Teaching Wind Engineering in the 21st Century: a co-player approach

John C K Cheung

School of Mechanical Engineering, The University of Adelaide, SA 5005, Australia

Abstract

The subject of Wind Engineering has been available for learning at workshops or conferences, or taught in class-room in specially organised short courses for practicing engineers and post-graduates. Until recently, the basics of Wind Engineering are introduced in some universities as an undergraduate elective for Mechanical and Civil Engineering students. As technology changes multifold in the past decade, instrumentation and equipment including teaching facilities are greatly advanced and so are the experimental and analytical techniques. Due to these technological changes, student learning at today's undergraduate level has also taken vastly different approaches than those of the graduate learners decades ago. Consequently, the pedagogy of Wind Engineering in the 21st century needs to be reviewed for effective student learning. This paper reviews these technological impacts and proposes a student-teacher play-together learning module for Wind Engineering that positions teacher and students as co-players within the framework of learning. This active learning strategy provides the opportunity for students to freely take part and reflect in their own learning process. The curriculum and assessment complement with peer-orientated components and promote experiential and life-long learning objectives.

Introduction

Wind Engineering has emerged in the past fifty years from the study of wind effects on buildings and structures to become an autonomous multi-disciplinary subject related to Meteorology, Fluid Mechanics, Aerodynamics and Structural Mechanics. Its content of study has increasingly expanded through the years, covering from the more traditional bluff body aerodynamics to socio-economic impacts, wind energy, fire propagation, vulnerability and risk assessments, and computational fluid dynamics, etc. Due to the global warming, it has been reported that extreme wind speeds are seen to have increased generally by about 5% in the last fifty years and the occurrence of tropical cyclone events is also shown to have become more frequent as a result of climate change. Innovative instruments such as laser displacement detector, high frequency base balance and electronic scanivalve have been developed during the last twenty to thirty years, enabling measurements to be made in a more accurate, automatic and instantaneous way. Getting a power spectrum by band-pass filtering or correlating two analogue signals recorded on tapes has been replaced by computerised technique achievable nowadays in the order of a second or less. The teaching of Wind Engineering inevitably has to change from what was learned twenty or thirty years ago. More importantly, the current student cohort of the Net Generation would have different expectations and would engage in different ways of learning from those adopted two to three decades ago. As Oblinger and Oblinger [1] have pointed out, university students nowadays are experiential learners who favour more graphics, rapid pace and immediate response. Working on peer-orientated team projects may be a more preferential learning activity than attending lectures inundated with notes of text and equations. The present paper attempts to develop a curriculum and assessment strategy for teaching Wind Engineering at undergraduate level to maximize effective student learning in the present technological environment.

The Objectives

The main goal of this paper on teaching in the 21st century is to change the traditional method of teaching or giving lectures in order to facilitate active learning in the student group by positioning the teacher as a co-director and co-player within the group. McWilliam [2] emphasized that now is the time to unlearn our old teaching habits and engage in the new ways to enable students' effective learning. Many previous works on teaching and learning have been published, such as Cannon and Newble [3], Biggs [4] and Race [5]. In particular, relating to wind tunnel studies, Baldock and Chanson [6] and Brodeur, Young and Blair [7] have applied problem-based learning strategies in engineering education. Yet there are few literatures so far adopting this active learning method in teaching Engineering. Halligan [8] and Gibbs, etc. [9] have suggested a number of active learning strategies, including games and role playing approach, some of which are adopted here.

The Co-player Approach: Learn as you play

The student-teacher play-together learning module provides the opportunity for students to freely take part and reflect in their own learning process within a framework of curriculum, as if they were playing tennis or any other ball games. They may move around freely within the boundary and hit the ball in any manner within a framework of some specific pre-set rules. The basic framework of curriculum for Wind Engineering to be delivered in a semester of 12 weeks of two 2 hour periods per week is given as follows:

1. The nature of wind
    - Basic meteorology
    - Types of wind storms
2. The atmospheric wind boundary layer
    - Wind profiles and power spectrum of wind speeds
    - Effects of topography and changes in terrain roughness
3. Wind climate and the analysis of design wind speeds
    - Probability distributions and extreme value analysis
    - Directionality of design wind speeds
4. Experiment: Wind characteristics of a turbulent boundary layer model of the natural wind
5. Flow around bluff bodies
    - Pressure and force measurements
    - Effects of turbulence, Reynolds number, surface roughness and aspect ratio
6. Along-wind response of structures
    - Aerodynamic admittance function
    - Gust factor approach
7. Cross-wind response of structures
    - Aerodynamic excitation mechanisms
    - Spectral approach
8. Experimental techniques in modelling wind effects
    - Model scaling requirements

