Chemical Engineering

Education
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… Words from the EdSIG's Newsletter Editorial Team…

If anyone would like to write an article for the newsletter about good practice, previous EdSIG events or school outreach, or anything else that you think our community would find it interesting - please do not hesitate to get in touch at edsig.news@ichemememember.org.

On top of that, EdSIG is trying our best to provide channels of communication and support to all Chemical Engineering Departments by sharing useful practices about online learning and assessment that are badly needed during closure of universities due to the Covid-19 pandemic. Please write to us if you have any good tips or experiences to share with the community at edsig.news@ichemememember.org.

Online Teaching & Assessment: Tips and Resources

The Utilisation of Virtual Field Trips As a Replacement to Engineering Real Field Trips

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Globally, incorporating real field trips into engineering courses has been on the decline. Given advances in computer sciences in the last decade, Virtual field trips have been introduced to replace Real field trips. The implementation of high-quality virtual field trips has a number of pedagogical advantages from both teachers' and students' perspective.

A study conducted by the University of Waikato investigated the essentiality and usefulness of virtual field trip on student's learning as well as the acquisition of insight for designing an industrial scale plant. A mixed methods approach, involving, a combination of quantitative and qualitative methods was used to investigate the importance of different types of field trips in promoting student's knowledge and perceptions.

The primary research questions of the study were whether virtual field trips could replace traditional real field trips and how virtual field trip can promote student's industrial insight and knowledge about wastewater treatment before going to a real plant (Figure 1). This study also explored how a virtual field trips can stimulate students' interests in a way that allows them to discover more aspects of bioprocessing. The sample for this study comprised of enrolled third-year students in Chemical and Biological Operations course. On the whole, more than 95% (n = 42) of the students participated in this survey.

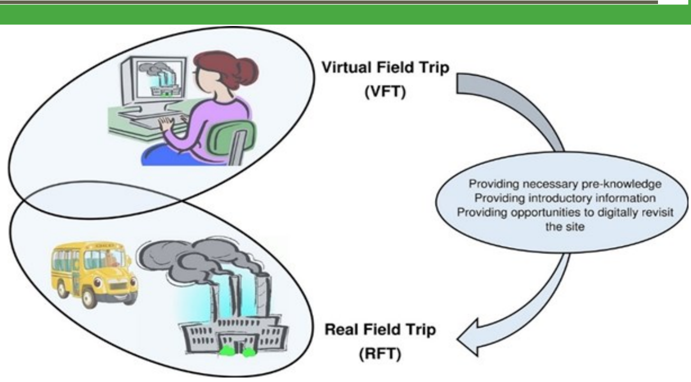

Figure 1. VFT can be a powerful supplement to RFT

Although this study reports on the indirect method used to capture students' perceptions of their learning through surveys, a direct method involving an evaluation of students' report and presentations upon completion of the course was also employed. Students were evaluated based on the quality of their reports and their performance in answering different aspects of wastewater treatment plant (Figure 2).

The results show that students rated real field trip higher as it enhanced their perceptions, provided an opportunity to communicate with experts in the field and witnessed how theoretical knowledge can be applied to practical knowledge. However, the lack of pre-information substantially decreased the effectiveness of real field trip. The results of this study clearly demonstrate that virtual field trips can be a powerful supplement to real field trip as it provides the necessary pre-knowledge to students in a way that maximises learning during the real field trip while concurrently providing opportunities to digitally revisit the plant after the real field trip has ended. However, the study also concludes that at this stage, the utilisation of virtual field trips as a standalone activity cannot guarantee an exact simulation of a physical plant visit.

Student survey statements.

