Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 2, 369 – 374

Using virtual laboratories in Chemistry through guided inquiry-based approach

J V Madhuri[1], LNS Prakash Goteti[2]

Assoc.Professor, FE Department, Geethanjali College of Engineering and Technology, Cheeryala, Hyderabad, India

Abstract –

Online learning and open online educational resources have been very helpful in continuous learning of the students. COVID -19 pandemic has disrupted in various sectors including education. These online resources and learning platforms have enabled students to learn from home, to keep in pace with their regular learning schedules planned as part of their curriculum. Imparting practical skills through virtual environments is of great interest and digital technologies are being explored in establishing such platforms. In the present work we present experiences based on the virtual labs adopted to impart laboratory module of chemistry, as part engineering curriculum at undergraduate level. The present work describes various stages pertaining to inquiry-based learning, leveraging virtual labs for enhancing the conceptual understanding of the students.

Keywords: Enquiry Based Learning, ICT, Open educational resource, STEM, Virtual Laboratories.

1. INTRODUCTION

Information, communication and technology (ICT) enabled education is imperative in the current educational scenario. They play an important role in enhancing the quality of teaching, learning and engaging both educators and students actively in an online platform. In this pandemic COVID-19 situation, when social distancing, avoiding crowds is new normal, usage of ICT enabled education took a big leap in its usage among educational community with innovative pedagogical approaches [1-5]. Considering this as an opportunity to explore innovative open educational platforms, practices and resources, there is a significant focus to fill the conceptual gap through visualisation of elements in virtual environment [6-10].

Virtual laboratories provide a platform for conducting experiments in a virtual environment for STEM subjects. For scientific, technical and economic progress of a country, STEM educated work force is essential. STEM education is being imparted to undergraduate engineering students; train them in modern science lying in the interface of different disciplines providing a multi perspective view of a problem. In general STEM lesson plans promote the development of methodological skills and competencies, investigation through experimentation, teamwork and communication among students through collaborative activities [11-13]. Open educational resources support the tnecessary educational innovations and they can act as catalyst for change in educational practices in regard to its form, space, functions, services, tools, roles and procedures. As a part of imparting STEM education, laboratories play a major role where the student needs to demonstrate higher levels of cognition. Implementing ICT in laboratory courses improves efficiency and effectiveness of the course as it integrates technology, curriculum design and instructor competency.

Due to the pandemic, in India there was a nationwide lock down is imposed [14] restricting the movement of 1.3 billion population as a control measure to curb the spread of COVID 19. But various measures were taken and in particular for continuing education and engaging the students actively with massive open educational resources. Ministry of human resource development (MHRD), has taken various initiatives like giving access to NDLI (National Digital Library of India), National Programme on Technology Enhanced Learning (NPTEL) etc. Virtual labs

were also initiative of MHRD, developed by AMRITA Vishwa Vidyapeetham for STEM subjects. In the present work, we have used the open educational resource of AMRITA V labs and conducted Chemistry practical in virtual environment. In this study, an effort is made to bring out the perspectives of students considering the learning experience of the participants during this journey.

Virtual laboratory is an interface created using computer hardware and software in way that it mimics real environment. In an online lab, investigation material is worked out in a way that the effects of this are measured or observed to draw a relation between the variables present in the conceptual model. Virtual laboratory environments are divided into five categories.

Simulations:

Simulations represent a process on the basis of a model that is cheaper, faster, less risky and more affordable than the real process.

Network Applets:

Virtual laboratories with small set up, use network applets. They are very easy to transport and are independent of operating system type and are popularly used in science subjects.

Virtual Labs:

A system is virtually simulated with the help of media technology and software technique. The important feature of virtual labs is the technical interaction either directly or indirectly between objects and parameters. In the present work we are using virtual labs.

Virtual Reality Laboratories (VRL):

VRL are highly interactive where, an user becomes a participant (virtual avatar) in the virtual world. It is an artificial three - dimensional optical environment where simulations of high level can be carried out through different sensory channels.

Laboratories Controlled by Distance (Remote Labs):

Remote labs generally involve real experiments conducted at some place and are accessed from a distance through telecommunications by the user. Data is generally manipulated by the organization and the outcomes of the data are analyzed and interpreted by the user.

