A total of 76 teachers teaching Physics, Botany, Chemistry and Zoology responded to the questionnaire. The following data is available for Section 2.

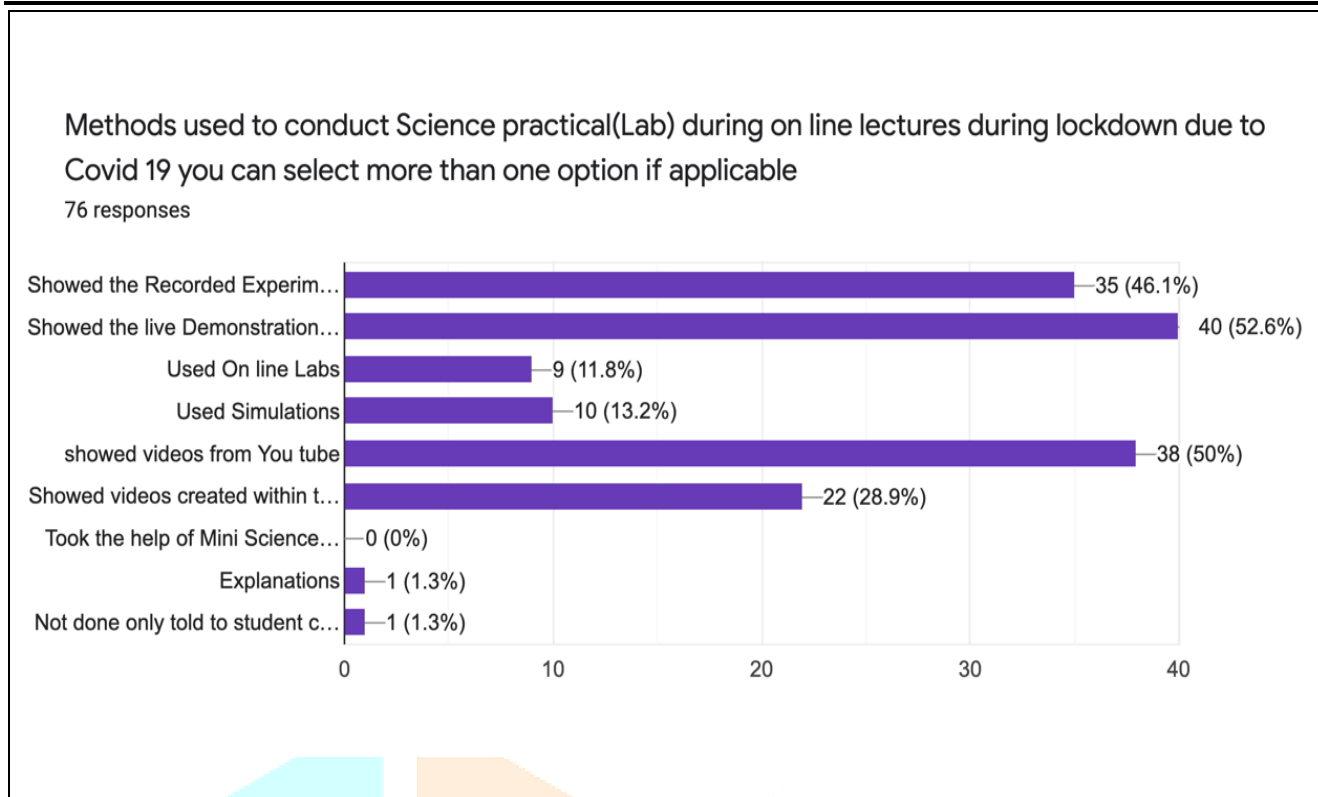
Gender	Male	30.7%
	Female	69.3%
Subjects Taught	Physics	52%
	Chemistry	29.3%
	Botany	22.7%
	Zoology	18.7%
		( a few of them have taught multiple subjects)
Age in completed years	Upto 30 years	7%
	31-40	34%
	41-50	29%
	>50 years	30%
Teaching Experience in completed years	<5 years	2.6%
	5-10	23.7%
	11-15	18.4%
	>15 years	55.3%
Level at which Taught	High school	5.3%
	Junior College (11 <sup>th</sup> , 12 <sup>th</sup> grade)	72%
	Diploma	5.3%
	Degree College	17.3%

**1. What are the Methods used by science Teachers to conduct practical (laboratory) sessions during off line Lectures (on campus)?**

All the teachers used to conduct Practical (Lab) in the Physical lab before Covid 19 outbreak. A few of them have also used online and virtual labs in addition to the physical lab.