No.	Statements
1	Virtual field trip increased my interest in learning more about wastewater treatment process
2	Real field trip increased my interest in learning more about wastewater treatment process
3	After watching the virtual field trip, I learned more information on wastewater treatment than I knew before
4	After attending the real field trip, I learned more information on wastewater treatment than I knew before
5	I am able to determine all wastewater treatment unit operations after doing a virtual field trip
6	I am able to determine all wastewater treatment unit operations after doing a real field trip
7	I am able to determine all wastewater treatment unit operations by combining both field trips
8	I am able to understand the exact reaction mechanism in each unit operation just by doing a virtual field trip
9	I am able to understand the exact reaction mechanism in each unit operation just by doing a real field trip
10	I can explain in detail where I was at all times while doing a virtual field trip
11	I can explain in detail where I was at all times while doing a real field trip
12	The virtual field trip provided the same sorts of information as the real field trip
13	I would have preferred to take the virtual field trip instead of visiting the site in person
14	I would prefer to take both real and virtual field trips together
15	I easily get lost when watching the virtual field trip
16	I easily get lost when going on the Real field trip
17	If time permitted, in real field trip I would prefer to stay and explore more details of the plant
18	If time permitted, in virtual field real I would prefer to watch and explore more details of the plant
19	I would take an engineering biotechnology course with a field trip instead of a course with no field trip
20	Both the virtual field trip and real field trip are required for understanding a wastewater treatment plant

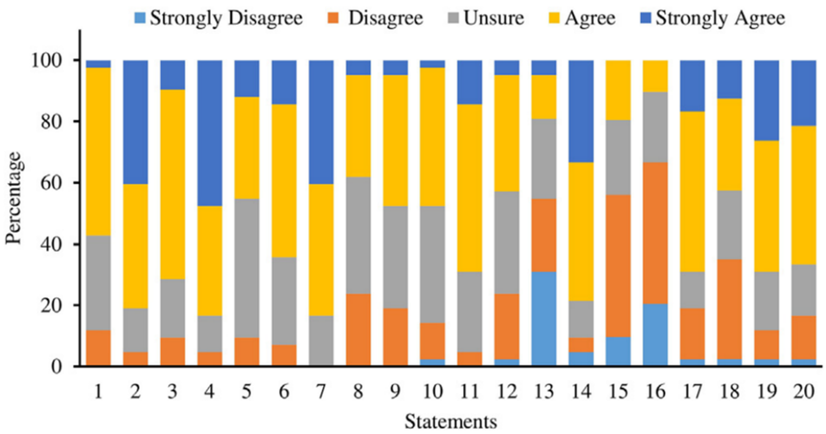

Figure 2. Students' responses to the survey statements

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Good Practice Exchange

Problem Based Learning in Introduction to Engineering Course for Chemical Engineering Students

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Introduction

Universiti Teknologi Malaysia (UTM) introduced their 'Introduction to Engineering' course in 2006 and it is a compulsory course for all engineering faculties. Problem solving is one of the key components in problem-based learning (PBL); therefore, students are assigned with actual case study in this course. For this year, 'Love Our River Campaign (LORC)' was chosen as the theme for the case study. Efforts had been made to liaise with the local city council and real case study was created for the students in the form of competition. In this competition, the students were required to propose innovative engineering solutions to improve the conditions and quality of Skudai River in particular, and rivers in Malaysia in general. The proposed solutions were expected to be innovative, practical and feasible, based on sound scientific principles of the product or process recommended. The solutions should be supported by detailed economic analysis and strong justification in accordance with the three pillars of sustainable development. At the end of the semester, the students' innovations were exhibited and judged by representatives from academia, city council and other relevant bodies.

Group Formation

In the beginning of semester, students were divided into groups of 4. The groups were formed based on careful consideration of various factors including gender, races, cultural (hometown) background and academic achievement. Each group must have diversity in all these aspect so that besides achieving the technical outcomes of this course, the soft skills especially related to interpersonal and team working skills can also be acquired as well.

Course Implementation

In this course, Cooperative-PBL (CPBL) approach is applied instead of conventional lectures. In CPBL, problems or case scenarios act as a stimulus for learning and encouraging active processing of information as well as activation of prior knowledge with opportunities for elaboration and organisation of knowledge. Basically, the CPBL process is applied in class to solve the case study comprises of three main phases of **Phase 1:** Understanding the problem, **Phase 2:** Learning and **Phase 3:** Solving (Figure 3).

