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Taking the Classroom to the Field

Hoong-Chor Chin, Soon-Hoe Chew
National University of Singapore (Singapore)
ceechc@nus.edu.sg; ceecsh@nus.edu.sg

Abstract

Civil Engineering students are trained to deal with a wide range of engineering work through solving well-structured textbook-type problems. However, in practice civil engineering problems are more complicated than what are typically presented in textbooks and tutorial problems.

To overcome this limitation, we design a third-year module that requires students to apply their broad engineering capabilities to tackle a real-life project involving a field trip and for the purpose of developing an infrastructure master plan for the village. The module is conducted in 3 phases over a 2-semester period: (1) a pre-trip phase, for students to receive instructions on infrastructure planning and to identify the field problem remotely, (2) a 2-week field-trip, for students to engage the villagers and township officials and to conduct ground surveys to scope the problem and (3) a follow-up phase, for students to acquire advance technical knowledge to finalize their proposed infrastructure master plan.

This module has 3 distinctive features: out-of-classroom learning, out-of-comfort-zone experience and out-of-box thinking. The out-of-classroom learning takes the students into the field where the real-life problem needs to be correctly identified and solution amiably derived through stakeholder engagement. The out-of-comfort zone experience is accomplished by adopting a field project in a small rural mountain village in China, away from the convenience of highly-urbanized Singapore. The out-of-box thinking requires students to draw on their understanding in various engineering and non-engineering disciplines to generate a feasible integrated infrastructure master plan for the village, while taking into consideration various constraints and conditions which are less familiar to the students.

The adopted teaching method proves to yield several important benefits as borne out in an evaluation survey. The complexity of the problem warrants the students to work as a team, particularly because they need to cross check their understanding of local issues. The opportunity to address real-life societal needs also helps to incentivise the students for life-long learning. The students find immense gratification, not just in producing a useful master plan for the villagers but also in winning the hearts of the villagers.

1. Introduction

To prepare them for professional practice, Civil Engineering students have to be trained to deal with a wide range of engineering problems such as structural design, hydraulics analysis, geotechnical investigation, transportation planning and environmental assessment. These problems are somewhat interrelated so that while there is room for specialisation, all civil engineering graduates are expected to have sufficient understanding in all these engineering fields. The typical undergraduate curriculum will include foundational technical modules targeted at helping students to acquire specialised knowledge and develop conceptual understanding in the various civil engineering disciplines. The ability to solve well-structured textbook-type problems is often considered a necessary test of student competency in each of these specialised disciplines.

In practice, civil engineering problems are more complicated than what are typically presented in textbooks and in tutorial problems. By nature, real problems are usually multi-disciplinary, multi-faceted and often ill-defined. Indeed, in a growing complex world, many of the civil engineering problems requires understanding of non-engineering issues, such as politics, law and climate change as well as soft skills, such as negotiation, conflict resolution and situation awareness. Hence, while the foundational modules are the basic building blocks in the Civil Engineering curriculum, they are insufficient to ensure students can function competently upon graduation. To overcome some of these limitations, most Civil Engineering programs will include some design projects to help students apply their acquired knowledge in the different civil engineering disciplines into an integrated whole. This is usually done at the later stages of the program when students would have sufficient knowledge and skills in the specific disciplines. However in such a setup, the exposure to inter-disciplinary studies

may be a little too late, especially when many students may desire to focus on building their specialisation in their senior years.

2. The Proposed Module

To provide an earlier exposure for Civil Engineering students to multi-disciplinary thinking in solving real-world problems and at the same time encouraging them to develop soft skills, we introduce a unique module in the third year of study known as “Socio-economically sustainable developments”. The module is set as a project to develop an integrated infrastructure master plan for a rural village in Yunnan, China. In achieving the project deliverables, students are required to appraise the engineering and non-engineering issues related to the project, acquire the relevant technical knowledge in the associated disciplines, source for the necessary input data using various appropriate engineering techniques, develop a technically-feasible master plan that is socially and environmentally sustainable as well as present the master plan professionally for acceptance by the community and political leadership.

The module is conducted 3 phases, spread over a 2-semester period: (1) a pre-trip phase, in which students will receive instructions and gather necessary information related to the field work, (2) a 2-week field trip, during which students conduct ground surveys and interact with villagers and township officials to prepare a master plan and (3) a post-trip phase, in which students acquire more advanced technical knowledge to finalise their proposed master plan and produce a professionally-written report.

