ONLINE RESOURCES FOR TEACHING CHEMISTRY EXPERIMENTS VIRTUALLY

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ABSTRACT

This review report looks at the possibilities of using the existing online resources for teaching exclusively chemistry experiments virtually. In the lockdown due to the coronavirus pandemic, access to the laboratories in the academic institutions are restricted. E-learning of theoretical courses are in line since April 2020 after lockdown. Unfortunately, students doing science, engineering and technology courses including chemical sciences are missing the learning of practical chemistry due to the restriction of access to the labs. Only very few virtual chemistry labs, web resources, simulation platforms are available freely for teaching and learning chemistry practicals. In order to create a one-point reference material for teaching chemistry experiments, freely accessible web resources are consolidated, reviewed and introduced to the readers. The web resources discussed in the article would help the teachers to teach exclusively the chemistry experiments and instruments remotely through virtual platforms. *[African Journal of Chemical Education—AJCE 12(1), January 2022]*

INTRODUCTION

It is realized worldwide that the virtual teaching is the only way for the students and teachers to continue the knowledge transfer process remotely during the lockdown period due to the COVID-19 pandemic. The teaching industry stumbled during the initial weeks of lockdown, March 2020. Although, the academic institutions and students, worldwide are not prepared for e-learning, the teaching-learning process was virtually initiated [1] during April 2020. Fortunately, the "*emergency remote teaching-learning process*" has become immediately feasible due to the adequate self-establishment of ICT facilities (*laptop, mobile phone, internet*) at individual level. With the available ICT facilities, the school teachers, university and college professors, and instructors of research institutions were able to teach to the students effectively through virtual platforms.

But online teaching has become feasible only for theoretical courses and subjects. Unfortunately, in the case of experimental courses, the teachers and instructors are unable to demonstrate the experiments due to the constraints of accessing laboratories physically during lockdown and lack of adequate virtual labs to teach practical sessions through e-learning tools.

Chemistry, in general has to be taught and learned through demonstrations, hands-on experiments, estimations, and measurements. Familiarization, learning and doing experiments are essential to enhance chemistry literacy of the students studying chemical sciences. Because, students acquire conceptual understanding on the subject while testing the materials, observing the reactions, measuring the chemical properties, utilizing laboratory instruments, glass wares, apparatus and estimating the relevant attributes. Moreover, the students would gain experience on material safety, chemical hazardous, chemical handling, risk factors and laboratory safety only while carrying out experiments in the chemistry labs.

Significance of chemistry laboratories in any chemistry course

Certainly, any chemistry course is a practical subject and hence the chemistry laboratories serve the learners to attain the overall objectives of the course. Laboratory skills of a chemistry student makes him/her placement worthy, chemistry literacy attained through experimental skills gives confidence to the student to work systematically and function independently in their future projects [2].

Purpose and need of the review

We know that conducting a laboratory experiment in a virtual environment would not be effective and won't help the teacher for complete knowledge transfer. In specific, chemistry laboratory experiments involve observations while weighing, burning, heating, dissolving, filtration, drying and also the risk factors while handling chemicals. The experience obtained through the real experimentation in laboratories could not be replaced by the virtual learning process. However, virtual labs available on the world wide web helps the teachers to give input to the students on the experimental concepts to some extent in the disrupted time like lockdown.

Different resources (websites) for learning chemistry experiments are existing in the world wide web. But the resources are scattered and identifying the relevant resource through google search would be time consuming for the teachers and students. Hence, with the objective of filling the gap in identification of suitable resource, this review systematically consolidates the online resources; websites, databases, servers that are suitable for teaching chemistry experiments virtually.

CHEMISTRY LAB CURRICULUM WORLDWIDE AND THE EXISTING ONLINE RESOURCES

The lab curriculum (syllabus, list of experiments) for chemistry practicals taught worldwide in the high school to graduate level could be generally classified as qualitative inorganic analysis, qualitative organic analysis and synthesis, quantitative analysis, titrations, physical chemistry experiments and spectroscopy. Hence, web resources that are useful for conducting chemistry experiments for free of cost (completely or partially or free for certain period of time) were identified and listed under the following four categories,

(i) General, Analytical and Inorganic Chemistry Experiments

(ii) Organic Reactions & Kinetics Experiments

(iii) Physical Chemistry Experiments

(iv) Quantum Chemistry Experiments

Hundreds of web sources are available in the worldwide web for teaching and learning theoretical chemistry concepts, however, very few web resources are useful for teaching chemistry experiments virtually through remote access and to reach the students through e-learning platforms.