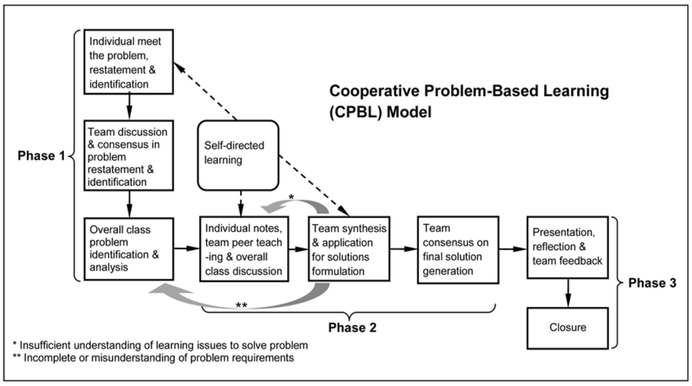

Figure 3. The Cooperative Problem-Based Learning (CPBL) Framework [1]

Phase 1 requires students to individually prepare and submit a problem restatement and identification (PR&PI). Problem identification allows students to link the problem to their prior knowledge. Learning issues identified during this activity guide them to do further information seeking and analysis before they solve the problem. Once the individual PR&PI is submitted, students need to present and discuss each of the learning issues they have identified together with the team mates before coming to a consensus on the finalized list to represent their team. Following this, the overall class problem restatement and identification is conducted.

In Phase 2, each of the team member prepares peer teaching notes based on the learning issues identified in Phase 1. Preparing teaching notes enable students to learn new knowledge by extracting important concepts and information, explaining what they understand, and inquiring what information they need to know to solve the problem. Students need to be responsible and accountable in determining the reliable resources they will need to use to accomplish their task. Each student must hand in their individual peer teaching notes through e-learning. Likewise the PR&PI activity, in this phase, students first need to learn in their team, followed by an overall class discussion (see Figure 4). Our role is to facilitate the overall class peer teaching discussion so that the students understand the learning issues well before reaching to the consensus in their learning of the issues that have been pre-determined in phase 1. At this stage too, students need to perform data collection based on the topic of the sustainability project assigned to them for that semester. For example, for the recent September 2019 session, students need to collect data on water quality from sampling premises within the campus area (see Figure 4). It is also our responsibility to provide support for students to be accountable for their own learning, and to learn together as part of a learning community.

Figure 4. Data collection (left) and overall class teaching activity (right)

In Phase 3, the teams submit the final report and present their solutions to the class. During the presentation, students are challenged to defend their solutions by justifying their choice of the best solution for the problem from the perspective of serving as an engineer in the future. During the closure, the facilitator provides feedback on the presented solutions. In some semesters, we also organized an exhibition for the students from all sections to showcase and present their innovations after working on it for the whole semester. Juries were appointed among lecturers from various schools in the university as well as other stakeholders (i.e. town council or NGOs) who are relevant to the topic of the project (see Figure 5).

Figure 5. Exhibition to showcase students' innovations

In addition, to internalize their learning process, students were required to write reflection journals as a closure to what they had learnt and went through throughout the CPBL process. The students were not only reflecting the technical content of the course, but also were encouraged to share their thoughts emotionally from different perspectives – as students, team member, group leader, member of the society, etc.

Overall, through CPBL process, students were able to develop various professional skills including communication, problem solving, critical thinking and life-long learning, as early as from their first-year study in the engineering course. Undoubtedly, CPBL that is currently implemented in some courses in UTM engineering program is a powerful approach in spreading the benefit of effective learning environment to develop high quality graduates of the future.

Reference
[1] K. Mohd-Yusof, Syed Ahmad Helmi Syed Hassan and F. A. Phang, Creating a Constructively Aligned Learning Environment using Cooperative Problem-based Learning (CPBL) for a Typical Course (2012). Procedia-Social and Behavioral Sciences, 56, pp. 747–757.

