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Redevelopment of undergraduate food microbiology capstone projects for unprecedented emergency remote teaching during the COVID-19 pandemic: then and now

Yianna Zhang[A] and Chaminda Senaka Ranadheera[A,*]

For full list of author affiliations and declarations see end of paper

***Correspondence to:**
Chaminda Senaka Ranadheera
School of Agriculture, Food and Ecosystem Sciences, Faculty of Science, The University of Melbourne, Vic. 3010, Australia
Email: senaka.ranadheera@unimelb.edu.au

ABSTRACT

Unprecedented emergency remote teaching (ERT) during the COVID-19 lockdowns has hindered research-based learning in the life sciences worldwide, holding potential consequences for the students' ability to develop essential skills for the contemporary workforce. In this article, we report redevelopment of an undergraduate capstone subject in the food science major at The University of Melbourne for bichronous ERT delivery, which previously aimed to provide students with analytical, problem-solving and communication skills through laboratory-based practical experimentation or internship projects. When in-person exchanges became unfeasible during 2020, we redesigned the online learning environment to best facilitate personalised learning and collaborative relationships between learners, instructors and subject content. This includes the redevelopment of laboratory-based projects as data mining or literature reviews delivered under four major themes including food microbiology. Despite the drawbacks in peer-based interactions through remote delivery, participation in design-based research remains a viable approach to support students in gaining essential transferrable skills during ERT.

Keywords: emergency remote teaching, food microbiology, food science, microbiology education, online delivery, research-based learning.

Introduction

The COVID-19 pandemic imposed abrupt disruption of the higher education industry worldwide, with institutions adopting emergency remote teaching (ERT) through the use of technology-assisted online learning and isolated use of on-campus facilities.[1] Particularly, ERT defined as temporary shifts in course delivery in response to a crisis, differs qualitatively to deliberately planned online or distance education due to rapid improvision of learning solutions by instructors.[2] Although online learning management systems (LMSs) were widely used among Australian universities as an adjunct tool to traditional learning in the years before the COVID-19 pandemic,[3] the lack of face-to-face instructions during ERT necessitated redevelopments of curriculum, pedagogy and assessments across various disciplines. This brought challenges for practical fields such as microbiology and food science that are underpinned by the application of theoretical knowledge combined with manual dexterity *pro forma* in the laboratory. In particular, the absence of hands-on inquiry for undergraduates may compound enduring concerns of declining trends in the number of life science graduates.[4] The inquiry–action experience cultivates not only subject engagement, but also the acquisition of core competencies needed to promote sustainable development in our ever-evolving society.

The nature of online environments provides flexibility in the mode and timing of instructional delivery, allowing students to participate anywhere they have internet access. However, the substantial social and physical constraints can highlight fundamental hurdles for student engagement, a factor that correlates with academic achievement, persistence, perceived satisfaction and sense of community.[5] It has been reported that learner engagement can be supported through personal and contextual facilitators, such as personalised learning and redesigning of learning environments.[6] Under a context of online-only instructional delivery, these strategies can be operated on two primary modes: synchronous and asynchronous.[7] Synchronous learning requires attendance and participation in virtual classes set in real-time, whereas asynchronous supports student learning with access to learning materials on their own schedule, usually within a longer timeframe. Courses that strategically incorporate

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synchronous events into flexible learning, later termed bichronous by Martin *et al.*[8] have been linked to improved learning outcomes, retention and preference by students in several studies.[9–11]

Although there are successful reports of ERT alternatives to laboratory-focused microbiology classes,[12,13] there have been few describing alternatives to experiences incorporating empirical research and industry involvement into coursework activities. Here, we describe the redevelopment of bichronous ERT strategies in a food science undergraduate capstone subject at The University of Melbourne in 2020.

Food research & development capstone

As per the curriculum model introduced since 2008 at The University of Melbourne, undergraduate students initially acquire knowledge generalised to the study area through core subjects, followed by the pursuit of disciplinary specialisation through major electives. 'Food Research & Development (FOOD30009)' is the final year capstone subject in the food science major of the Bachelor of Science, which takes an explorative approach to synthesise the students' existing fundamentals with intimate knowledge of a contemporary issue or trend observed in the food industry. This allows them to embed design-based learning in applying the microbiological, chemical and processing principles that the students have previously acquired studying the major. In the subject, students are led by a series of lectures (face-to-face delivery before COVID-19 pandemic) and reading material on the systematic and regulatory processes involved in food science research process and product development. This is followed by the preparation and revision of a research proposal, either as individuals or small groups (2–3 students) and the design is executed under a laboratory or industry internship setting within the semester. This process allows students to build on new knowledge through creativity and problem finding, in addition to developing transferrable research and problem-solving skills.[14] Additionally, the freedom in project selections promotes a learner-centred environment, in which the students' individual skills, knowledge, attitudes and beliefs are accounted for in their learning process.[15] Such inclusion is particularly important given the diversity of cultural and language backgrounds in Australian universities, where 23% of all students were born outside of Australia, representing over 140 countries and 125 languages.[16]