Web resource which fulfils any one of the following criteria has been identified as suitable tool for teaching chemistry experiments, listed, introduced to the readers and its unique features are highlighted in Table 1.

Criteria (i): web resource that is useful for performing chemistry experiments,

Criteria (ii): web resource in which user can do simulation/animation to understand chemistry concepts and to quantify (calculate) chemical attributes.

Table 1. Descriptions of online resources for teaching chemistry experiments

Website name	URL	Description
General, Inorganic and Analytical Chemistry Experiments		
ACS virtual chemistry simulations	https://www.acs.org	Chemistry simulation portal Perform experiments
RSC practical resources	https://edu.rsc.org/resources/practical	Chemistry experiments portal Tutorials and handouts
Virtual labs	https://www.vlab.co.in	Experiments on basic chemistry Perform experiments
Olabs	http://www.olabs.edu.in/	Learning lab experiments Perform experiments
ChemCollective	http://www.chemcollective.org/	Perform experiments MCQ concept test
Virtual chemistry laboratory	https://chemistry.dortikum.net/en/home/	Self-test facilities Interactive lab exercises
Virtlab	http://www.virtlab.com/main.aspx	Perform experiments Hands-on demonstrations
Virtual chemistry experiments	https://chm.davidson.edu/vce/	Interactive tutorials Simulative animations
Organic Reactions & Kinetics Experiments		
Virtual Chemistry	http://www.chem.ox.ac.uk/vrchemistry/	Interactive periodic table Reaction mechanisms, Quiz
OrganicERs	https://www.organicers.org/	Organic synthesis and reactions Simulate reactions
ChemReaX	http://www.sciencebysimulation.com/chemreax.aspx	Reactions using 1200+ species 80 pre-defined reactions
goREACT	https://www.msichicago.org/science-at-home/games/goreact/	Design reactions Simulate reactions
ChemSims	http://chemsims.com/	Learning rate of reaction Simulations for kinetics
Physical Chemistry Experiments		
GasSim	http://www.sciencebysimulation.com/gassim.aspx	Simulating gas law Database of 76 gases
Molecular workbench	http://mw.concord.org	Molecular simulation Molecular dynamics
Quantum Chemistry Experiments		
PhET Interactive Simulations	https://phet.colorado.edu/	Simulations on quantum chemistry Language options
QuVis	https://www.st-andrews.ac.uk/physics/quvis/	Simulations for teaching quantum mechanics concepts

Skills, familiarization and transformation

The immediate temporary closure of educational institutions left the students, teachers and instructors with no time to plan, prepare and acquire required skills for teaching experiments online. In order to initiate and carryover the e-teaching, teachers should acquire skills in working with the existing virtual labs and familiarize with the simulators for a transformation.

Challenges

Teaching and learning experiments online certainly requires desktop/laptop with a high speed internet connectivity. Smartphones/tablets are not suitable for running simulations and experiments. In India only 54.4% of population have access to internet and this clearly reflects the challenge in reaching students through online.