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Integrating Environmental Concerns Into the ChemEng Syllabus

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Protecting our natural world and having to learn how to do so, might seem obvious for a XXI century Engineering student. Nevertheless, this environmental awareness is a fairly recent development. It might seem unreal to read for instance this quote from 1907 by Henry G. Stoott (president of the American Institute of Electrical Engineers): "*Engineering is the art of organizing and directing men and **controlling** the forces and materials of nature for the benefit of the human race*". Clearly, for that engineer, human beings were above Nature and not part of it. With the current environmental awareness, it appears important to change this paradigm.

Our intellect has taken us very far in fields such as medicine, architecture, agriculture, industry, to name just a few. In order to achieve this level of "progress", our educational system induces us, as individuals, to become specialized in a particular occupation. Thus, we end up assuming jobs titles such as nurse, fireman, banker or even chemical engineer. In the narrow frame of a single species, we are very successful, our lifespan, quality of life, and population, have all increased remarkably. This is considered to be a positive development, but has become a problem when we look at the whole biosphere and its natural cycles.

For decades, scientists have been warning us about climate change, the alarming rate of disappearance of species, the increasing number of polluted water sources, etc. The reasonable conclusion is that our so called "modern civilization", created by industrial research and its implementation, does not fit in well with the biosphere that contains it. Our biosphere operates in cycles. Indeed, all "waste" from any living creature constitutes "food" for another. Therefore, in the natural world "waste" does not accumulate. Our industrial societies "extract" natural resources from somewhere in our Planet, "transform" these resources into "products", but in doing so, produce vast amounts of "waste" that end up somewhere else (in the Planet) and most of the time cannot serve as "food" for any natural cycle.

The story is actually worse than this simple picture. The so-called "products" are converted into "waste" too after a shorter or longer lifespan. Sadly all this waste is accumulating in our biosphere, damaging it both physically and chemically. Our linear progression of producing stuff is at the root of the problem. Our challenge should not be, "What do we do now with all this waste?" but instead, "How can production and consumption be organized so that there is no waste generation?" Indeed it might be interesting to go a step further: "Waste" is a human concept; the material flow in the biosphere does not produce waste.

What we are witnessing is that in the last few years different universities around the world have been integrating environmental concerns into the syllabus of Chemical Engineering, mostly through elective courses. Given the extent of today's environmental problems, it seems reasonable that environmental concerns come to permeate a university education. But, sometimes it is not easy to bring environmental topics into highly technical subjects. Our research group have recently published a paper in the Education for Chemical Engineers journal [1]. In it, we show how to integrate environmental considerations into the subject of mathematical optimization that might make it a worthwhile read (https://doi.org/10.1016/j.ece.2020.05.005).

Reference
[1] Fernández-Torres, M., Hildebrandt, D., Sempuga, B. and Caballero, J., (2020). Integrating environmental concerns into the teaching of mathematical optimization. Education for Chemical Engineers, 32, pp.40-49.

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Elsewhere in IChemE

ChemEngDayUK 2020— Postponed until 2021

Amid the evolving COVID-19 situation, the annual conference for researchers, scientists and engineers to share the latest technological advances and research in chemical engineering and related professions is postponed to 2021. New date for the event will be announced in due course. Registration and further information is available at https://www.bradford.ac.uk/ei/chemical-engineering/chemengdayuk2020/

Free Access to Education for Chemical Engineers Issue on Remote Labs

Virtual labs offer a teaching and learning solution in a rapidly adapting Covid-19 higher education landscape. Acquiring practical skills is a very important part of learning outcomes in any chemical engineering degree. Ensuring effective achievement of these skills with limited physical delivery is particularly challenging. This collection of papers focusing on virtual labs aims to help practitioners in developing their own resilient solutions to effective education in the context of restricted physical interaction with students.

This issue of the Education for Chemical Engineers journal is free to access at https://www.sciencedirect.com/journal/education-for-chemical-engineers/special-issue/1040RH69WVP until **November 2020**.