Blended Learning Approach using Virtual Laboratory Applications in Engineering Chemistry

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***Abstract*— Traditional classroom teaching practices often lacks the active engagement of students in the class. Performing experiment in the laboratory is one of the most effective methods for getting deep knowledge in chemistry. But sometimes listening theory lectures and performing related experiments in the laboratory does not helps the students to understand the concepts clearly, as this lacks repeatability and visualization of concepts. Induction of virtual laboratory in combination with theory lectures and physical laboratory could solve this problem. Virtual laboratory have multi-faceted advantages such as repetitive performance, easy to handle simulations and remote triggered experimentations. Such remote triggered laboratories found to enhance students' academic performance as it enables them to perform anytime-anywhere. In this paper, we report our observations regarding the use of virtual laboratory experiments in chemistry subject and their role in enhancing First Year B. Tech. engineering students' performance when induced as a blended classroom. UV-Visible spectrophotometry experiment was performed to verify the usefulness of virtual laboratory from student's knowledge perspective. Effect of a blended learning approach was carefully studied and evaluated in comparison with traditional classroom teaching and virtual laboratory. Our study reveals the enhancement of student's performance in a blended learning environment compared to just physical performance in laboratory and performing individually with the virtual laboratory.**

Keywords - virtual laboratory, chemistry, UV-Visible spectrophotometry, blended learning, knowledge

I. INTRODUCTION

Traditional classroom based teaching-learning methods require the time bound presence of teacher and students. Traditional classroom based education methods involve some elements of student control over time, pace and place [1-3]. It also requires regular attendance and attentiveness of students to understand the concepts. It is observed that few concepts in Engineering Chemistry subject needs visualization at micro and macro levels. This can be supported by theory based laboratory experiment in the curriculum. Traditional chemistry laboratory practices involve handling of chemicals, glassware and few experiments needs sophisticated and costly equipment for demonstrating and explaining the practical applications of such theoretical concepts. But the laboratory courses in engineering curriculum have limited time period and in such a short span it is difficult to get correct ideas about the experiments. In the self-financed institutes lack of sufficient funds, high cost of chemicals, equipment's and issues with personal safety are the important factors for developing laboratory experiments. Reagents and chemicals needs to be prepared as per required concentrations which demands good analytical skills. In case of re-conduction of experiments several factors which are responsible for failure in getting expected results are time, equipment and materials. Careless preparation and casual approach may lead to accidents. Due to the high cost of the reagents and instruments, experiments conducted conventionally in colleges cannot be given to individual student and assigned in groups to perform them in laboratory. The experiments based on spectrophotometric techniques such as UV-Visible, IR, NMR spectroscopy, pH-metry, conductometry, viscometry cannot be given to the individual student due to high cost of equipment's. Hence just demonstrating the experiment to a group of students and teaching the similar module in the class does not help students to understand the theory. Also teachers have to speed up their teaching to cover the syllabus on time. This creates the gap between student's understanding and actual theory practices.

Virtual Laboratory exercise provide an individualized learning that helps to meet the needs of both urban areas and economically and geographically challenged rural areas with high level of flexibility and reduced the concerns regarding cost for laboratory set-up [4, 5]. Virtual learning allows students to work at their own pace, making sure they fully understand new concepts before moving on. Virtual laboratory is ICT enabled e-learning tool which could overcome the difficulties faced by the traditional laboratory [6, 7]. It helps in realistic visualization of experiments using various animations, simulations and remote triggered experimentation.

Blended learning (BL) is an approach that combines traditional face to face modes of instruction with online modes of learning. It was observed that student achievement was higher in blended learning experiences when compared to either fully online or fully face-to-face learning experiences. Few reports in the literature suggest that blended learning systems can combine face-to-face instruction with computer mediated instructions [8-10]. By

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using a combination of digital instruction and one-on-one face time, students can work on their own with new concepts. Such incorporation is found to be valuable contributor to student satisfaction and success.

In engineering chemistry, spectroscopy is the most difficult module perceived by the student. As it requires students to understand structural determination of chemical compounds, application of UV-visible spectroscopy for the detection of different organic and inorganic compounds Hence laboratory experiment based on UV-visible spectrophotometer is introduced in their physical laboratory practices. But there are some practical issues such as high cost, safety of the instrument and due to limited time slots; it is not possible to make each and every student to perform the experiment individually. So it was decided to perform demonstration experiment in group under the supervision of faculty member. Even this practice could not help much to the students as it was observed that few students take it very casually as it was a demonstration experiment and they use to copy the readings without much attention to the demonstration. So they were lacking in understanding concepts and applications of this technique.

In this paper, we focus on the role of blended learning approach with the help of virtual laboratory experiments in combination with traditional laboratory for better understanding of concepts in spectroscopy techniques in Engineering Chemistry subject. For this study, we carried out analyzing performance of First Year B. Tech. (F. Y. B. Tech.) students in self-financed institute by conducting the experiments on traditional and virtual laboratory platform.