**2. What are methods are used to conduct Science practical(Laboratory) during online lectures during lockdown due to Covid 19?**

Teachers used various methods such as showing recorded experiments, showing live demonstrations, using on line labs , simulations ,showing videos from You tubes and also created with in the institutions. the details are shown in the following graph.



**Figure 2.1. Methods used to conduct online Science lab practical during Covid 19.**

### *Discussion*

Figure 2.1 shows that the only 13.2% of teachers were equipped with the knowledge, skill and technology to conduct experiments by simulations while 11.8%(09) used online labs. Majority of teachers (52.6%) showed live demonstrations of experiments while 50% (38) showed videos of experiments from You tube and 46.1% (35) showed recorded experiments, 28.9% of the teachers have shown videos created within the institutes.

This reflected clearly that the mode of teaching was mostly the use of multi-media and the learning process therefore was focused only on the teacher without getting students engaged in the actual conduct of the experiments. Therefore, one could say that in this scenario the role of the teacher was that of a performer rather than a teacher/facilitator.



3. What are the challenges faced while conducting Science practical(Laboratory) during online lectures during lockdown due to Covid 19?

No reliable Internet

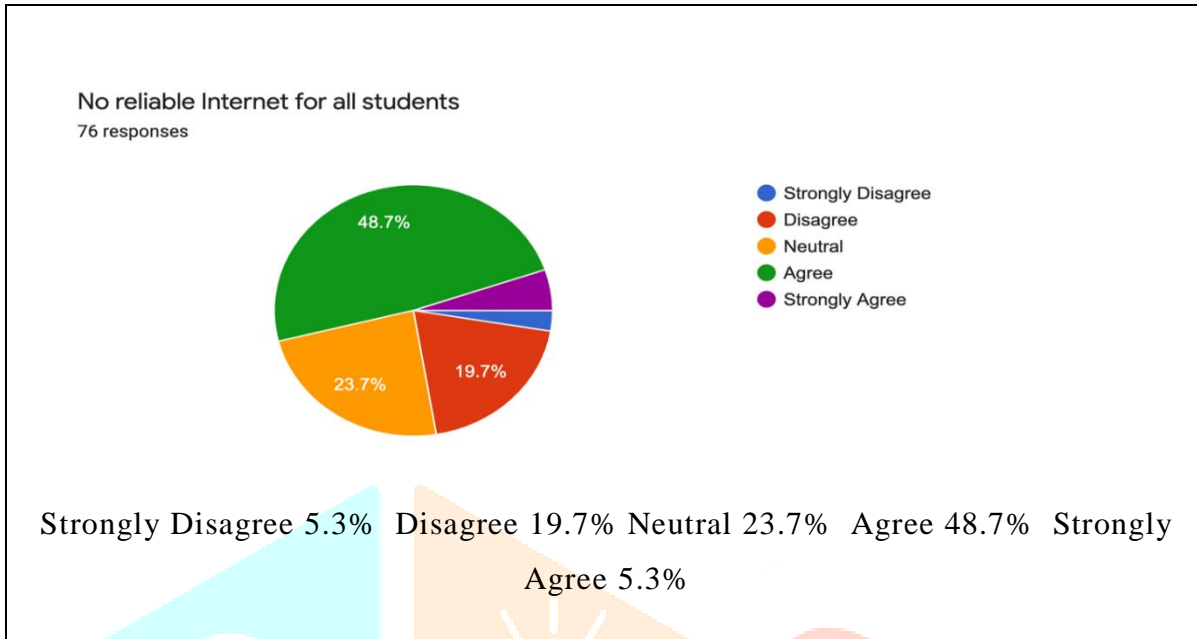


Figure 3.1 No reliable internet

It was difficult to create Laboratory atmosphere

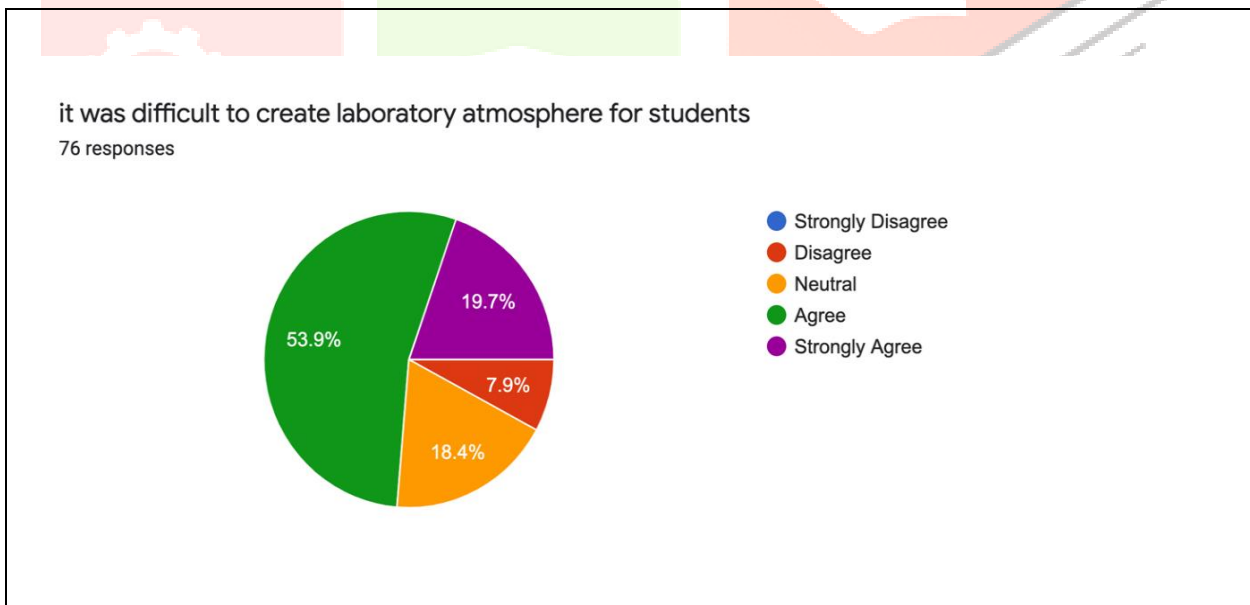
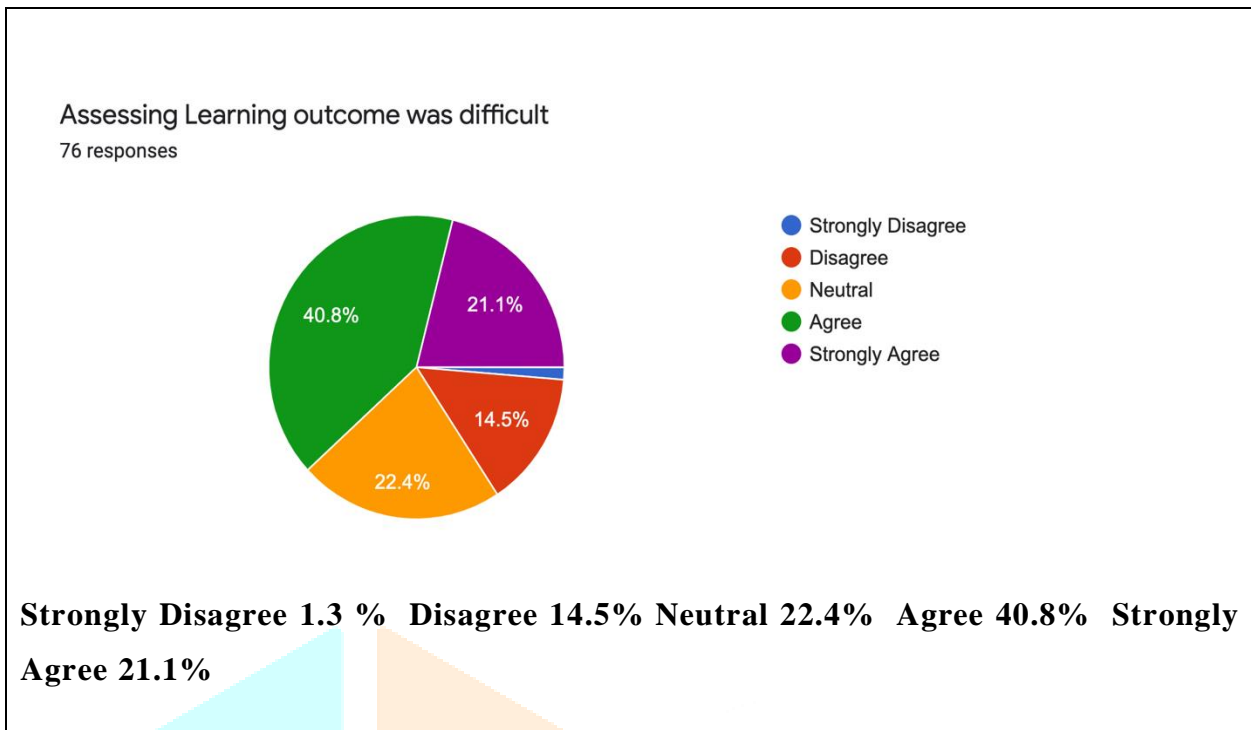


