University Programmes during COVID-19 Pandemic

Subjects: General Engineering
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(This entry belongs to Entry Collection "COVID-19")

Definition

Within the physical sciences and other STEM-based disciplines, the need for physical, laboratory-based practical activities is essential to complement the more theoretical content associated with learning a subject. This entry reviews the transition from traditional to online/e-delivery that could be realised by educational providers when seeking to limit the spread of infection associated with viral pandemics (such as Covid-19), whilst remaining cognisant of the ability to retain a quality student learning experience and continue to achieve programme learning outcomes.

1. Introduction

In study sectors such as chemistry, physics, engineering, biology, computing, psychology, languages, nursing, medicine, and other allied professions, programme outcomes stress the importance of developing theoretical (content) and practical (processes) aspects. When developing the practical aspects, special emphasis is given to the activities that teach students experimental methods, how to synthesise observations, a range of lifelong and communication skills and laboratory practices.

In December 2019, for the first time, Wuhan City in China officially declared the presence of an unknown virus (now called COVID-19) that soon gained pandemic status, taking many lives around the world (https://www.nature.com/articles/d41586-020-00154-w). The COVID-19 pandemic quickly led to the closure of universities and colleges following the advice of public health officials to maintain social distancing [1]. Consequently, educational institutions quickly adopted e-learning under the distance education mode [2][3]. Even though this approach works well for knowledge building through delivering content and oversight of some processes, it has limitations of developing one's practical laboratory skills. For example, if working in a laboratory setting, one would often encounter many types of expensive and complicated instruments and machines. However, operating under a distance learning mode denies valuable hands-on exposure to such facilities and to appreciate the subtleties of being immersed in such an environment. Therefore, it is important to review how universities are currently introducing lab-based practical experiments to students, how they were introduced through online delivery in the pre-COVID-19 period, and what approaches must be taken in the post-COVID-19 period, especially to achieve learning outcomes whilst maintaining a high-quality educational experience.

2. Online Teaching and Laboratory Practices: Pre-COVID-19

With the advancement of e-learning during the first decade of the 21st century, online approaches have become more widely used in many educational setups [4]. For example, web-based activities are used extensively in distance education courses, whereas blended approaches are used to support teaching and learning activities in campus-based courses. Dantas and Kemm discuss a blended learning approach in which web-based e-learning tools are used to undertake hypothesis testing and predictions prior to the practical class, interpret the results and review the submitted predictions after the class [5]. Goldberg and Dintzis discuss a blended laboratory class carried out at Johns Hopkins University for the "Organ Systems Histology" course [6]. Pre-laboratory instruction on a web-based overview lecture, a series of web-delivered slide-specific micro-lectures and a set of virtual slides with annotations are introduced to the traditional laboratory experiment.

The class and associated laboratory exercise "Use of PCR for detection of genetically modified sequences in soybean DNA" were discussed in Gibbins, Sosabowski and Cunningham [7]. Two sets of learning materials, manuals for instructor and students (traditional approach), and web-based support centered on a computer aided learning (CAL) package were used for two groups. Both sets of supporting materials were designed to meet the same educational objectives and used descriptive text, static diagrams, and problem-based learning. However, the CAL package has interactive animated diagrams, instant feedback on problems, a hyperlinked glossary, and a simulated optimisation exercise.

An interactive, online dynamic laboratory manual was developed by the Bristol ChemLabS project (www.chemlabs.bris.ac.uk/). The manual incorporates video clips, interactive simulations, formative and summative assessments, and eliminates the need for lab recordings after every class. Some of the complex concepts and techniques can be easily illustrated by videos, which students find a useful resource to prepare them before the actual laboratory work. This also enables students to understand the level of hazards associated with laboratory work as well as to follow safe practices to prevent such conditions.

In a completely different class, Quinn and Robert describe the development of practices of art-making using the internet [8]. They briefly touch on trends in digitally mediated art-making practices, including digital photographic manipulation and collaboration. These art-making methods are important in art education because they increase the possibilities of idea generation and image making for artists in the field, and provide a source of inspiration for students in art classrooms. Such methods for eliciting creativity have potential application in subject matter taught in laboratory-based environments where creative thinking is required.

Endean and Braithwaite report a preliminary study carried out to investigate longer-term collaborative working between the Faculties of Science and Maths, Computing & Technology (MCT) and East China University of Science and Technology (ECUST) in Shanghai, China [9]. The work reported informs a plan to jointly develop an online experiment. The outputs from this preliminary project reveal the similarities and differences in approaches to the development of computer-based experiments in each institution; potential for and challenges in the adaptation of software and hardware for use in both locations; practicable approaches to sharing common facilities for the use of students of either institution; possibilities for creating inter-institution student teams to enhance learning and promote inter-cultural awareness.