II. Design and implementation of Blended learning activity

The course, 'Engineering Chemistry' is one semester compulsory subject for F. Y. B. Tech. students. It has also the laboratory component which has been allotted time of 2 hours per week. Thus in each semester there are about 320 students enrolled for the subject. General practice of performing the experiments traditionally is by dividing 320 students in to group of 16 batches containing nearly 20 students per batch. To study the effect of blended learning approach, we have divided them into two groups CG (control group) who have performed the experiment first in traditional laboratory exercise and EG (experimental group) have performed the experiment first using virtual laboratory platform. Hence 8 batches out of total 16 batches were made as a CG and allowed to perform first the experiments in a traditional way in a chemistry laboratory. While remaining 8 batches were made as EG and allowed to perform first the same experiments using virtual laboratory. The pre-blended learning performance of both the groups was analyzed by MCQ based quiz and laboratory viva.

In the next study blended learning (BL), both CG and EG groups were interchanged. For this purpose, CG students were allowed to perform the experiment through virtual laboratory that had already done the experiment using traditional laboratory and EG students were allowed to perform using traditional laboratory that had done the experiment using virtual laboratory. The effect of post blended learning performance of students on BL was evaluated using final MCQ based quiz and feedback questionnaire about the experiment.

Virtual laboratory sessions were conducted in a Common Computer Facility laboratory where there is a facility of high speed internet connected computer. To evaluate the effect of virtual laboratory for UV-Visible spectrophotometer experiment and the virtual laboratory experiment selected was developed by Amrita Vishwa Vidyapeetham University.

III. Observations

Following observations were made by an instructor through this step-wise study:

1. Understanding of theoretical concepts behind UV-Visible spectroscopy using only traditional teaching-learning method and only through virtual laboratory was not satisfactory.
2. The students who performed traditionally could understand how to prepare various concentrations of different chemicals required for the experiment. The students who performed through virtual laboratory have not got opportunity to handle any chemical.
3. In traditional method, students could watch the demonstration once they prepared the solution and note down the observations. But this could be practically done only once due to time constraint. This problem was overcome through virtual laboratory as students could repeat the experiment as per their wish.
4. In case of traditional method only one chemical substance with different concentration could be studied with UV-Visible spectrophotometer. But using virtual laboratory students have the provision of analyzing various chemical substances with varying concentrations.
5. In case of traditional method, since it was demonstration, each student could not individually perform the experiment because of time constraint and safety aspects of the instrument. But students could individually perform virtual laboratory experiment at their own pace.
6. Few students were finding difficulties in doing the experiments because of lack of computer knowledge and expertise. Few weak and less interested students were found simply copying the readings in conventional experiment due to lack of individual involvement and interest.
7. The group of few students who found demonstration and working physically in the laboratory is less interesting practice and shown less active participation could actively participate when the experiment was performed in virtual laboratory. They found virtual laboratory more interesting and challenging as they could perform the experiment on individual basis.
8. Even slow learners could understand the theory and experiment at their pace and convenience in virtual laboratory.

IV. Results and Discussion

The following instruments were used to evaluate the effect of blended learning on students' performance.

a. Feedback questionnaire:

The feedback of both EG and CG groups were taken using following survey questionnaire,

Q.1 The conceptual understanding of the course in UV Spectroscopy can be improved by performance of laboratory work.

Q.2 Skill-set required for handling the equipment, solution preparation and accuracy has improved by laboratory performance

Q.3 Social skills like team working and lifelong learning has improved by laboratory performance

Q.4 Enjoyable and user friendly as compared to traditional way of performing the experiment in laboratory

Q.5 Virtual laboratory cannot substitute traditional way of performing the experiment in laboratory

Feedback received from above survey questionnaire was analyzed to understand the effectiveness of traditional and virtual laboratory individually. This was considered as pre-blended learning feedback. The graphical representation of the data obtained from the feedback questionnaire is represented in Fig 1. Only strongly agree and agree components are considered in the graph.

The Analysis of feedback survey for Q.1 related to understanding of basic concepts of spectroscopy based on strongly agree and agree components showed the higher percentage of student's achievement in EG group. This can be attributed to more timing given for the understanding of basics of spectroscopy, ease of visualization of theoretical concepts and due to repeatability of experiments.