Figure 3.2 Difficulty to create laboratory atmosphere

**Assessing Learning outcome was difficult**



**Figure 3.3 Difficulty in assessing learning outcomes**

The results are summarised as below: **Table 1**

Challenges Faced	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<b>3.1 No reliable Internet</b>	<b>2.60%</b>	<b>19.70%</b>	<b>23.70%</b>	<b>48.70%</b>	<b>5.30%</b>
<b>3.2 It was difficult to create Lab atmosphere for students</b>	<b>0.00%</b>	<b>7.90%</b>	<b>18.40%</b>	<b>53.90%</b>	<b>19.70%</b>
<b>3.3 Assessing Learning outcomes was difficult</b>	<b>1.30%</b>	<b>14.50%</b>	<b>22.40%</b>	<b>40.80%</b>	<b>21.10%</b>

**Discussion.**

Figures 3.1, 3.2 and 3.3 reflect the three major challenges faced by the teachers. Though the teachers took it in their stride by using the most feasible method as seen in Figure 1, the teaching - learning was hampered greatly due to lack of collaborative efforts from the students. Assessment of learning outcomes was tricky as teachers had no way to gauge the actual hands on learning taken place specially in case of practical

#### 4 Opinion of Teachers about online lab

##### Effectiveness of online Lab

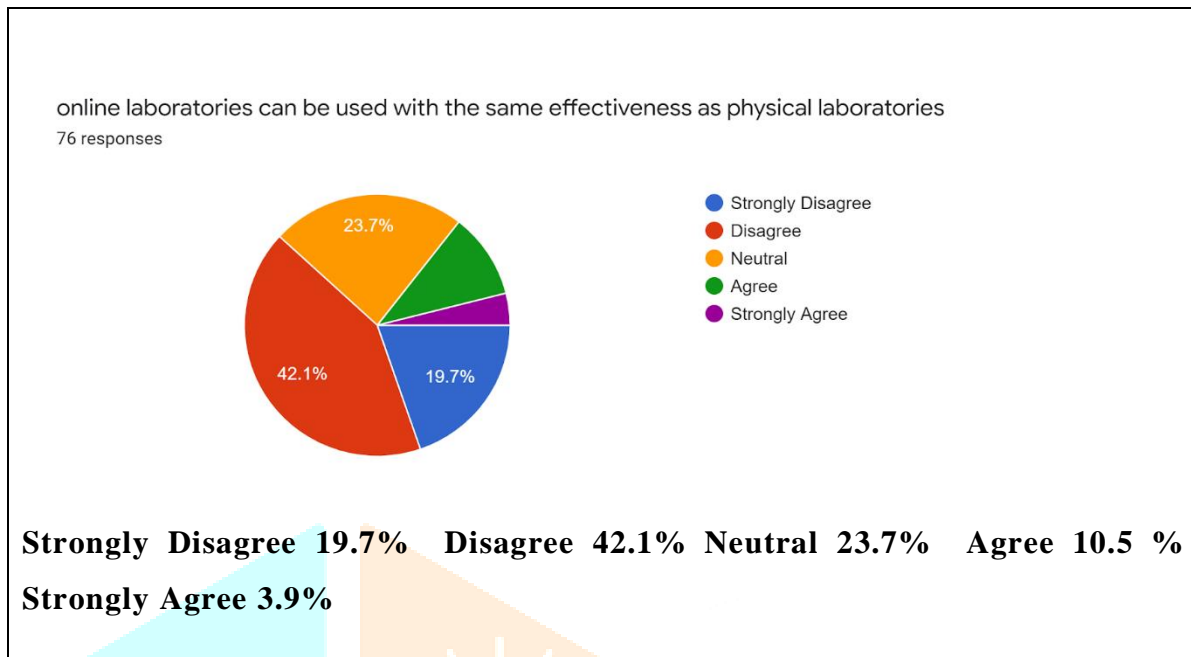


Figure 4.1 Effectiveness of online Labs

##### Recommend online labs to my institution in addition to physical lab

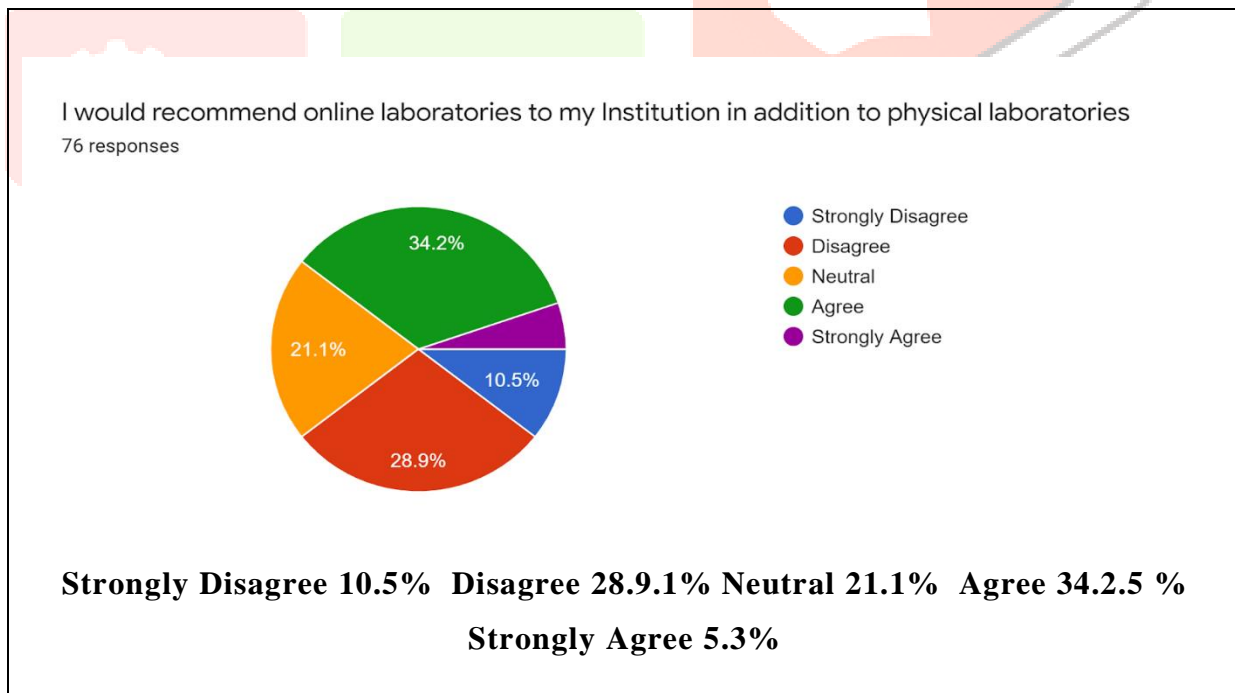
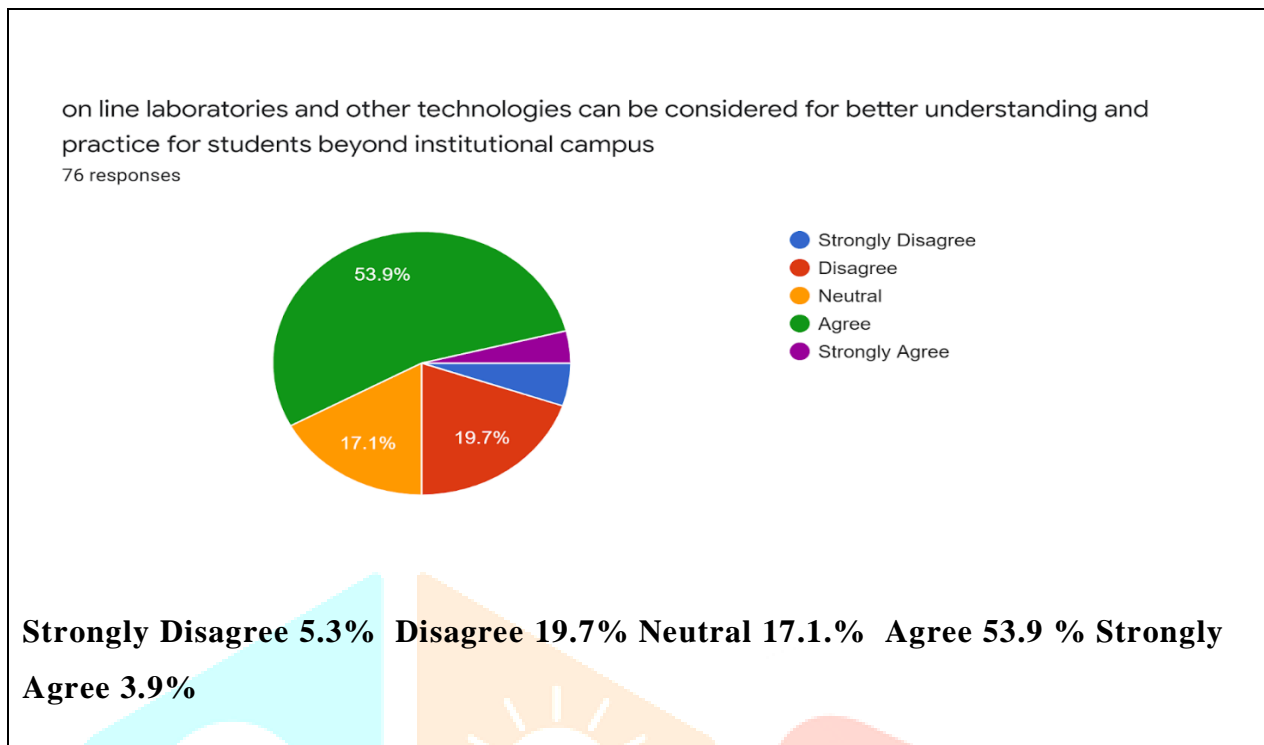


