



An Overview of Chemistry Teaching Transformation during COVID-19 Pandemic: An Experience from University of Botswana

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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Short Communication

ABSTRACT

COVID-19-related disruption in teaching in the University of Botswana led the school to prepare new strategies for running classes and to design innovative way of instruction. The most notable change was to replace face-to-face lectures with online teaching at least partially (blended teaching and learning). This posed many challenges, especially in the teaching of science and technology subjects. In a laboratory-based discipline such as chemistry the problems encountered were especially daunting. Moreover, writing mathematical equations, chemical reactions and reaction mechanisms posed their own difficulties. The present communication provides a brief overview of how chemistry education at the University, the premier national university of Botswana, has been transformed during the last three semesters. It is based on experience of the author and as judged by the feed-back received from colleagues and the students. Admittedly, the experience is limited and much discussion is still in progress to meet the unresolved challenges. Theory classes at undergraduate levels are now mostly taught online using packages such as Moodle and MS Teams. The tutorial and laboratory sessions have faced the greatest disruptions and the instructors continue to explore ways to conduct these virtually. Online examinations were found to be limited in their effectiveness, especially in the assessment of drawing chemical structure and reaction mechanisms as well as the students' ability in scientific writing.

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1. INTRODUCTION

The outbreak of COVID-19 pandemic due to SARS-CoV-2 virus has impacted every walk of life. It forced several nations including Botswana to implement complete lockdown in installments. Though it helped in controlling the spread of disease to some extent it led to several other problems such as the loss of livelihood of the people. The economy got ruined due to complete industrial lockdown and the education sector was not an exception. In fact, the education sector suffered the most because learning institutions were closed for longer periods than any other sector [1]. Prolonged closure of schools was justified because they were dealing with large numbers of children and young students.

Botswana is a sovereign nation in the Southern African region. It has an area of over 600,000 sq. km. with the population of around 2.5 – 3.0 million. Although the country is not very densely populated the SARS-CoV-2 virus was detected here in March 2020, when three visitors from abroad were found Corona-positive [2]. The Government was very proactive and convened a special session of the parliament. After due consultation, the President declared the state of emergency in the country for six months. As a first step, a four-week complete lockdown was announced. Only retailers of essential items were open for which e-permits were required. Strict steps were taken to implement social distancing and hygiene. The University of Botswana is the premier institution of Botswana situated in the capital city of Gaborone. It has strength of over 15000 students and over 2000 staff. By the time of first lockdown, the first half (seven weeks) of the semester of the university had been completed. It was the second semester of academic session 2019-2020. Lectures and practical were conducted during these seven weeks in conventional manner (face-to-face classroom teaching). When the university opened after a closure of about six weeks, there were many challenges before managers and academics. The almanac had to be revised, curricula had to be amended, teaching methodology had to be evolved and agreed upon, and lastly the most important one – the assessment criteria had to be changed after thorough consultation with all the stakeholders. The university decided to adopt a blended teaching and assessment methodology, which

was partial or full replacement of face-to-face classroom teaching with web-based or online teaching (replacement blending model) for the second semester of 2019-2020 [3]. The challenges were enormous both in the implementation of anti-pandemic precautionary measure such as maintaining social distancing in conventional teaching, and in ensuring students' connectivity to network and data accessibility for online learning. There was increased emphasis on online teaching during the first semester of 2020-2021 session and then second semester of 2020-2021 for which most academic staff lacked the necessary training. This transformation has been extremely challenging for chemistry teachers especially in laboratory experiments and equations writing skills during the lessons. Even though online instruction can be imparted from anywhere it requires different skills, strategies, and tools. The methods of online teaching and learning are different from the conventional face-to-face teaching model in a classroom. Mastering the unique skills necessary for the smooth conduction of online classroom teaching requires extensive training. Moreover, it is not easy for students to learn perfectly all at once in a completely new method of teaching.

