International Journal for Empirical Education and Research

Inclusive Curriculum Design: Application to Open Channel Hydraulics Module

Jaan Hui Pu
School of Engineering, Faculty of Engineering and Informatics, University of Bradford, Bradford DB7 1DP, UK
Email: j.h.pu1@bradford.ac.uk (Author of Correspondence)

Abstract

This study investigates an inclusive curriculum design based on student-centred approach. This proposed design approach has been applied to Open Channel Hydraulics module (CSE6008-A) at School of Engineering, University of Bradford, United Kingdom. This paper will introduce in step-by-step manner the full curriculum design and how the student-centred approach is being adapted in each step of the design. The required criteria will be designed based on learning outcomes design, curriculum organization, assessment strategies and student achievement evaluation. Besides, a key discussion will also be allocated for the inclusive practice that allows the vastly diverse student group to benefit from this approach, and a separate section will also be utilized to fully discuss this inclusive approach in the proposed curriculum design. This paper proposes a useful student-centred curriculum design concept, which is adaptable for different engineering modules.

Keywords: Inclusive Curriculum Design; Open Channel Hydraulics; Learning Outcomes; Curriculum Organization; Assessment; Student Evaluation

1. Introduction

According to study by Harris [1], the mis-match in skill profile has become one of the key factors for engineering graduates to struggle in industry's recruitment. This suggests that a well-designed module learning outcomes is significant in dictating an engineering student's future career. For effective design of the course, suitable and achievable learning outcomes for students are needed. To measure the achieve-ability of the learning outcomes, Biggs and Tang [2] proposed the constructive alignment in teaching, in which all teaching and assessment strategies are suggested to be aligned with the learning outcomes.

In this paper, the teaching of Open Channel Hydraulics (OCH) module's curriculum design will be examined and evaluated to determine its suitability under the inclusive educational practice. The module has been taught to the Stage 3 (Level 6) student under the Frameworks for Higher Education Qualifications (FHEQ). It has been run by the Department of Civil and Structural Engineering at School of Engineering, Faculty of Engineering and Informatics, University of Bradford. OCH is a crucial theoretical- and application-based module which aims to enhance students' hydraulic and hydrological knowledge. Along with Structural and Earth-Science based subjects in Civil Engineering, OCH represents an important module to prepare students for possible future career in hydraulic, hydrology and environment related sectors, and to widen their choice of career. However, unlike the traditional Structural and Earth-Science related modules, OCH faces many challenges in its design and implementation, e.g. to maintain its link with other existing modules, while design it according to the suitable knowledge level for Stage 3 students. Due to this, careful curriculum design was required.

2. Learning Outcomes Design and Implementation

To start the OCH module design, the identified learning outcomes were communicated and discussed with academic and industrial colleagues who have years of experience in the hydraulic and hydrology teaching/consultancy. The previous Staff-Student Liaison Committee (SSLC) and examination histogram reports were also investigated to identify the student feedbacks and performance, respectively, for possible improvements in learning outcomes design. An OCH teaching model from University of Leeds was also used as one of the guidelines for designing my module's learning outcomes [3].

First of all, since this module was designed to be taught to Stage 3 students, the module learning outcomes were structured to meet their adequate level. Students at similar level are expected to achieve a good in-depth understanding in hydraulic principles of free surface flows and to solve the practical engineering problems. [3] This poses a challenge as key attention should be given to the detailed technical designs and calculations, which students have not been very much exposed to prior to this stage of their degree. However, the effective utilization of laboratory-based lesson together with tutorial sessions in this module helped them to understand the key calculations and application concepts more effectively and less time-consuming. YouTube and engineering videos has also been used to give students good visualizations of various key hydraulic flow concepts and to strengthen their understanding of OCH.