2. Methods

In this work, we consider learners of engineering chemistry and their experiences in leveraging virtual laboratory simulations, A Likert type survey form is used the responses of these students is recorded. In a qualitative approach, students were asked to share their experiences in a free-text comments where they were able to express themselves more explicitly about their experience with the simulation. Through this, an approach it is possible to identify the gaps in the educational practice and can be improvised later on.

Amrita Vishwa Vidyapeetham Virtual Lab (vlab.amrita.edu) [15,16], an open educational resource is used to conduct experiments like, Determination of Viscosity of Organic Solvents, adsorption isotherm, surface tension that were part of the course curriculum for Engineering students of firstyear. The sample size of the students is 120. Before the student performs the experiment in the simulator, the student is advised to read the theory behind the experiment being performed. Here, the role of instructor is to emphasize to make them understand the variables that change during the simulation and perform the necessary calculations to arrive and interpret the result. There is also procedure for the student to understand the steps involved to perform the experiment virtually as well as in the real laboratory. Now, the student is ready to perform the experiment in the simulator. During the performance of the experiment, student needs to take down the values for doing the calculation later on virtually. Students were performing experiments virtually related to Engineering Chemistry laboratory. Due to lockdown, students and faculty connected virtually. As a part of it, students were asked to create an account for themselves in amrita labs and install adobe flash player if it is not present. A google classroom was used to conduct class and then simultaneously students and the teacher logged in their respective accounts. First virtual laboratory concept was introduced; later introduction to experiment and how it is performed in the simulator is explained. Then, everyone performed the experiment virtually, and if any doubt arises, faculty was present to clarify. If any student wants to perform the experiment again in the simulator, they were free to do so. The survey was conducted after they performed all the experiments. Qualitative

data is also collected in the form of free text comments, where student can express themselves freely and this cannot be captured in Likert type of responses.

3. Results and Discussion

Students created their accounts in Amrita labs and some of them explored other domains as well. Under the guidance of the faculty, they understood the theory and principle involved in the experiment. While progressing through the simulation, student intervention becomes necessary, where the student is required to stop the experiment and make a note of the reading. This is one of the checking steps, where it may be ensured that the student has understood important step of the experiment. A survey was conducted based on the following questions:

- Could execute the simulation on my own.
- Can apply the knowledge learnt in the virtual lab session to the real-world situations.
- Found simulation interesting and engaging.
- Learning objective of the experiment was clear.
- Learning outcomes of the experiments were met.

It was observed that nearly 90% of the students, who performed the simulation, could do it on their own and felt itinteresting and engaging. Some students felt that they can apply the knowledge, to real world situations as well. The results captured in Likert type responses [17-19] from students are graphically depicted as shown in Figure 1.

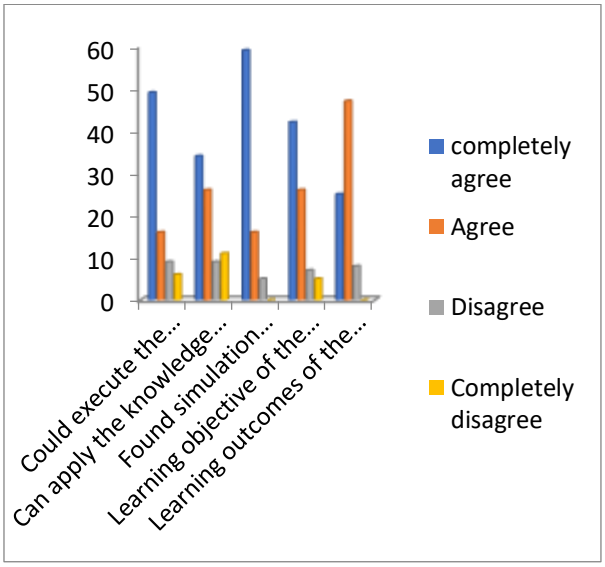

Figure 1: Student's response after completing the simulation

To gain an insight into what aspects of the simulation student liked, another survey was conducted comprising of questions related to simulation. They were asked, to give their opinion on the following:

- Time allotted to the simulation is appropriate
- The theory given in virtual laboratory environment is sufficient to perform the experiment
- User interface used in virtual lab is close to real laboratory.
- Questions given in the assignment are interesting and are providing further insights into the experiment.
- 'Self-evaluation' questions are testing the understanding of the experiment

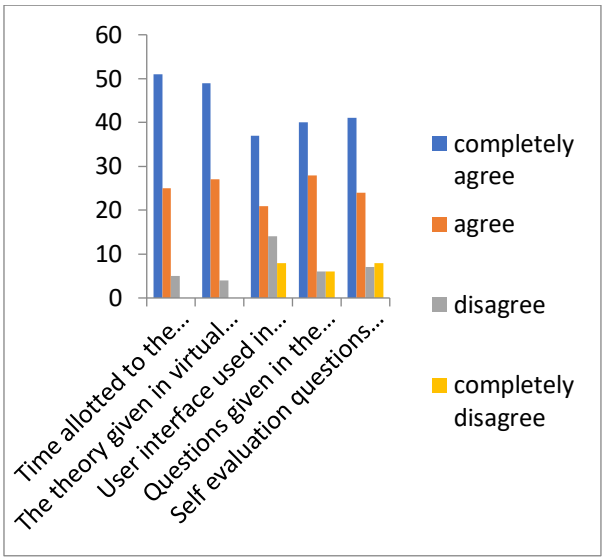

Figure 2: Student's response regarding the experience of the simulation environment

From these responses, it may be noted that students had a mixed response for the fourth question, related to assignment questions. In the, free-text responses, some students mentioned that the questions can be more challenging. Some of the free text responses are as follows:

Experiments were well understood in virtual environment.

Doing experiments virtually is interesting but hands-on experience in lab is good.

Virtual experimentation is helpful before performing the experiment in the lab.

Very good tool for those students who don't have prior experience in performing laboratory.

Also it is quite understandable that a virtual laboratory cannot be a substitute for real laboratory.

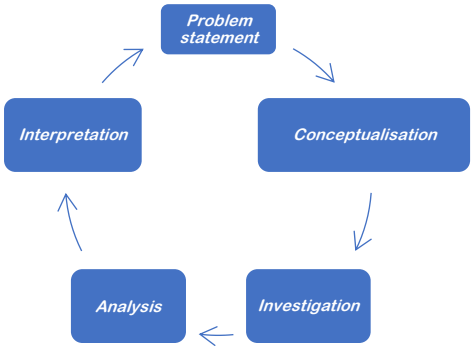

Figure 3 - Various stages in the inquiry-based approach followed during virtual laboratory session.

Just by getting into virtual laboratory environment effective learning is not ensured. Inquiry based learning along with guidance leads to conceptual knowledge [20,21]. Guidance is the support, given by a teacher at various phases in the process of inquiry cycle undergone by the student. Inquiry cycle starts with problem statement, where the student is encouraged to ask a question about the experiment, here in specific what we are going to do in the experiment virtually. During the next phase, i.e., conceptualization, where the student needs to concentrate on one or two domains. In this, context learning objective needs to be clear to the student. In the investigation phase, student plans an experiment

and executes it. In this context, he executes experiment in the simulator. In the conclusion phase, the student does analysis and calculates the parameter to be determined and interprets the results.

4. Conclusions

By the studies conducted, we report that chemistry virtual laboratory is interesting and prepares the student for performing experiment with his own hands. It also enhances the conceptual understanding of the student through various steps involved in the guided inquiry-based learning process. When compared to physical laboratories, virtual labs are re-configurable, flexible, scalable, isolated, secure and cost efficient. Learning STEM disciplines is a combination of understanding, conceptualization and applying the same in practical scenario. Also, observation and experimental methods help in understanding of the concept in a vivid manner. In virtual laboratories, students have a flexibility to explore the possibility of integration of an idea of science and technology on to content of other subject areas as well.

References

[1] Ratheeswari K, Information Communication Technology in Education, Journal of Applied and Advanced Research. 3 (suppl.1), (2018) 45-47.