During the first phase, lectures related to infrastructure planning, sustainable developments and survey methods are given. Non-engineering issues that influence infrastructure planning in China such as the Chinese cultural, geographical and political landscape along with the changing land-reform and rural development policies are also discussed. At the same time, in preparation of the field work, students are required to research into and present the socio-economic patterns, development plans and recent events of the county areas to be visited. This culminated in the students producing a set of documents, including maps and survey templates to be used during the field trip.

While the field trip is led and supervised by the academic staff serving as faciliators, students are required to organize themselves to manage the entire study trip with each student playing a specific role in trip administration, program execution and logistics coordination. As a final part of the trip preparation, a risk assessment exercise is conducted to ensure students are ready for the trip.

During the field trip, students toured the study village and the surrounding areas in the county, including the nearby villages, to gain a ground feel of the topographical, cultural and environmental landscape. In understanding the urban-rural contrast, the students also visited the Provincial capital city of Kunming and the County capital of Xinping.

However, most of the time is spent in the target village, engaging in sessions with the villagers at various levels – the village leadership, individual households as well as individuals. A *Participatory Rural Appraisal* is conducted in selected households by small groups of students to engage the villagers in the planning process and to ensure that the needs and aspirations of the villagers are considered in the planning proposal. In mapping out the study area, students are required to conduct a physical survey in the form of a *Transect Walk*, covering the settlement area and the arable lands as well as the village water catchment. This is necessary to determine the current land use and the natural drainage and transportation network. An important component of the field trip is the *Stakeholder Consultation Sessions*, a series of discussions with various stakeholders, particularly the township officials and those involved in land-use and infrastructure planning. Towards the conclusion of the stay, a draft master plan is shared with the villagers as well as the village and township leadership. Throughout the exercise, students are reminded constantly that to ensure sustainability and local adoption, their role is only instrumental and their views are subservient to the needs and desires of the villagers.

Upon completion of the field trip, students spend the last phase preparing for the final report. In finalising the details of the master plan and technical designs, students may need to gain advanced knowledge and understanding on specific engineering issues, such as drainage designs, natural energy designs, water treatment and bio-waste treatment methods. These are undertaken as independent studies according to the specific requirements arising from field study.

3. An Innovative Approach

Unlike other project-based modules, this module has 3 distinctive features making this an innovative approach to train Civil Engineering students. The unique features are: out-of-classroom learning, out-of-comfort-zone experience and out-of-box thinking.

(1) The ***out-of-classroom learning*** takes the students into the field where the real problem resides. While there are still several structured lectures and discussion sessions conducted in the classroom during the first phase, much of the learning is done in the field in the second phase. Typically students spent 20 hours of contact time and another 50 hours of personal and group study during the first phase but about 100 hours of engagement time with the villagers and town officials as well as among themselves and the facilitators. Students are encouraged to learn by observation and discovery while raising questions with facilitators and discussing or debating among themselves to seek deeper insights. For example, they are compelled to listen intently to the villagers and to observe their response and non-verbal behaviour and subsequently to validate their observations through triangulation. They are also forced to interpret and validate the ground conditions against their prepared documents such as google maps and published reports. This arrangement encourages student-centric learning and greater knowledge retention as well as cultivates a desire for continual learning. It also facilitates the development of soft skills such as verbal and non-verbal communication, project management, social interaction and situation awareness. For example, students observed how the facilitators engage the township officials in an official capacity to gain political support and in informal sessions to establish trust in relationships particularly with the village and township leaders. The facilitators need to demonstrate their ability to engage through service and negotiation and sometimes amicable resolution of potential conflicts.

(2) The ***out-of-comfort zone experience*** is accomplished not just by studying an area which is less familiar but also by gaining a rural experience, vastly different from the comfortable and convenient conditions of the urban environment in Singapore. Much of the work has to be undertaken on foot (including climbing of mountainous areas) and with a lack of modern technologically-supported amenities and sanitary facilities. The experience gives the student a greater awareness of the various social needs of the village but at the same time impresses them the tranquillity of rural living that is free of the many ills of urban developments. The “shock” experience enables students to be more mindful of the need for sustainable and eco-friendly planning, and a balance between needful development and harmonious quality of living. Obviously this awareness cannot be attained through mere reading or even watching a video on sustainable developments. The experience also inculcates in the students, a better sense of personal preparedness and resilience and as well as inspire students to have a deeper love towards fellow human beings and a sense of commitment towards society.