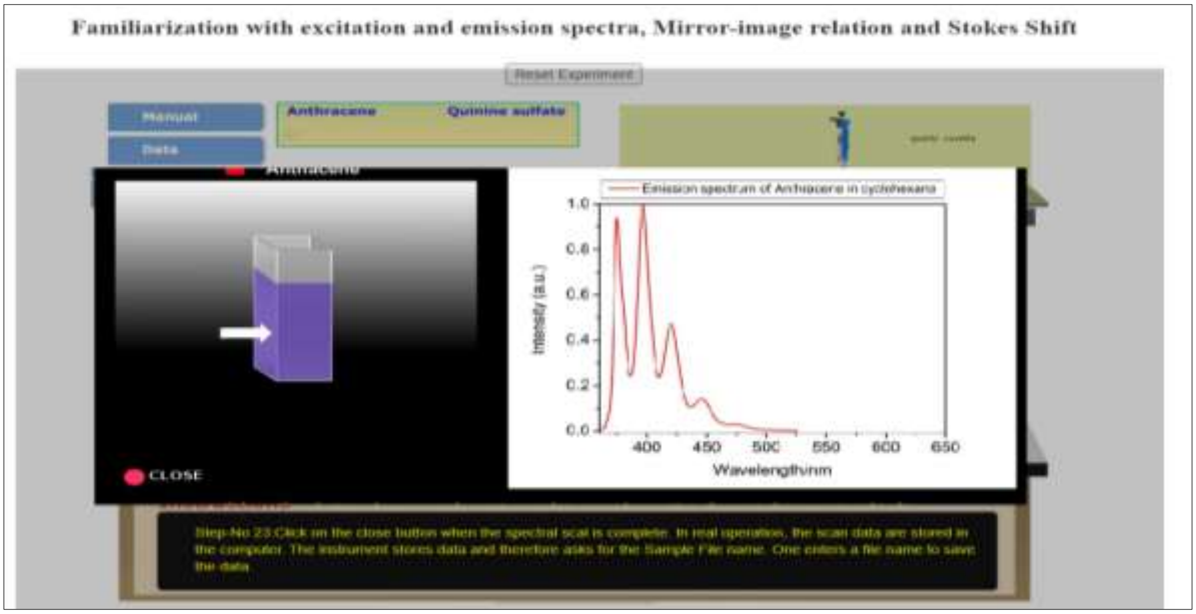
Features of online resources for chemistry experiments

Access to the instruments, equipment, apparatus and glassware makes the laboratories a non-replaceable component of a course. Online resources are designed with the animation of instruments and apparatus are significant rather than resources with the software in which chemical parameters can be simulated. Hence, few web resources that are designed exclusively with the animations of instruments, spectrometers and equipment are demonstrated with a brief discussion in the following sections.

http://mfs-iiith.vlabs.ac.in/ - The Ministry of Human Resource and Development, Government of India has developed Virtual Labs for various science and engineering disciplines under the National Mission on Education through ICT. The chemical science portal of this virtual lab consists of simulators and animation for various spectrometers such as absorption spectroscopy, fluorescence spectroscopy, and circular dichroism spectroscopy. The instructors can teach the experiments and students can perform experiments through the user-friendly multimedia animations. Every spectroscopic technique is accompanied by different experiments and the relevant procedure. A step by step instruction manual guides the user for a systematic learning of experiments. Screen shot of the home screen of fluorescence spectroscopy lab and the simulator is shown in Fig. 1a and Fig. 1b respectively.