Compared to typical fluid-based subjects e.g. Fluid Mechanics (FM), the scope of this OCH module is narrower but deeper. Besides focuses on the fundamental free surface flow aspects, OCH also emphasizes the hydraulic design and application components. Thus, it provides an ideal platform for students to develop necessary technical skills and build their skills profile, which is aligned with the expectation of their future employers. Students would also develop experimental skills in their laboratory session that could help in their future field work as engineer. Students were given a wide range of literature and reading materials in this module to further support their self-study, which classified as directed study. Besides, various support actions, e.g. class discussions and tutorials session, were also given to students to improve their learning and help to achieve the learning outcomes.

3. Curriculum Organization

It is a difficult task to maintain students' attention during any large class lecturing as investigated and agreed by Mann and Robinson [4] who found in their study that almost 98% of students bore at least some or half of the time during lecture. This further consolidates the need for change in traditional engineering teaching and learning (T&L) classes, since high quality students' learning depends on the teaching quality as suggested by Dickens and Arlett. [5] Besides, it is also crucial to always emphasize and maintain the student-centred approach in teaching as agreed by Ramsden's third level of thinking for teaching. [2,6] In other words, in order to maintain a student-centred approach in teaching, lecturer must facilitate the learning to take place and the class should be structured in a way that students can dictate the pace, e.g. by focusing on 'what the student does' as suggested by Biggs and Tang. [2]

In the design of curriculum for OCH, the key students' learning stimulator came from three key elements: the laboratory session, guided tutorials, and restructured lectures. Since this module only had a two-hour slot per week, all learning activities had to be organized efficiently. More specifically, the lectures were carefully designed to include more concise theories and calculation/worked examples, where the heavy derivation of formulae and long theoretical concepts were reduced or omitted. The lectures were also linked tightly with the laboratory and tutorial sessions, in which students could visualize the learnt theories and practice the conceptual designs and calculations.

ISSN Online: 2616-4833 ISSN Print: 2616-4817

In terms of organization of module, students were taught with the basic and general hydraulic knowledge during the early weeks of the term. Those lectures were mostly consisted basic ideas of design and straight-forward calculations. Various visualization techniques, such as videos and clips, were also used during this stage (more heavily used in this period, but also used throughout the module term) to stimulate students' attention and understanding. In those early lectures, the basics for further and deeper computational concepts were seeded into students during their learning. To facilitate good students' learning and to promote the deep-learning among them, the deeper concepts of hydraulic computation were systematically introduced to them in the later weeks of the term with right pace. This was supported by the tutorial and laboratory sessions, where 1) the tutorial sessions help students to refresh and practice the hydraulic calculations and designs they learnt during lectures, and 2) the laboratory session helps them to relate learnt concepts with the physical flow phenomena and to let them apply the concepts directly to compute those phenomena. The outcome on students' learning using such approach is encouraging, where positive feedbacks from students were given during the SSLC meetings.

This module was assessed in summative manner by a final examination. Before the examination, two fully-supported lectures were used for the revision purpose. In the first revision session, the basic concepts and designs introduced in this module were revised. During this revision session, small worked-examples were used to re-consolidate and refresh the concepts students learned before. In the second revision session, a previous-year examination paper was fully discussed with the students in question-by-question manner. Unlike the tutorial, in this second revision session students were encouraged to solve the questions by themselves (rather than to discuss with their classmates). After given time for them to solve each question, the full solutions would also be presented and discussed with them. Students found these revision sessions very useful for their preparation of final examination as indicated in SSLC meetings.

Overall, the organization of teaching sessions and curriculum varied throughout the term, to support maximum learning outcomes from students. Sufficient contact hours in well-designed manner to facilitate the students' learning and needs, were supported by the students' self-study (directed study) hours. As reflected in SSLC discussion and final examination results, in which it was evidenced by the increase of the mean examination mark from previous year by about 3.5 marks and pass rate increased by about 10% during my first year took over as the module leader, the proposed method worked well. The main challenges faced in the design of this module's curriculum were to balance the time available and module contents, while balancing with the students' learning pace. The combination of lecture-tutorial-laboratory were useful to have coupling and multiple-dimensional teaching to fully facilitate the students' learning, and it was also found that this coupling method help to cover the module contents more efficiently as students' understanding increase while promotes students' deep-learning approach. The overall organization of curriculum will also need continual reviewing in every academic year to ensure the module deliverables and quality are maintained and even improved, where possible.