(3) The ***out-of-box thinking*** requires students to draw on their understanding (or even lack of it) in the various civil engineering and non-engineering disciplines to generate suitable solutions through a team effort. In deriving a suitable master plan, students need to appreciate the hitherto not-so-familiar historical, cultural, social and environmental setting that may constrain the problem and influence the solution. For example, in considering the evolution of Chinese society over the centuries, from feudal lords to kingdoms and to communist rule and modern socialism, the students become aware of the complex setup of land ownership and resource distribution in China, so that they need to shed some of the orthodox thinking in western land-use planning. Another example is the need for students to rethink the solutions, designs and engineering standards that are developed for multi-racial, highly urbanised, tropical island of Singapore to take into account the vastly different 4-season weather, mountainous and quake-prone environment as well as the minority-tribe cultural setting of the small rural village of interest. Clearly, students need to embark on exploratory thinking to challenge their potential prejudices. To facilitate this rethinking process, they have to draw lessons from practices elsewhere and from other applications. For example, they have to consider cases of rural developments in other parts of China as well as in other Asian and African countries. They will also have to examine the work in other disciplines, for example in rural health care and education, to draw parallel applications for infrastructure planning.

4. An Evaluation

A simple survey was undertaken at the end of the module to assess the learning outcomes based on the 10 criteria adopted by the Engineering Accreditation Board in Singapore, which are based on those set forth by the American Board of Engineering Accreditation. The results are shown in Figures 1 and 2.

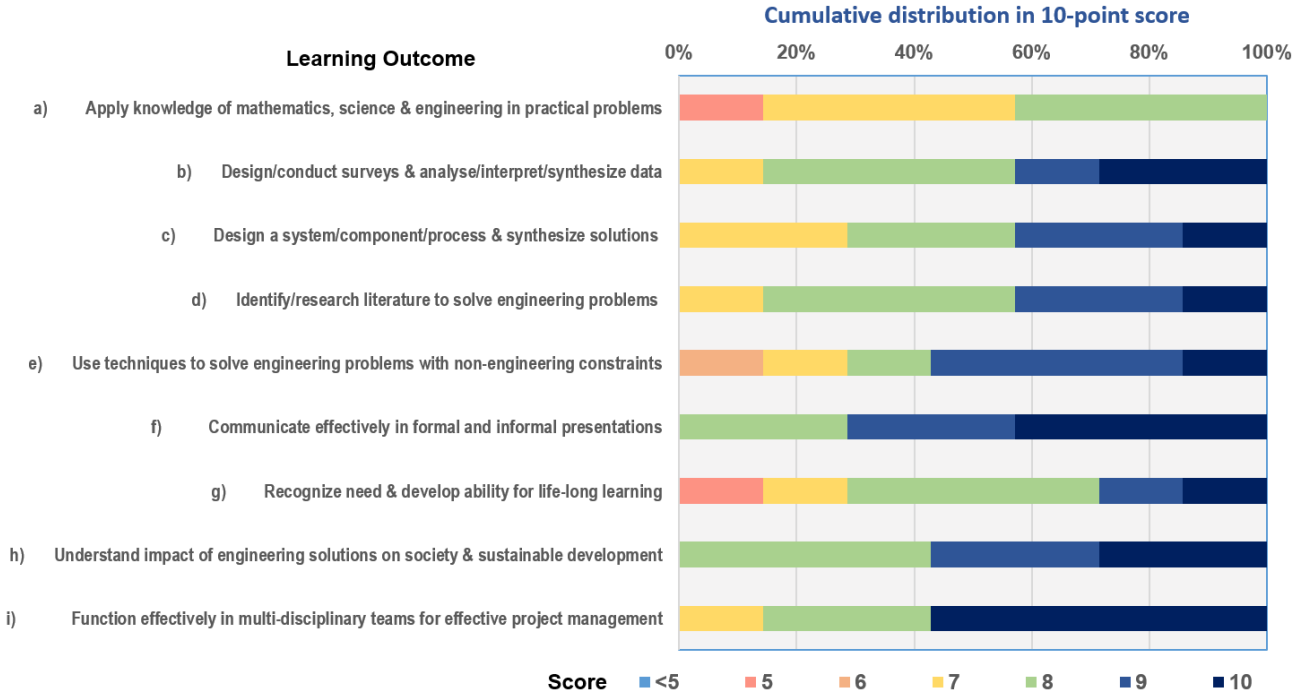

Figure 1 Cumulative distribution of score for each learning outcome

Figure 1 shows the module has achieved very high scores on almost all learning outcomes. In particular, the students valued the module highly for learning within multi-disciplinary teams and in communication. On the latter, it is not just technical communication but also inter-personal communication towards building relationships. The students considered the module to train them well in data analysis and interpretation as well as in system design and problem solving. They also gained understanding of the impact of engineering on society and sustainable developments. The module fared less well in training students to apply knowledge of mathematics, science and engineering. But this is because in deriving technical solutions, they had to go back to first principles rather than to rely on advanced theories of mathematics and science.