- Wind tunnel test expectations

9. Experiment: Dynamic response of a tall building model in turbulent wind flow
10. Environmental wind speed studies
    - Criteria for human perception and comfort
    - Mitigation of wind effects
11. Dispersion of atmospheric pollutants
    - Basic concepts
    - Physical modelling
12. Applications of design wind loading codes
    - Evaluation of design wind speeds
    - Evaluation of alongwind and crosswind response

Peer orientated: Learn to enjoy

In week 1, students are allocated into five or six groups of 4 to 6 members on the basis of their academic performance in previous years. Each group consists of a mix of high, average and low achievers according to their previous academic results. Each week, students are given a set of tutorial problems to solve among each group. The group solutions are then marked by another group in the following week provided with a marking scheme, by rotation, so that each group will mark at least once of the other groups throughout the semester. Also, two experiments are set up in Week 4 and Week 9. Experimental data are collected and analysed as a team for each group. However, each student is required to compile an individual report for each of the experiments to be assessed by the staff member. This enables team investigations of wind-structure behaviour through experiments and individual conceptual development and analysis from the data collected in groups. Both assessments of the group tutorials and the individual experimental reports are formative, which enable feedbacks to students on their progress and ways to improve in their learning process.

From Week 2 onwards, at the beginning or the end of each class period, two to three students are given 5 to 10 minutes each to present a micro-teaching of a forthcoming topic within the framework of the curriculum. This peer teaching (students teaching students) presentation will be assessed by each individual student provided with guidelines on this diagnostic assessment in class.

Experimental learning: Learn from mistakes

Before the commissioning of the large wind tunnel with a working section of 2m by 3m at the Thebarton Research Precinct of the University of Adelaide by early 2010, model tests are conducted in the existing 0.5m by 0.6m wind tunnel with a 1/400 scale standard CAARC building model. This creates a huge error in the experimental results relative to full scale design values due to the wind tunnel wall constraints with a large blockage ratio of over 12%. However, the main aims of the experimental work are to broaden the understanding of the fundamental principles of wind engineering and bluff body aerodynamics in turbulent wind flow and to highlight some of the important features and requirements in modelling full scale natural phenomena in a laboratory.

Experiential learning: Learn from experience

Around Week 10 to 11, on a windy day, the class is to conduct a full scale study out-door at various high wind locations on campus depending on the wind direction at the time, such as at the base of tall building corners, on a rooftop, along the riverside, on an elevated plaza, in the gap between buildings or behind sets of sliding doors. Wool tuft and smoke flow visualization are used to demonstrate the wind flow through or around the building and topography. Each student is required to submit a learning reflection on this out-door exercise to increase the appreciation of the impact of natural wind on environment and to illustrate ways of mitigation of wind effects for human comfort. This 2-stage model (experience-reflection), as pointed by Neill [10], is an effective way to structure and facilitate experiential education.

Technological tools: Learn up-to-date

Apart from up-to-date technological instrumentation and analytical techniques as part of the curriculum, the use of multimedia presentation with videos, graphics and animations enables students to achieve deeper learning and easier understanding of basic principles. One example, as shown in Figure 1, has been used to demonstrate the Coriolis Effect causing an apparent deflection of moving objects (air mass) due to the Earth's rotation and how it relates to the tropical cyclone turning in the clockwise direction in the Southern Hemisphere. Also, virtual discussion board, on-line blog and wiki are seen to be welcome tools in today's collaborative learning.

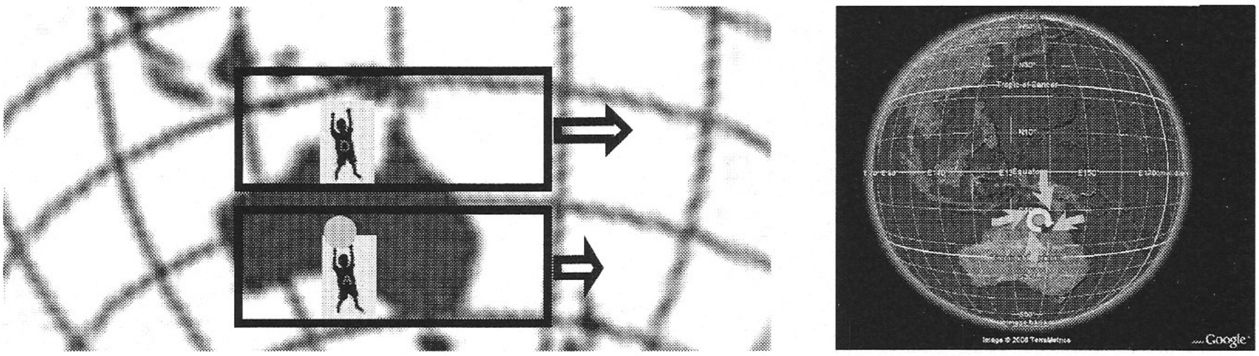

Figure 1. An example of using graphical animation to demonstrate the Coriolis Effect causing an apparent deflection of air motion from high to low pressure region, resulting in tropical cyclone turning in clockwise direction in the Southern Hemisphere