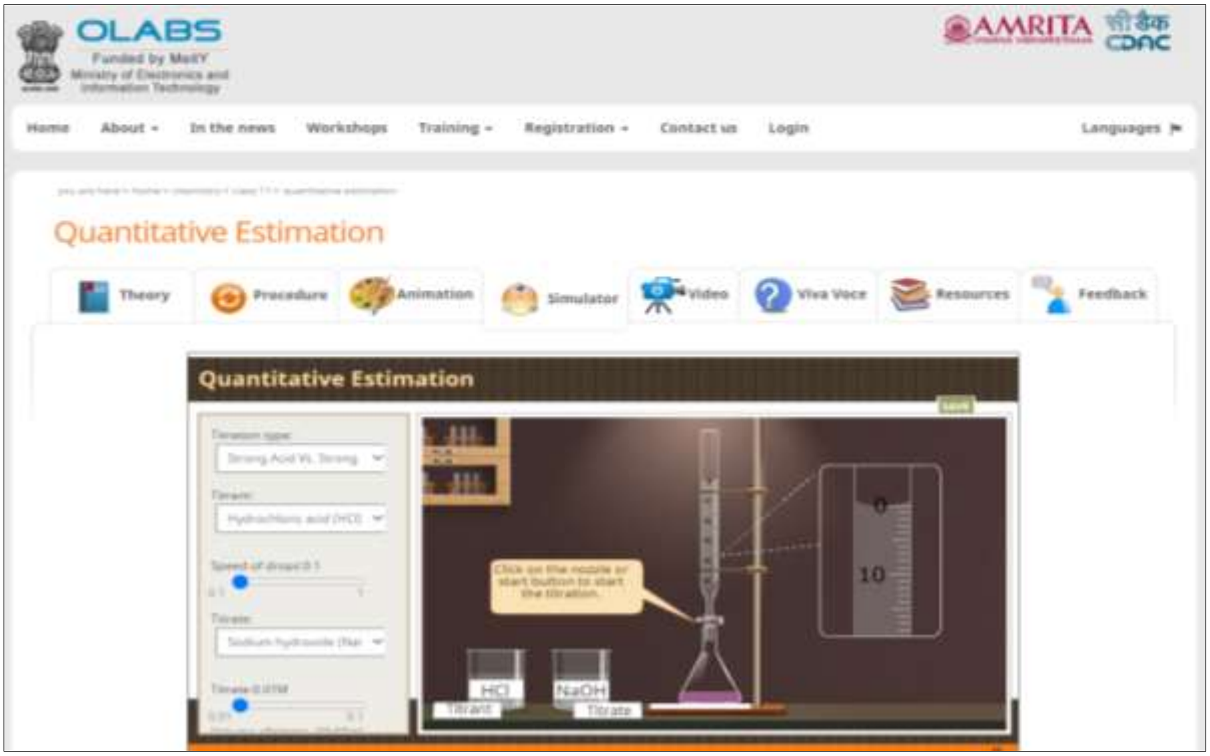
Fig. 1a: Home screen of fluorescence spectroscopy lab of http://mfs-iiith.vlabs.ac.in/

Fig. 1b: Screen shot of the simulator for fluorescence measurement inhttp://mfs-iiith.vlabs.ac.in/



http://www.olabs.edu.in/-The Ministry of Electronics and Information Technology, Government of India has developed online labs (OLABS) for science subjects. The chemistry portal consists of experiments on inorganic, organic and physical chemistry. Registered users can freely access the reading materials, video demonstrations, perform experiments through simulators, test the understanding by making attempt to the quizzes. Uploaded videos tutorials captured in the real labs assist the students for a guided learning. Animated instructions guide the learners for running the simulations. Screenshot of the quantitative estimation simulator is shown in Fig. 2.

Fig. 2: Screenshot of the quantitative estimation simulation in http://www.olabs.edu.in/



CONCLUDING REMARKS

The existing virtual chemistry labs and online instrument animation resources are designed with the objective of "learning by doing". Virtual labs render free learning environment to the students to handle the animated instruments, vary the input values, simulate the experiments any number of times without any risk. Hence, the web-based chemistry labs and instrumentation labs, simulators can be used effectively to teach experiments virtually through remote access. Although, the virtual labs cannot become the substitute with equal potential as hands-on labs, teaching instruments and experiments through online labs during this indefinite lockdown would help to increase student chemistry literacy [3].

REFERENCES

1. PetarJandrić, David Hayes, Ian Truelove, Paul Levinson, Peter Mayo, Thomas Ryberg, Lilia D. Monzó, Quaylan Allen, Paul Alexander Stewart, Paul R. Carr, Liz Jackson, Susan Bridges, Carlos Escaño, Dennis Grauslund, Julia Mañero, Happiness OnesmoLukoko, Peter Bryant, Ana Fuentes-Martinez, Andrew Gibbons, […]Sarah Hayes. (2020). Teaching in the Age of Covid-19. *Postdigit Sci Educ,* 2, 1069–1230. https://doi.org/10.1007/s42438-020-00169-6
2. Norman, R., Iqbal, S., (2007). The role of laboratory work in university chemistry. *Chem. Educ. Res. Pract.*, 8 (2), 172-185. https://doi.org/10.1039/B5RP90026C.
3. American Chemical Society. (n.d.). *Position statement: importance of hands-on laboratory science.* https://www.acs.org/content/acs/en/policy/publicpolicies/education/computersimulations.html.