Assessments for the subject comprised a 1-h mid-semester exam of lecture content (25% of total, week 7), a 10-min oral presentation of their project outcomes (25%, towards the end of the semester) and a written project report of 2000 words (25%, at the beginning of the examination period). These assessments involved in research project are designed to support students through two major learning outcomes, which are to:

(1) design and execute product development trials and experimental food studies, and
(2) critically evaluate and effectively communicate food research & product development experimental outcomes.

Subject redevelopment for ERT in 2020

Prior to the pandemic, the subject was delivered throughout the semester over a total of 48 contact hours, consisting of 1 h of in-person lecture, and 3 h of practical project-based work equivalent weekly. The learning outcomes and pacing remained consistent when face-to-face delivery of the subject was initially disrupted during the 2020 COVID-19 lockdowns. Firstly, we redesigned the LMS to support the reciprocal interactions and collaborative relationships (between learner and instructor, among learners, and learners with content) required for learner engagement in an online community.[17] The weekly lecture (1 h) and project-based activities (3 h) were delivered across total of 4 h weekly to facilitate the learning time, maintained through synchronous live-video teleconferencing. In addition to didactic instruction, attempts were made to provide students with opportunities to engage in interspersed brainstorming activities during these sessions. To enhance the perspectives covered in these sessions, we have invited guest lecturers from both industry and academia, as well as research students to present their experiences on research, collaborating with industry partners and seeking employment in the field as well. These interactive meetings aimed to connect the students with prospective colleagues, where they could gain insights on the hands-on components of their career pathways where physical access was unavailable. Additionally, a range of multimedia learning resources were added in the form of videos (e.g. Zoom, PowerPoint), readings and examples of previous student work.

The learning objectives were kept unchanged during ERT as those learning objectives are highly appropriate for an undergraduate capstone project integrating the students' existing knowledge with new applications. Whereas practical projects were achieved prior to the pandemic through industrial or on campus laboratory settings, during ERT delivery they were redeveloped into individual online research projects, which can be undertaken either through data mining or literature review. Similar to the design of practical project work prior to the pandemic, the projects during ERT delivery covered four major themes: (1) food chemistry & biochemistry, (2) sensory & consumer sciences, (3) food processing, and (4) food microbiology. The food microbiology projects were delivered under three timely sub-themes: (1) the gut microbiome, (2) food fermentation, and (3) microbiological aspects of food safety. Those undertaking literature review projects were allowed to choose any topic of their interest pertinent to these themes after discussion and approval from the subject coordinator, although a selection of suggested topics was also supplied (Table 1). This option enabled students to investigate the existing scientific literature or legislative framework governing the topic, either to provide a generalised coverage or to focus on a subtopic.

The data-mining projects involved the process of discovering patterns and correlations within existing datasets. Students who selected the option were provided with a list of mock data, where one or two topics were provided for each of the major themes to choose from Table 1.

Both instructor and peer-based feedback were integrated to support students through project-based work. This included

Table 1. Example food microbiology literature review and data mining projects developed during ERT delivery of food science capstone project at the University of Melbourne.

Literature review projects	
Sub-theme 1: gut microbiome	Dietary influence on the human gut microbiome and its impact on health
Sub-theme 2: food fermentation	Microbial profile and organoleptic changes of kimchi during fermentation
Sub-theme 3: microbiological aspects of food safety	Microbiological safety of ready-to-eat fresh produce
Data mining projects	
Probiotic viability in plain and fruit yoghurts	

a mid-semester progress meeting with the subject coordinator, weekly virtual office hours, as well as participation through discussion boards. We ensured that students' oral presentations were given ~1 month prior to the final report was due for assessment, so that sufficient time was provided for the students to incorporate constructive feedback from peers, the subject coordinator and tutors. ERT delivery changed the nature of this subject significantly compared to face-to-face delivery before the pandemic. Although redevelopment of the subject was unable to provide laboratory-based research skills as previously, this helped in achieving learning objectives at a highly satisfactory level.