Life-long learning: Learn to learn (and unlearn as necessary)

It is important to conceptualise student research skill development in undergraduate years to enable self-learning to explore and evaluate independently throughout the life-learning process. Willison and O'Regan [11] have formulated a Research Skill Development Framework with various levels of student autonomy, which can be applied in the present course. Each student is to embark on an individual inquiry, either provided or self-generated, at the beginning of the course. The research work is assessed based on a summary report of finding at the end of the semester.

Assessments

The overall curriculum is based on 48 contact hours in 12 weeks including two wind tunnel experiments and one outdoor study on wind environment. Assessments are based on 15% peer orientated and 85% marked by a staff member. The peer assessment includes a peer-teaching (5%) and 10 group tutorials (10%). The rest consists of an outdoor learning reflection (5%), a research summary report (10%), 2 laboratory reports (20%) and a final examination (50%). Last but not least, special references to the prevention of plagiarism as well as unintentional plagiarism, as McGowan highlighted [12, 13], should be emphasized in the overall assessment.

Conclusions

The teaching of Wind Engineering in the 21st century can be greatly enhanced using a co-player approach with active hands-on strategy to enable students' effective learning process. This paper details the framework of the required curriculum designed with student orientated peer teaching, peer assessment, laboratory and outdoor experience as well as undergraduate research on an inquiry based topic. As in Confucius saying, 'I hear and I forget, I see and I remember, I do and I understand', the proposed teaching method with active student involvement would promote life-long learning and understanding of the basic principles. As this teaching method is to begin in 2009, this project is still a work-in-progress. Although the overall teaching method aims to achieve student-teaching co-playing active learning approach, evaluations from the students' perspective are yet to be found out next year.

References

[1] Oblinger D.G. and Oblinger J.L. (2005) Educating the Net Generation, http://www.educause.edu/educatingthenetgen

[2] McWilliam E. (2008) Unlearning how to teach, *Innovations in Education and Teaching International*, Vol. 45, No. 3, August, 263-269.

[3] Cannon R. and Newble D. (2006) A Handbook for teachers in universities and colleges, a guide to improving teaching methods, 4th edition, RoutledgeFalmer.

[4] Biggs J. (1996) Enhancing Teaching through Constructive Alignment, *Higher Education*, Vol. 32, No. 3, October, 347-364.

[5] Race P. (2007) In at the deep end – starting to teach in higher education, Leeds Metropolitan University, CLPD site licence for intranet use only.

[6] Baldock T.E. and Chanson H. (2006) Undergraduate teaching of ideal and real fluid flows: the value of real-world experimental projects, *European Journal of Engineering Education*, Vol. 31, No. 6, December, pp. 729-739.

[7] Brodeur D.R., Young P.W. and Blair K.B. (2002) Problem-Based Learning in Aerospace Engineering Education, *Proceeding of the 2002 American Society for Engineering Education Annual Conference & Exposition*, American Society for Engineering Education.

[8] Halligan C. (2008) Hands On, Minds On – Active Learning Strategies: (Engaging the Student in Learning), http://www.en.wikibooks.org/wiki/Foundations_of_Education_and_Instructional_Assessment/Edition_1/Table_of_Contents/Chapter_11/11.1.1

[9] Gibbs T., Brigden D. and Hellenberg D. (2005) Effective teaching through active learning, *South African Family Practice*, Vol 47, No 9, pp. 5-7.

[10] Neill, J. (2004) Experiential Learning Cycles, http://wilderdom.com/experiential/elc/ExperientialLearningCycle.htm

[11] Willison J. and O'Regan K. (2007) Commonly known, commonly not known, totally unknown: a framework for students becoming researchers, *Higher Education Research & Development*, Vol. 26, No. 4, December, 393-409.

[12] McGowan U. (2007) International Students: A Conceptual Framework for Dealing with Unintentional Plagiarism, In: Tim S. Roberts (ed.) Student Plagiarism in an Online World: Problems and Solutions. Information Science Reference, Hershey, New York. Pp. 92-107.

[13] McGowan U. (2005) Does educational integrity mean teaching students NOT to 'use their own words'? *International Journal for Educational Integrity,* 1(1), no pagination. Retrieved March 23, 2006, from http://www.ojs.unisa.edu.au/index.php/IJEI/issue/view/3