4. Inclusive Practice

The students' diversity has long been recognized as one of the utmost identity of the UK's universities. Each year at University of Bradford, the undergraduate student cohort, e.g. for Civil and Structural Engineering Department, is comprised from hugely diverse backgrounds, experiences and nationalities, mainly due to the oversea students' recruitment strategy. Thus, crucial attention has to be given to inclusive practice in the design of OCH curriculum. There are several researchers who have considered the inclusive and diversity issues in T&L. Grace and Gravestock [7] provided a multi-dimensional study of students' inclusivity in T&L for the Higher Education (HE). Anderson [8] has considered global diversity in learning, in order to achieve the 'knowledge inclusion' in between the HE sector and industries. Wolffram et al. [9] have more specifically investigated the gender barrier and inclusivity issues in engineering studies. All the above studies have concluded that inclusivity in HE T&L is an important yet hard issue to tackle, and the current global HE system needs further improvement to handle it.

In the current discussed OCH module, students were taught from the basic concepts of FM, which was required for the further designs and calculations in the later part of this module. Due to the students' diverse backgrounds and knowledge, no prerequisite was set for this module. This increases students' inclusivity to the module, but it also means that the contact hours should include the teaching of basic FM concepts. In this module, tutorial sessions have been utilized to discuss some of the basic FM designs and calculations at early of the term-time to give students better understanding on those concepts and to increase inclusivity of students from different backgrounds. The laboratory sessions for different group of students were run in mixture of male and female students, and the tasks were divided into physical works and laboratory calculations to make sure no students will be disadvantaged from the laboratory setting. At the inter-sections of the laboratory, student groups with different tasks would also discussed with each other about their respective findings.

In terms of learning process, most students tend to learn in a four-stage cycle (1. Concrete Experience - CE, 2. Reflective Observation - RO, 3. Abstract Conceptualization - AC, and 4. Active Experimentation - AE) as suggested by Kolb [10]. Even though it was a high-impact study, there were also several criticisms to the Kolb's cycle i.e. by Wierstra and de Jong [11], and Coffield et al. [12] Coffield et al. [12] summarized numerous criticisms on the perfectness of Kolb's model; while Wierstra and de Jong [11] proposed a one-dimensional

ISSN Online: 2616-4833 ISSN Print: 2616-4817

bi-polar model (reflection versus doing) as a substitute to the four-stage cycle. In the summary given by Kolb and Kolb's [13] factor analysis study using 17 different publications on the supportiveness to Kolb's model, it was found that seven studies supported; four mixed supported/criticized; and six did not support the Kolb's theory. As a concluded from afore studies, students' learning can occur in all or a single phrase in the four-stage learning cycle. Thus, all different stages of the learning cycle should be emphasized in the T&L strategy to facilitate the maximum and complete learning for students. In OCH module, students were taught by several different methods (including lecturing, experimenting and discussing) each complementing others to achieve maximum learning outcomes among students from different backgrounds and to completely cover all four phrases in the learning cycle proposed by Kolb's model. Lecturing can promote the conceptualization (AC) of the hydraulic and hydrology theories; discussion during the tutorial sessions can enhance the students learning by observations and reflections (RO) among classmates; and experimentations during the laboratory works can help students to experiment (AE) and hence achieve the required hand-on experiences (CE) that were useful for the understanding of the concepts and designs taught in OCH lectures. This complete teaching method can inclusively promote learning among the diverse cohort in OCH module.

5. Assessment Strategies

According to Maclellan [14], there are different perceptions from tutors and students in terms of the assessment for students' learning. In Maclellan's study, 80 faculty staff and 130 undergraduate students were surveyed for their experience in course assessment. The study revealed that majority of students took part thought assessment was an educational grading process; while their tutors thought that it is a process to aid students in their learning. Houghton [15] further investigated the assessment techniques for engineering students in HE and summarized that 1) the feedback and 2) the relevance of assessment materials to real-world engineering issues were crucial elements for successful assessment of students' learning.