Figure 4.2 Recommend online labs to my institution in addition to physical lab

### Online labs and other technologies can be considered for better understanding and practice beyond institutional campus



**Figure 4.3 online labs can be considered for better understanding**

To summarise

**Table 2**

Opinion about online labs	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
<b>4.3 online labs can be used with the same effectiveness as physical lab</b>	<b>19.70%</b>	<b>42.10%</b>	<b>23.70%</b>	<b>10.50%</b>	<b>3.90%</b>
<b>4.4 I would like to recommend on line laboratories in addition to the physical laboratories</b>	<b>10.50%</b>	<b>28.90%</b>	<b>21.10%</b>	<b>34.20%</b>	<b>5.30%</b>
<b>4.5 online laboratories can be considered better understanding and practice for students beyond institutional campus</b>	<b>5.30%</b>	<b>19.70%</b>	<b>17.10%</b>	<b>53.90%</b>	<b>3.90%</b>

Table 3

<b>Online labs can be used with the same effectiveness as physical lab</b>	<b>Strongly Agree &amp; Agree</b>	<b>Strongly Disagree &amp; Disagree</b>
	<b>14.4%</b>	<b>61.8%</b>

**Null Hypothesis:** Ho There is no significant difference in the effectiveness of physical lab and online mode of delivery of lab sessions.

**Alternate Hypothesis:** H1 There is significant difference in the effectiveness of physical lab and online mode of delivery of lab sessions.