The MARVEL project reported by Müller and Ferreira helps to arrange online labs, combined with simulation training and learning-by-doing on real-life systems, in an enriched learning environment [10]. It comprises learning tools or media, learning places and learning activities. The paper gives two examples of online labs, one providing access to a purely remote electronics experiment through LABVIEW and the other one combining remote devices and simulation models in a mixed-reality electro-pneumatics experiment. The equipment and devices used are connected to remote users via the internet. The trials conducted within this project led to conclusions that online labs provide flexible working hours with ubiquitous access and students were able to carry out the real experiments without safety concerns.

3. Transformation from Traditional to Online Delivery

It is recognised globally that higher education institutions are highly vulnerable to community transmission of the COVID-19 virus and almost all universities suspended face-to-face academic activities, implementing alternative ways of teaching. One of the techniques adopted by many universities was switching to online delivery. COVID-19 is not the only time universities have switched to online delivery; for example, according to Murphy [1], in Fall (autumn) 2009 some universities switched from face-to-face classes to online delivery during the H1N1 Influenza virus. Further, after Hurricane Katrina's landfall in August 2005, a consortium of 153 colleges and universities reacted quickly to create an online catalogue of more than 1300 courses.

Endean discusses a number of points to be considered when developing online experiments. The author states that it is important to offer virtual experiments while incorporating pictures/data of actual equipment, show good results from real experiments and to connect to real industrial processes [9].

Crawford discusses the responses of higher education institutions in 20 different countries including China, USA, Germany, UK, Singapore, India, and Hong Kong to COVID-19 and how academic programmes were conducted [11]. Even though the paper provides a comprehensive review, no particular information is provided for the delivery of laboratory experiments except mentioning that in Hong Kong, laboratory work was suspended.

4. Student Experience

The COVID-19 outbreak has disrupted learning activities and the university life of students, and introduced anxiousness about when life will return to "normal". Even though face-to-face teaching is now substituted by online options, very little has been done to fulfil the myriad of opportunities provided by university life for entertainment, leadership, socialising, community engagement, etc.

During the university closure and lockdown, students may be developing feelings of fear, stress, worry, and isolation. Many universities are providing online help for students to overcome these feelings. For example, the University of Melbourne advises students to move to activities that they can do while staying at home so as to continue learning, such as maintaining studies, reading a book, listening to a podcast, trying out a new hobby or skill, starting a virtual book or movie club, joining an online group or peer forum, etc. [13]. In addition, students will have plenty of opportunities to expand their education. There are a good number of options such as Coursera, FutureLearn, and edX available for one to pick from, develop skills and acquire knowledge.

There is a high probability of graduating some of the COVID-19 cohort of students without adequate laboratory skills and practice; they may be at a long-term disadvantage, compared to those who studied "normally," when they move to another level of study or enter the labour market [12].

The opportunities to obtain collaborative learning experiences enhance the effectiveness of learning. Müller and Ferreira report how online labs allow students to work together as peers, applying their combined knowledge to the solution of a problem and to test and refine their understanding [11]. Furthermore, they pointed out how the interactions among students provide opportunities to acquire various soft-skills, such as the ability to work in teams and to achieve objectives in co-operation with others and to integrate the know-how of others in order to accomplish a given task. Online delivery through a solely asynchronous mode at best hampers and at worst denies most of the above opportunities.

5. Quality Assurance

For quality assurance, benchmarking is used to identify examples of excellence and best practice, and then these examples are used as the standard of comparison. Ensuring quality in online education is not primarily a question of IT support, but of academic strategy and educational design. Oliver states that the successful application of e-learning depends on such aspects as the scope and nature of the learning materials, appropriate selection of the learning design and resources and the manner in which it is delivered and supported [14]. These elements can be isolated and identified for benchmarking purposes.

The European Association for Quality Assurance in Higher Education published a document with standards and indicators for quality assurance for e-learning courses [15]. It states that the institutional policies for e-learning may include the constituent elements of quality such as institutional support, course development, teaching and learning, course structure, student support, faculty support with compulsory e-learning training for new members of staff, technological infrastructure, student assessment (learner authentication, work authorship and examination security) and certification, and electronic security measures.

The UK Quality Assurance Agency (QAA) issued a set of guidelines for Practice and Lab-based Assessment[16]. QAA has developed this guidance with their members and sector bodies for the benefit of the UK higher education community. It recognised that often there exists an element of psychomotor skill and competence involved in using or manipulating equipment and states that the method of assessment of these can be modified so that it can take place remotely. The alternative methods that can be used for remote assessments include presenting students with datasets and asking them to interpret them, using remote simulations such as an experiment being conducted in a video presentation where students can see the data being produced and finding programming tasks that can be undertaken remotely rather than in a laboratory. The QAA document also states that such remote assessment methods should consider the degree to which the learning outcomes assess skill and competence in the use of equipment, and if the learning outcomes require the demonstration of laboratory skills using laboratory equipment, then those assessments have to be postponed. However, if the competence in handling equipment has already been demonstrated elsewhere in the course, then even if such a skill is listed as a learning outcome of the module, the assessment of that particular competence can be ignored.

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Keywords

COVID-19;pandemic;higher education;student learning;online delivery;laboratory workshops