In the context of OCH module, final examination was use as the summative assessment due to the module are mainly mathematical and calculative-based. It was a two-hour closed-book written examination that consisted four questions in Section A (students had to choose two of them to answer) and a compulsory question in Section B. The use of standard scientific calculator was permitted in the examination as it consisted high-level of calculative-based questions. It aimed to test students' understanding on various taught topics and calculative concepts (as prescribed by the learning outcomes). To promote the student deep-learning, all main taught topics were embedded into questions in Section A (without exclusion), and the laboratory works were tested in the compulsory question in Section B.

Besides, a formative assessment was also utilized for this module in its laboratory session. During the laboratory class, groups of students were required to measure experimentally the characteristics in different types of flow setting. Then, they were required to use their respective measurements to calculate each flow behaviors. Through this, they can apply what they learn in the lectures into real engineering practice as emphasized by. [15] Also, this would prepare them to answer the compulsory question in Section B of their final examination, the summative assessment. After they completed their calculation tasks, feedbacks would be given to each group based on their own calculation. This can improve students' understanding on the lecture materials (since if they have any doubts during lecture, they can visualize the flow concepts in the experimental environment), and to immediately and effectively correct their mistakes, if any, in their respective calculations and flow designs. This also received good comments from students during SSLC as they found this feedback method very effective in correcting their misconceptions or doubts in practical (experimental) and theoretical (lecture and tutorial) aspects.

As outlined by Walker and Palmer [16] and more recently by Bamber [17], there is a challenge in examination preparation and how its feedback, if possible, to students can happen. Walker and Palmer's [16] study showed that statistically there was a strong correlation in between students' satisfaction and understanding on the course to their examination performance; while Bamber [17] proposed that the marking transparency can improve students' confidence to the examination. For the OCH examination assessment, general feedbacks were reported in the Examination Board for discussion with academic colleagues, and discussed with student representatives during SSLC. The correlation of issues, such as attendance, students' understanding during tutorial and laboratory sessions, to their examination performance were fully exploited during those meetings. During the SSLC occasion, feedbacks from students were also discussed for possible further improvement of the module's assessment method. Besides, the histogram of the examination results was compared to that of the previous year to identify the key improvements in assessment strategy.

6. Student Achievement Evaluation

In this OCH module, the final examination accounts of 100% of module mark. It was a reflection from the fact that this module is a heavy mathematic-based module where all hydraulic and hydrology concepts were taught in the calculative way to promote technical calculative skills among students. The hydraulic design theories taught in this module were also heavy mathematic-based as students were required to show the theories in relation to their calculations. Even though examination accounts of 100% of module mark, it was aided by several key formative components in this module (e.g. tutorials problems solving exercises, and laboratory works).

ISSN Online: 2616-4833 ISSN Print: 2616-4817

The laboratory session (together with its formative calculation exercises) were used for student to answer a compulsory part at the examination (compulsory question at Section B of the examination). To further promote the deep-learning among students as suggested by Biggs and Tang [2], the examination is constructed in such a way that all parts of the main taught topics were mixed and embedded into all four questions at Section A in the examination (so that students can not have any selective learning on the topics), and it presented a fairer way to judge students' progression and achievement for this module. During the tutorial sessions, students would be discussing the assigned problems/tasks (calculative or design-based questions) with their friends and classmates to promote maximum learning by cooperation among students. In this way, the stronger students can help the poorer students as to achieve the aim of learning outcomes and maximize the achieved understanding of students. This is also informally used as an indication and evaluation for the tutor to construct further and more helpful tutorial materials for improving students' understanding in the following years, and hence improve students' examination performance.

7. Conclusions

In this paper, an inclusive design approach has been proposed for adapting into the Open Channel Hydraulics module. The inclusive practice has been adopted into each and every designed element of the module, which include learning outcomes design, curriculum organization, assessment strategies and student achievement evaluation. The proposed inclusive curriculum design of the module has also been evaluated through meetings with students (e.g. through Staff-Student Liaison Committee - SSLC), and positive feedbacks have been received. The proposed inclusive method in designing the discussed module can also be applied into other engineering modules.