Researchers from various countries have shared their experiences with challenges and opportunities in chemistry teaching during the last two years. Pilkington and Hanif from New Zealand have published a report on strategies and innovations for chemistry teaching during the COVID-19 pandemic [4]. They have described their lecture mode, experience of online tutorials, and how they conducted the laboratory sessions. Giri and Dutta have published an article on identifying the opportunities and challenges in online chemistry teaching in India [5]. Most opportunities and challenges described are not limited to chemistry but are general to other science and technology subjects as well. Lee has described his experience of chemistry teaching during COVID-19 at a national university of Korea [6]. To the best of my knowledge, there is no published report of chemistry teaching at tertiary level during the pandemic in Africa, so it was considered pertinent to share the experience of transformed chemistry teaching and learning in the University of Botswana. Therefore, the present communication provides an overview of the transformation of chemistry teaching since the outbreak of COVID-19.

2. TRANSFORMATION IN TEACHING: AN OVERVIEW

The sub-sections in this section provides an overview of the opportunities and challenges in transforming, i) delivery of lecture material, ii) conducting tutorials, iii) conducting laboratory experiments, and iii) conducting assessment. This qualitative report is a descriptive analysis of author's personal observations and information received from some colleagues and students during personal interactions.

2.1 Delivery of Lecture Material

The academic session at the University of Botswana is divided into two semesters, each comprising fifteen weeks including a week-long semester break in each semester. The first semester begins in August and ends in the second week of December while the second semester starts from the third week of January and stretches up to the first week of June. As mentioned in introduction, teaching of the first-half (seven weeks) of the second semester of 2019-2020 had been completed by the time of the first lockdown announcement in Botswana. Since there was not a single case of Covid-19 reported during that period, the teaching was conducted by traditional face-to-face classroom teaching. In fact, the web-based or online teaching was very uncommon at that time and limited to uploading lecture notes by some lecturers on Moodle that was only online teaching platform available for use. When classes resumed for the remaining half of the semester after a six-week long gap, it was extremely challenging situation for teachers and students. The first year course had a large enrolment (over 1200), making it impossible to maintain social distance in even the largest lecture halls. The lecture delivery became limited to lecture notes and pre-recorded videos being posted on Moodle, supplemented by meetings where practical, using Microsoft Teams. The use of pre-recorded videos has been identified as better alternative to live streaming by Pilkington and Hanif [4].

For higher levels where it was possible to maintain social distancing, the classes were divided into two groups. The lectures were delivered in conventional face-to-face manner. Since the same lecture had to be delivered twice, some topics had to be left out. In the following semester that was the first semester of the academic session 2020-21, there was greater emphasis on web-based or online teaching

through Moodle and Microsoft team. However, the graduate classes with small number of students (around 10) were given lectures by conventional methods. Although many lecturers were not fully trained in use of all the features of Moodle, most of them were able to post their lecture notes either in PDF or in PowerPoint through this platform. Lecture notes in MS PowerPoint were embedded with audio where necessary, emulating delivery of the lectures in classroom as far as possible. Use was also made of Microsoft Teams for the larger year one and two classes. Since this kind of online teaching was a complete new experience for both teachers and students, it had many challenges. However, it also provided opportunity to learn new technics of teaching for teachers and new ways of learning for students. The Center for Academic Development (CAD), responsible for promoting and facilitating the overall development of academic staff and students at the university, was constantly supporting teachers with online training of Moodle features on teaching and assessment. Fortunately, most students of the University of Botswana have smart phones, tablets, and laptops, etc. available and have access to internet connections via the university Wi-Fi, and thus, the logistics for online lectures appeared satisfactory for most students of the university. However, a data collection to know the level of students' satisfaction about availability of logistics is in progress and will be reported in due course of time. Network data were also given to the students so that they could access teaching from outside the campus as well. At this point of time, it is also noteworthy to mention that a previous survey of the students of the university about mode of teaching, most had indicated a preference for conventional teaching using white boards [7]. They did not even like the use of transparencies and projector in teaching because it was increasing the pace of lecture delivery. By the second semester of the session 2020-21, both lecturers and students were mentally prepared for web-based or online teaching/learning. The instructions for all other levels were delivered either by uploading notes on Moodle or through Microsoft Teams meeting. The teaching in these two years thus transformed from conventional face-to-face teaching to almost complete online teaching for most undergraduate chemistry courses. There was general feeling that this mode of teaching was too time consuming and labor intensive with lower efficacy compared to conventional teaching. Moreover, the personal interaction of

the author with several students of year two gave impression that most students felt uncomfortable in learning with online-delivered teaching material and preferred teachers coming to the class for lecturing.