The students were also asked to rank the module against all the modules they have done on the basis of each of the learning outcome. Figure 2 shows the distribution of students ranking. Interestingly, the students ranked the module very highly with a significant proportion considering this as the best module in achieving some of the learning outcomes. In particular, many students considered this as the best module in enabling them to learn design and research as well as to appreciate engineering in society and sustainable developments. All these confirmed that the module has given them an early exposure on how to deal with complex real-life civil engineering problems.

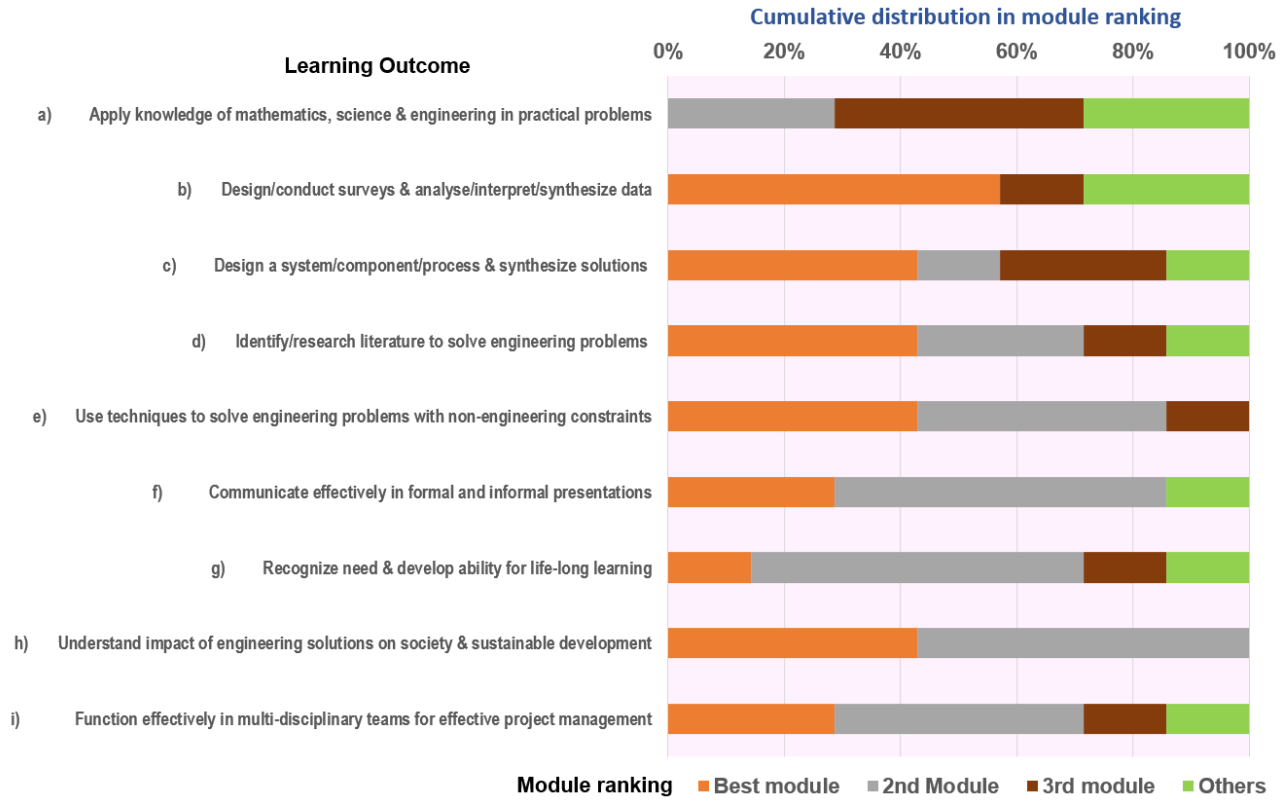

Figure 2 Cumulative distribution in module rank based on each learning outcome

5. Conclusion

In general, it can be said that the approach taken in this module has allowed students to learn, experience and think more effectively. Much of these rest on the field-trip experience and the intimate involvement of the facilitators, who served as role models in creative system thinking, diplomatic community engagement as well as down-to-earth engineering service. The module exposes students, not only to the wider world with its complex physical and environmental makeup but also to the diverse cultural and human system that will influence the practice of Civil Engineering.