Acknowledgments

The materials used in this paper were formulated by the author during his dissertation submitted to the course for achieving Fellowship of Higher Education Academy (FHEA). It has been confirmed that there is no conflict of interest in this publication.

References

1. Harris S (2014). Why are Engineering Firms Struggling to Recruit Graduates? The Engineer Magazine.
2. Biggs JB, Tang C (2007). Teaching for Quality Learning at University. 3rd edn, SRHE and Open University Press.
3. Wright N (2011). CIVE3400 – Open Channel Hydraulics, School of Civil Engineering, Faculty of Engineering, University of Leeds, UK. (Electronic version:

http://webprod3.leeds.ac.uk/catalogue/dynmodules.asp?Y=201516&M=CIVE-3400%20-%20last%20accessed%2017/05/2017).

4. Mann S, Robinson A (2009). Boredom in the lecture theatre: an investigation into the contributors, moderators and outcomes of boredom amongst university students. British Educational Research Journal, 35(2): 243-258.

5. Dickens J, Arlett C (2009). Key Aspects of Teaching and Learning in Engineering, pp.264-281 in: Fry H, Ketteridge S, Marshall SA (eds.) Handbook for Teaching and Learning in Higher Education: Enhancing Academic Practice. 3rd edn, Routledge, New York.

6. Ramsden P (2003). Learning to Teach in Higher Education. 2nd edn, Routledge Taylor and Francis Group, London.

7. Grace S, Gravestock P (2009). Inclusion and Diversity: Meeting the needs of all Students. 1st edn, Routledge, London.

8. Anderson M (2007). Diversity Learning, Knowledge Diversity and Inclusion: Theory and Practice as Exemplified by Corporate Universities. Equal Opportunities International, 26(8): 743-760.

9. Wolffram A, Derboven W, Winker G (2009). Women Withdrawers in Engineering Studies: Identity Formation and Learning Culture as Gendered Barriers for Persistence? Equal Opportunities International, 28(1): 36-49.

   Kolb DA (1984). Experiential Learning: Experience as the Source of Learning and Development. Englewood Cliffs, NJ: Prentice-Hall.

10. Wierstra RFA, de Jong JA (2002). A scaling theoretical evaluation of Kolb's Learning Style Inventory-2, pp. 431–440 in: Valcke M, Gombeir D (eds.) Learning styles: Reliability and validity. Proceedings of the 7th Annual European Learning Styles Information Network Conference, 26–28 June, University of Ghent, Ghent.

11. Coffield F, Moseley D, Hall E, Ecclestone K (2004). Learning Styles and Pedagogy in Post-16 Learning: A systematic and critical review. London: Learning and Skills Research Centre.

12. Kolb AY, Kolb DA (2005). The Kolb Learning Style Inventory – Version 3.1 2005 Technical Specifications. Experience Based Learning Systems, Inc., HayGroup.

13. Maclellan E (2001). Assessment for Learning: The Differing Perceptions of Tutors and Students. Assessment ad Evaluation in Higher Education, 26(4): 307–318.

14. Houghton W (2004). Engineering Subject Centre Guide: Learning and Teaching Theory for Engineering Academics, The Higher Education Academy – Engineering Subject Centre.

15. Walker DJ, Palmer E (2011). The Relationship between Student Understanding, Satisfaction and Performance in an Australian Engineering Programme. Assessment and Evaluation in Higher Education, 36(2): 157-170.

16. Bamber M (2015). The Impact on Stakeholder Confidence of Increased Transparency in the Examination Assessment Process. Assessment and Evaluation in Higher Education, 40(4): 471-487.

Author Details

Jaan Hui Pu received his BEng (1st Class Honors) and PhD from University of Bradford (UoB), UK. He has been appointed as a lecturer at School of Engineering, Faculty of Engineering and Informatics, UoB after working at five different engineers, research fellow and academic positions at different countries. He is also active in research publication, review and editorial tasks for various well-reputed journals.