2.2 Conducting Tutorials

Tutorial programs are common at the university level teaching. It helps students to better prepare for the exams and subsequently increases their confidence level [8]. The tutorials are conducted in our department at first year and second year levels on weekly basis (one tutorial hour/week). The students are given exercises based on lectures in a particular week at the end of that week. The tutorial groups comprise 30-40 students. A tutor is assigned to each tutorial group. Tutorials are normally conducted in conventional face-to-face teaching in a classroom and provide opportunity of personal interaction to teachers and students. Conducting tutorial classes in conventional manner was possible while still adhering to COVID-19 protocols because of the smaller number of students. However, most students preferred to stay away from the campus during online lecturing that made smooth running of tutorials in conventional manner almost impossible. It was, therefore, considered most appropriate to provide the solutions of exercises given through Moodle at the end of every week. Students were also instructed to contact their tutors through email or on lecturers' cellphones. However, very limited interaction was observed. The disadvantage was that the students did not have the opportunity of expressing themselves in class and taking part in supervised group discussion, activities that are helpful in developing confidence and generating interest of students in the subject.

2.3 Conducting Laboratory Experiment Sessions

Laboratory work is an integral part of learning an experimental science such as chemistry. The importance of laboratory experiments in learning of chemistry has been recognized earlier by educators and learners [9,10]. In our undergraduate program, the laboratory experiments are component of general chemistry courses CHE101 (mainly first semester) and CHE102 (mainly second semester). However, they stand as separate courses from level 200 to 400. Each practical course consists of ten to twelve experiments. The laboratory sessions are of two hours at year one and of three hours from

year two to four levels. We have a lab capacity of fifty students at year one and two levels and of 30 students at year three and four levels. The students do the experiments independently. Sometimes year one and year two students do experiments in group of two. By the time of first lockdown announcement, about four to five experiments had already been conducted in all the courses of second semester of session 2020-2021. After the university opened, the classes had to resume after mid-semester break. The students were left with another five to six experiments. It was impossible to maintain social distancing in the laboratory with the large numbers in the courses from level 100 to 300. It was agreed to reduce the number of experiments in each course to half, so that each student was doing an experiment in alternative week. In the following two semesters of session 2020-2021, the same strategy was used to maintain social distancing. This definitely disadvantaged the students but there was no better alternative. The experiments had to be selected carefully looking at the importance of the concepts and learning outcome of the course. Some dry experiments had also to be designed. For example, models of organic molecules were placed at each work station and the students were asked to draw the structures of the compounds and write their IUPAC names. However, this strategy is not going to work in the coming semester looking at even larger number of students at first (1500+) and second (400+) years than previous year. The discussions are going on about how to conduct laboratory courses. The concerned staff are collecting information from the literature on how the chemistry lecturers across the globe are trying to cope with this situation. The learning in chemistry with virtual laboratories was reported long back in 2003 [11]. Some reports have appeared in literature on implementing virtual chemistry labs to simulate the practical classes [12-14]. Nais et al. have studied the potential of virtual chemistry laboratory in hybrid learning [15]. The findings of this study revealed that the quality of the virtual chemistry-lab integrated hybrid learning was in a good category. In one model of such labs, one person can conduct the experiment that can be video recorded. During the practical class, the video of the experiment can be shown to students. After showing the video, students can be provided with data obtained from the experiment. Several hypothetical sets of data that students would have generated can be prepared and then students would be asked to perform the required calculations and get the results. The students

would then submit a typed laboratory report for assessment. The students would not acquire the practical skills but would be able to learn the concept without any compromise. This kind of laboratory sessions have been organized by Pilkington and Hanif [4].