Remarks and future directions

There are many key challenges highlighted in various recent reports of tertiary education that transitioned to ERT during the COVID-19 outbreak. For example, 'lack of/insufficient peer interaction' was observed in 29% of the responses in a national survey of 118 registered Australian higher education providers, administered by the Tertiary Education Quality and Standards Agency (TEQSA) in November 2020.[18] Similarly, a national survey of 1008 undergraduates in USA, conducted in May to June 2020, reported a fall prior to transition to ERT from 51% of students being very satisfied to only 17% after.[19] Both studies have suggested that the learners did not attribute these issues to poor preparation, instruction or digital skills of the instructor, but the nature of online interactions that do not equate to the colour and spontaneity involved with face-to-face interactions.[18,19] Our key challenges during this redevelopment were to maintain the quality of subject material and make understanding of assessments, which were also reported among the most frequent problems in those studies. Innovations we implemented such as online discussions, mid-semester individual student progress review meetings and weekly virtual office hours in this capstone subject were useful for addressing these challenges. Apart from the subject design, students' agentic engagement is likely to play a role in their personal interpretation of their studying requirements,[20] students have reported to being more receptive to asking questions online compared to in-person,[21] and the decision to maintain of 3–4 h of contact hours per week in synchronous sessions during the redevelopment of the subject was to further enhance such student engagements. Efforts to personalise learning can allow for better differentiation of needs from individual students, fostering student comprehension but less collaborative discussions with their peers.

One of the most frequently referenced frameworks in effective online learning is the Community of Inquiry (COI) model, which considers that teaching and learning is an interactive process that requires cognitive, social and teaching presence.[22] Some elements of the model are inherently reflected in process of research-based learning, which actively explores cognitive presence through the integration of new empirical findings with existing knowledge, reiterating optionality through a series of systematic decision-making processes, and finding resolutions to the initial inquiry. Key concept we used in this subject redevelopment was that teaching presence, through the instructors' role in providing foundational knowledge and feedback, is achievable virtually without students perceiving the contact hours as being excessive. The key barrier appears to be cultivating better social presence, where future online peer-to-peer communication may be improved by mediating the use of inclusive language, verbal indicators in place of text (e.g. emojis) and being responsive to others.[23,24] Brzezinska[24] also suggested that participation in project-based group work and engagements may augment social presence, which can be encouraged among students.

Despite the return of on-campus learning worldwide, there is recognition that the shift to remote learning modes is likely to remain in science education to varying degrees.[13,25] As such, further research on designing science, technology, engineering and mathematics (STEM) curricula with elements of online delivery is critical to enhance interest and development in the life sciences in the post-COVID world. To solve modern society's 'wicked problems' such as antibiotic resistance, modern science graduates are not only expected to have a broad knowledge base, but also the ability to adduce, reconcile and seek competing evidence through higher-order thinking.[26] Design-based learning, such as through the subject described can play a key role for students to integrate their basic knowledge in creative, more interconnected ways.[27] Evaluations of online education, particularly those moving beyond didactic instruction, are thus instrumental to create student experiences that maintain engagement and promote honing of research and critical thinking competencies.

The subject continued to be delivered online in 2021, as local COVID transmission conditions in Melbourne saw continued lockdowns in the city. Similar to 2020, we maintained the subject apparatus, learning outcomes and project options of literature review and data mining to students enrolled in 2021. In 2022, the subject returned to a contemporary model of face-to-face delivery with digital support, similar to before the pandemic. Although ERT

during the lockdowns was designed to provide a temporary teaching solution that is not robust long term,[28] feedback from the remote experience was valuable in creating more articulated use of technology for conventional learning today. In 2022, with returned to the face-to-face delivery of the subject, we have adopted designated support for asynchronous learning through weekly virtual office hours, and personalised feedback through mid-semester project progress meetings with the subject coordinator. These activities, among other beneficial examples of the flexibility offered by digital access currently recognised in the literature,[29] can be valuable adjuncts to enhance the students' hands-on learning experiences and to ensure that their learning objectives are met.

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Author affiliation
[A]School of Agriculture, Food and Ecosystem Sciences, Faculty of Science, The University of Melbourne, Vic. 3010, Australia.

Biographies

Yianna Zhang is a PhD candidate and an academic support in food sciences at the University of Melbourne.

Dr Senaka Ranadheera is a food microbiologist and innovative educator. His research interests focus on probiotics and prebiotic food applications.