[2] Jo Shan Fu, ICT in Education: A Critical Literature Review and Its Implications, International Journal of Education and Development using Information and Communication Technology, 9(1), (2013) 112-125.

[3] Habiba Hafa, Mohammed Moubtassime, The Use of ICT in Learning English: A Study of Students in Moroccan Universities, SAR Journal, 4(1) (2021) 19-28.

[4] Bilyalova, A, ICT in teaching a foreign language in high school, Procedia-Social and Behavioral Sciences, 237, (2017). 175-181.

[5] Hannatu Abdullahi, The role of ICT in teaching science education in schools, International Letters of Social and Humanistic Sciences 19 (2014) 217-223.

[6] Jennifer Van Allen, Stacy Katz, Teaching with OER during pandemics and beyond, Journal for Multicultural Education 14 (3) (2020) 209-218.

[7] Blomgren C, OER awareness and use: the affinity between higher education and K-12, The International Review of Research in Open and Distributed Learning, 19(2) (2018) 56-70.

[8] Brandle, S.M., Katz, S., Cooney, C., Beth, A., Disanto, J., Hays, A., Miles, L. and Morrison, A. But what do the students think: results of the CUNY cross-campus zero-textbook cost student survey, Open Praxis,11 (1) (2019) 85-101.

[9] Hilton J, Open educational resources and college textbook choices: a review of research on efficacy and perceptions, Educational Technology Research and Development, 64(4), (2016) 573-590.

[10] Morgan T), Instructional designers and open education practices: negotiating the gap between intentional and operational agency, Open Praxis, 11(4) (2020) 369-380.

[11] Sarah K. Coleman, Caroline L. Smith, Evaluating the benefits of virtual training for bioscience students, Higher Education Pedagogies, 4(1) (2019), 287-299.

[12] AzzaAbouhashem, Rana Magdy Abdou, Jolly Bhadra, NithaSiby, Zubair Ahmad and Noora Jabor Al-Thani, COVID-19 Inspired a STEM-Based Virtual Learning Model for Middle Schools—A Case Study of Qatar, Sustainability (13) (2021) 2799.

[13] JinSuJeong , David González-Gómez, A STEM Course Analysis During COVID-19: A Comparison Study in Performance and Affective Domain of PSTs Between F2F and F2S Flipped Classroom, Frontiers in Psychology (12) (2021), 697-713

[14] PM Narendra Modi announces Lockdown of India, for 21 days, https://cfo.economictimes.indiatimes.com/news/pm-narendra-modi-announces-lockdown-of-india-for-21-days/74797779 (accessed on 1st April 2020)

[15] Radhamani, Rakhi &Sasidharakurup, Hemalatha& Sujatha, Gopika& Nair, Bipin &Achuthan, Krishnashree& Diwakar, Shyam. (2014). Virtual Labs Improve Student's Performance in a

Classroom. Lecture Notes of the Institute for Computer Sciences, Social-Informatics and Telecommunications Engineering, LNICST. 138. 10.1007/978-3-319-13293-8_17.

[16] MHRD promotes digital platforms for students and teachers, https://www.hindustantimes.com/education/coronavirus-outbreak-mhrd-promotes-digital-platforms-for-students-and-teachers/story-oNsHUsNV7mUZpVKNIxgXXL.html (accessed on 26th March, 2020)

[17] Likert R, A technique for the measurement of attitudes. Archives of Psychology, (140) (1932) 1–55.

[18] Joshi, Ankur, Kale, Saket, Chandel, Satish, Pal, Dinesh. (2015). Likert Scale: Explored and Explained, British Journal of Applied Science & Technology, (7) (2015), 396-403.

[19] Croasmun JT, Ostrom L, Using Likert-type scales in the social sciences, Journal of Adult Education, (40) (2011) 19-22.

[20] G. V. Madhuri, V. S.S.N Kantamreddi& L. N.S. Prakash Goteti Promoting higher order thinking skills using inquiry-based learning, European Journal of Engineering Education, 37(2), (2012) 117-123.

[21] Ismail, Noriah& Alias, Suhaidi&mohdariffalbakri, Intan, Inquiry-Based Learning: A New Approach to Classroom Learning, English Language Journal, 2(1)(2006)13-24.