2.4 Assessment Methods

Our assessment method consists of continuous assessment through quizzes/assignments, and tests (50% weightage), and the final examination (50% weightage) for most theory courses. The laboratory courses are assessed by marks obtained in report for each experiment. Most courses for the second semester of session 2019-2020 when the pandemic started had paper-based examination. However, the institution had decided to curtail the time of examination and advised that the examinations use a short paper consisting of material covered during the second half of the semester. However, the teachers were at liberty to decide the material to be covered and the time allowed. The guiding principles were to maintain social distancing in the examination hall, use multiple-choice or short-answer type questions in the paper, and lastly the most important one was to keep the questions simple. In order to maintain social distancing, the examinations for large classes were conducted in the indoor sports stadium. Most examinations were of one-hour duration. In subsequent semesters, it was decided to conduct fully online assessment using Moodle platform for year one students while for the higher levels, the lecturers were given liberty to conduct the assessment looking at the class size. Lecturers had to be trained for using assessment tools on Moodle. It was observed that the marks obtained by students were surprisingly high and the result jumped from 70-75% pass to >90% pass in online assessment even though the structure of the question paper for online examination was almost similar to offline examinations. In both the examinations, 60% marks were for multiple choice questions while 40% marks for short-answered question. Since dishonest practices in online examinations have been reported in various places [16], some of the teachers developed doubt about plagiarism by students. With the assistance of IT Department experts, we learnt that there were multiple login on Moodle for over 10% students' accounts. Later on, it was decided to conduct the online examination under invigilation. Obviously, this required physical presence of students and social distancing to be maintained. However, we opted for this because it eliminated the need for the instructor to grade

the work manually. Hence the examinations for 1200 students of second semester (2020-2021) of year one were conducted in six sessions and six sets of questions had to be set and model answers had to be written. The students were warned that the IP address for their login would be checked after the examination. They were also warned that if there are multiple logins on any account zero mark would be awarded to that account and disciplinary action would be taken. This strategy worked well but the overall result came down to around 55% pass only for the same group of students whose pass rate was >90% in the first semester. The drop in result was attributed to the low attendance in classes, stressful circumstances created by the pandemic, and a lack of environment at home similar to class room. These reasons are based on perception of the author developed from discussion with other faculty members and students and need to be investigated further. Another problem typical to chemistry was that students could not be asked questions such as i) drawing of chemical structures for a given name of the molecule, ii) writing the mechanisms of chemical reactions, and iii) questions involving multiple-steps calculations. However, for some of academics it seems that writing skill is going to be an outdated skill sooner or later. For all other higher level classes, the examinations were conducted physically in the traditional manner. However, the pass rate for most classes were slightly lower than the years before COVID-19.

3. CONCLUSION

The COVID-19 pandemic forced a change in the strategies of teaching chemistry in a very short time. The biggest hurdle in this was the stressful circumstances in which the staff (academic and support staff) and students had to work. After many resources were spent on maintaining social distancing and hygienic conditions, the emphasis was mainly on moving from conventional face-to-face classroom teaching to web-based or online teaching. This technology-based teaching posed some challenges but offered some opportunities as well. The lecturers are given training for this type of teaching. Most undergraduate classes were taught using Moodle platform and MS Teams meetings. Students missed the opportunity for tutorial sessions and hands-on experience in the laboratory and hence the idea of web-based tutorials and virtual laboratory sessions are to be discussed. The Moodle assessment tool has some limitations for chemistry courses. It does not make provision to

test molecular structure drawing and mechanism writing skills of the students. Even though a simplistic approach was used in testing a negative impact on results was discernable. Generally, students did not appear fully satisfied with online teaching. However, a detailed study on the perception of students about web-based teaching is in progress and will be published later on. Thus, it can be seen that the current web-based learning cannot replace the conventional on-campus learning.

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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