**Data Analysis:** Researcher tested the hypothesis using testing of proportion. As per the primary Statistics

$$Z \text{ test for single proportion is given by } Z = \frac{p - P}{\sqrt{\frac{P(1-P)}{n}}}$$

The sample proportion  $p=0.144$  and the population proportion  $P=0.5$ , sample size  $n=76$  substituting the values we get calculated Z value = 6.24

Critical value of Z at 5% level of significance is 1.96 since the calculated z value is more than the critical value hence we reject the null hypothesis.

There is a significant difference between the perceived delivery of science subjects ie online physical lab versus the traditional lab.

Table 4

<b>online laboratories can be considered better understanding and practice for students beyond institutional campus</b>	<b>Strongly Agree &amp; Agree</b>	<b>Strongly Disagree &amp; Disagree</b>
	<b>57.8%</b>	<b>25%</b>

**Null Hypothesis:** H0: There is no significant impact of online labs for understanding of students as perceived by the teachers in addition to physical lab.

**Alternate Hypothesis:** H1 There is significant impact of online labs for understanding of students as perceived by the teachers in addition to physical lab.

**Data Analysis:** Researcher tested the hypothesis using testing of proportion. As per the primary Statistics

$$Z \text{ test for single proportion is given by } Z = \frac{p - P}{\sqrt{\frac{P(1-P)}{n}}}$$

Sample Proportion  $p = 0.578$  and Population Proportion  $= 0.5$  and sample size  $= 76$

$$Z = \frac{0.578 - 0.5}{\sqrt{\frac{0.5(1-0.5)}{76}}} = \frac{0.078}{\sqrt{0.003}} = 1.44$$

Thus Calculated  $Z = 1.44$  and critical  $Z$  at 5% Level of significance is  $1.96$

We accept  $H_0$  since Calculated  $Z$  is less than Critical  $Z$

There is no significant impact of online labs for understanding of students as perceived by the teachers in addition to physical lab.

**Discussion:** From the above results it is clear that as per the teachers' opinion or as perceived by the teachers there is significant difference between the perceived delivery of Science practicum in online mode and physical lab. However, there is no significant impact of online labs for understanding of the students as perceived by the teachers in addition to the physical lab. The above conclusion is based on only the perception of the teachers as can be seen from the data collected many of them have not got the experience of using online or virtual labs only 11.8% of the teachers have got experience of using online or virtual labs. When we look at the teachers opinion about recommending online lab to their Institution in addition to the physical lab 39.5% percentage of teachers fall under (agree and strongly agree), 39.4% of teachers fall under (Disagree and Strongly Disagree)

**Conclusion:** The results indicate that before the outbreak of covid19 Science practical was conducted in the traditional lab and after the sudden shift in the online mode of teaching due to closure of educational institutions to contain the virus, majority of the teachers used various methods of multimedia such as showing live demonstrations, recorded videos of the experiments, videos created within the institutions. As per their response on descriptive question very less percentage (11.8%) of the teachers used online labs created by Amrita University which is available for the educational institutions. A few of them have also used the resources created by IITs (Indian Institute of Technology) Though the teachers of all age group switched over to online mode and got digitally equipped as the situation warranted, they did have challenges in terms of internet issues, not able to create lab atmosphere and direct way of measuring learning outcome. Despite the teachers have a positive opinion about online lab for better understanding and practice for the students beyond class room.

The current study focussed only on teachers. A separate study focussing the students' perspective needs to be undertaken. Since the uncertainty about the time of ending of the pandemic is prevailing, the current challenges can be converted in to opportunities by considering the following steps:

- i) Systematic training for teachers to use various technological enhanced methods like online lab, Virtual lab, simulation for effective teaching and learning.