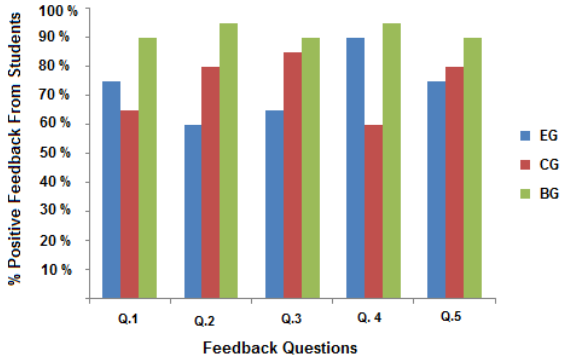

Fig. 1: Analysis of feedback questionnaire

Q.2 demand skills related to performance of experiment, accuracy and precision. In traditional laboratory experiments students need to make calculations, prepare solutions and handling of equipment which is tedious and time consuming but improves the performance skills. The feedback analysis of Q.2 showed higher level of achievement in CG group. Q.3 focuses on student's team working and knowledge sharing ability. The feedback analysis of Q.3 reveals that working in a group and knowledge sharing has been improved by performing experiment in traditional laboratory experiments. Analysis of Q.4 showed that performing experiment virtually was more convenient, user-friendly and enjoyable. However feedback analysis of Q.5 showed that both CG and EG students was in agreement with the fact that virtual laboratory cannot be a replacement of traditional way of performing the experiments.

There was significant amount of increase in learning was observed for all the questions using blended learning approach for BL group and it can be seen in the feedback analysis as shown in Fig. 1. It was found to have positive impact of blended learning approach on the learners. This has helped the students to achieve better conceptual understanding of the subject and to improve their marks through blended learning.

b. MCQ based quiz

After performance of experiments traditionally and virtually, MCQ type questions were given to the students. Results of this MCQ test were evaluated to check the understanding of the students about theoretical concepts of spectroscopy. The following questions were asked in the quiz.

- The units of absorbance and molar absorptivity is _____
- If 100 % light passes through a solution without any absorption, then the value of absorbance is _____
- An aqueous solution of Co^{2+} absorbs from red region of the visible spectrum. The probable color of the solution is _____
- The relation between absorbance and % transmittance is _____
- A solution of 0.12 M has an absorbance of 0.3 while another solution of same compound measured under same condition has an absorbance of 0.75. Then the concentration of the latter is _____
- The molar extinction coefficient of a solution of concentration 0.04 M and thickness 8.5 cm is 50.8 L mol^{-1} m^{-1}. The value of optical density is ----
- Absorbance of a solution is found to be 0.73. The % Transmittance is _____
- When a wavelength of 350 nm is passed through a solution, the light intensity is reduced to 25% of its initial value. Then absorbance is given by _____
- The absorbance of 1 mm of a sample solution whose concentration is 0.03 M is _____. (Given that the molar absorption coefficient is 10 L mol^{-1} m^{-1})
- An unknown solution showed absorbance 3.0 and molar absorption coefficient, ε = 260 L mol^{-1} m^{-1}. (Thickness, l=1.5 cm). The concentration of the solution is_____

The marks obtained in MCQ based quiz were segregated in to four categories of grades as shown in Table. I.

TABLE I. GRADES OBTAINED BY STUDENTS IN MCQ BASED QUIZ

Grades	AP-AA	AB-BB	BC-CC	CD-DD
% Marks Obtained	85-100%	70-84.99%	50-69.99%	40-49.99%

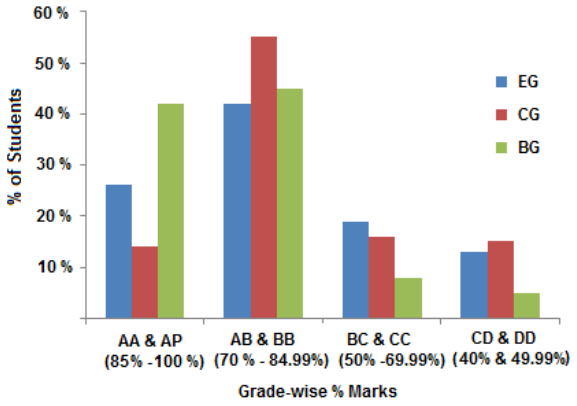

Fig. 2: Analysis of student's performance in MCQ based quiz

The performance of students in MCQ based quiz is shown in figure 2.

The analysis of the marks showed that performance of EG group students was slightly better than CG group in MCQ test. As it can be seen from fig. 2 that the number of students scoring 85-100 % marks in MCQ test of EG group is about 20 % higher than in CG group. This could be attributed to the convenience, ease of visualization and repeatability of virtual laboratory performance. While the traditional laboratory experiment demands time for calculation, solution preparation and actual performance of experiments. This will results in inadequate time for learning and understanding the theory and concepts behind the experiments. The statistics in fig. 2 showed that in blended learning environment performance of the students improved significantly which can be seen for BL group. It incorporates positive features of both traditional and virtual way of laboratory performance. Hence it has both the advantages of repeating experiments several times, improving the skill set for performing experiments and also the convenience of performing experiments anywhere anytime.

CONCLUSION

Impact of implementation of blended learning in the subject of Engineering Chemistry for understanding of UV-Visible spectroscopy is studied and evaluated. It was found to have positive impact on the learners. This has helped the students to achieve better conceptual understanding of the subject and to improve their marks. This has also enhanced their interest and approach looking towards theoretical topics.

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