- ii) Government can take necessary steps to minimize digital divide and to provide reliable network infrastructure. Policy makers, Educational Institutions and Educational Technology providers can come together by making all the technologies available for the institutions at an affordable cost so that teachers and students can be benefitted and our country can have the required 21<sup>st</sup> Century STEM (Science, Technology, Engineering and Mathematics) skilled work force

### References

1. Al Abiky, W.,B. (2021). Lessons learned for teacher education: Challenges of teaching online classes during COVID-19, what can pre-service teachers tell us? *Revista Argentina De Clínica Psicológica*, 30(2), 110. doi:<http://ezproxy.svkm.ac.in:2160/10.24205/03276716.2020.411>
2. Bacon, K. L., & Peacock, J. (2021). Sudden challenges in teaching ecology and aligned disciplines during a global pandemic: Reflections on the rapid move online and perspectives on moving forward. *Ecology and Evolution*, 11(8), 3551-3558. doi:<http://ezproxy.svkm.ac.in:2160/10.1002/ece3.7090>
3. Bretz S., Fay M., Bruck L. B., & Towns M. H., (2013). What faculty interviews reveal about meaningful learning in the undergraduate laboratory. *Journal of Chemical Education*, 90(3), 5–7. <https://doi.org/10.1021/ed300384r>
4. Campos, N., Nogal, M., Caliz, C. *et al.* Simulation-based education involving online and on-campus models in different European universities. *Int J Educ Technol High Educ* 17, 8 (2020). <https://doi.org/10.1186/s41239-020-0181-y>
5. Darrah, M., Humbert, R., Finstein, J., Simon, M., & Hopkins, J. (2014). Are virtual labs as effective as hands-on labs for undergraduate physics? A comparative study at two major universities. *Journal of Science Education and Technology*, 23(6), 803-813. <https://doi.org/10.1007/s10956-014-9513-9>
6. <https://doi.org/10.1007/s10956-014-9513-9>
7. Fernando F. Patrizia Grifoni and Tiziana Guzzo (2020) Online learning and emergency remote teaching: Opportunities and challenges in emergency situations. *Societies*, 10(4),86.doi:<http://ezproxy.svkm.ac.in:2160/10.3390/soc10040086>
8. Hardianti, R. D., Wusqo, I. U., Savitri, E. N., Pamelasari, S. D., Yanitama, A., Suanto, A., & Widyatama, A. S. (2021). LMS–supported science blended learning design workshop as an effort to improve learning quality for science teachers. *Journal of Physics: Conference Series*, 1918(5) doi:<http://ezproxy.svkm.ac.in:2160/10.1088/1742-6596/1918/5/052089>
9. Hofstein, A., & Kind, P. M. (2012). Learning in and from science laboratories. In B. Fraser, K. Tobin, & J. M.Campbell (Eds.), *Second international handbook of science education* (pp. 189-207). Springer. [https://doi.org/10.1007/978-1-4020-9041-7\\_15](https://doi.org/10.1007/978-1-4020-9041-7_15)
10. Johnstone, A., & Alshuaili, A. (2001). Learning in the laboratory: Some thoughts from the literature. *University Chemistry Education*, 5(2), 42-51

11. Noor, S., Filzah Md. Isa, & Faizan, F. M. (2020). Online teaching practices during the COVID-19 pandemic. *Educational Process: International Journal*, 9(3), 169-184. doi:<http://ezproxy.svkm.ac.in:2160/10.22521/edupij.2020.93.4>
12. Shidiq, A. S., Permanasari, A., Hernani, & Hendayana, S. (2021). Chemistry teacher responses to learning in the COVID-19 outbreak: Challenges and opportunities to create innovative lab-work activities. *Journal of Physics: Conference Series*, 1806(1) doi:<http://ezproxy.svkm.ac.in:2160/10.1088/1742-6596/1806/1/012195>
13. Soni, S., Katkar, M.D.: Survey paper on virtual lab for E-learners. *International J. Appl. Innov. Eng. Manag. (IJAIEM)* 3(1) (2014)[Google Scholar](#)
14. Usman, M., Suyanta, & Huda, K. (2021). Virtual lab as distance learning media to enhance student's science process skill during the COVID-19 pandemic. *Journal of Physics: Conference Series*, 1882(1) doi:<http://ezproxy.svkm.ac.in:2160/10.1088/1742-6596/1882/1/012126>
15. Wisanti, Ambawati, R., Putri, E. K., Rahayu, D. A., & Khaleyla, F. (2021). Science online learning during the covid-19 pandemic: Difficulties and challenges. *Journal of Physics: Conference Series*, 1747(1) doi:<http://ezproxy.svkm.ac.in:2160/10.1088/1742-6596/1747/1/012007>

