Outcome-Based Approach to Teaching, Learning and Assessment in Geomatics Higher Education: the Hong Kong Experience

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Key words: geomatics, outcome-based education, curriculum, engineering surveying.

SUMMARY

Over the years of development, the paradigm of outcome-based education (OBE) has evolved from traditional OBE, through transitional OBE into the era of what William Spady refers as transformational OBE. The transformational or rigorous OBE is now a worldwide trend in higher education and has been adopted by local universities in Hong Kong. At subject or curriculum level, essential elements are: (1) identifying the intended learning outcomes for students; (2) the design of curriculum, teaching, learning and assessment to enable students to achieve the intended learning outcomes; (3) the criterion-referenced outcomes assessment; (4) the continual improvements to both subjects and programme. The approach is illustrated in this paper by the design, teaching, learning and assessment activities of an engineering surveying curriculum at The Hong Kong Polytechnic University (PolyU). At programme or university level, work-integrated or coop programmes are being offered to students for all-round development of their professional knowledge and skills, generic competencies, social attitudes and societal values. The success of OBE demands high standard of student learning outcomes and active involvement of all stakeholders – students, faculty, employers, parents, and others. Despite at high cost, the OBE approach offers students the opportunity to develop employability skills, preparing them for effective participation in labour markets, and allows learning and knowledge to be applied and integrated with work time and life time.

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1. INTRODUCTION TO OUTCOME-BASED EDUCATION

Over the years of development, educational administration has gone through reforms under the neo-colonial models, centralised (state-led) models, decentralised-sectoral models, community- and school-based models, transformative (societal) models [1], and globalization models. Under these administrative reforms that called for quality and accountability in higher education, outcome-based education (OBE) and policies had evolved during the 1990s [2, 3]. Since then, educators worldwide have been "increasingly focusing their efforts on what are variously being called outcomes, results, performances, competencies or standards [4, p. 1827]" in OBE.

What is OBE? OBE is a process of curriculum design, teaching, learning and assessment that focuses on what students can actually do (i.e., learning outcomes) after they are taught. It attempts to embrace learning outcomes with the knowledge, skills, attitudes and values that match the immediate social, economic and cultural environment of society. According to William Spady [3], there are three broad types of OBE:

- Traditional OBE which measures the learning outcomes in terms of students' mastery of the established curriculum.
- Transitional OBE which measures the learning outcomes of students in terms of generic or higher-order competencies such as critical thinking, problem solving, communication skills and teamwork.
- Transformational OBE which measures the learning outcomes of students in terms of broad category of disciplinary knowledge and skills (i.e., multi-disciplined), generic competencies, attitudes and values required by the industry or society.

Under the transformational or rigorous OBE, curriculum, teaching and assessment are developed jointly by all stakeholders – students, employers, faculty staff, parents and community. Each student's needs and learning outcome are accommodated in this approach through multiple instructional strategies and assessment tools including assignments, projects, oral presentation, traditional tests, and the totality or portfolio of the student's work [2]. Common teaching and learning methods include interactive lecture, case-based learning, problem-based learning, simulation, role play and fish-bowl observation, tutorial, self-directed learning, experiential learning, laboratory work, fieldwork, peer tutoring, PISER (Peer Instruction and Student Electronic Response) and e-learning; together with a choice or combination of different assessment methods such as objective tests, case studies, essay questions, projects, end-of-chapter type problems, reflective journals, seminar presentation, practicum, portfolio, examinations, and peer and self-assessment [6]. Students will complete rigorous academic coursework under high expectation and assessed by measurable criterion-based standards. Norm-referenced tests are prohibited.

This rigorous approach may not be applicable in age-based education system, for example, the primary education in North America, which would allow students to study at higher level without scoring a passing grade at the pre-requisite level. It is criticised for high costs, high expectations, excessive number of curriculum outcomes, difficulties in fulfilling individual needs of each student, and increasing number of failures (or 'delayed success').

Nevertheless, the transformational OBE is now a worldwide trend in higher education, and has been adopted by local universities in Hong Kong [6, 8]. At university or programme level, work-integrated education (WIE) programmes are being organized at university or programme level to link students and faculty with the industry while engaging knowledgeable workers of the industry in enriching the teaching and learning activities. At the same time, offering students with the opportunities for all-round development of their professional knowledge and skills, generic competencies, social attitudes and societal values. In PolyU, the following credit-bearing and non-credit bearing WIE or coop programmes are being offered to students:

- Summer Training Schemes co-organized by faculty and employers of the industry.
- Preferred Graduate Development Programme (PGDP) co-organized by faculty and Student Affair Office for placements relevant to students' study programmes.
- Overseas placements under the International Association for the Exchange Students for Technical Experience (IAESTE) co-organized by faculty and Student Affair Office.
- Community service training co-organized by faculty and Student Affair Office, for example, building schools and bridges by students in remote villages of China Mainland.

At subject or curriculum level, as shown in Figure 1, the process comprises the following four essential elements [5, 6, 7]:

- Identification of what students should be able to perform on completing the course of study in accordance with the requirements of particular profession or industry. That is, identification of the intended learning outcomes (ILOs).
- Design of the curriculum, teaching, learning and assessment to enable students to achieve the ILOs. That is, mapping and alignment.
- Data collection for assessing students' achievement of learning outcomes. That is, the outcomes assessment and feedback.
- Use assessment result to inform further development and enhancement of the programme and subjects. That is, the continual improvements.

The following section illustrates author's experience of aligning the curriculum, teaching, learning and assessment with the intended learning outcomes using an engineering surveying curriculum.

2. OUTCOME-BASED APPROACH TO TEACHING AND LEARNING OF GEOMATICS CURRICULUM

Subject LSGI2961 – Engineering Surveying is being offered by the Department of Land Surveying and Geo-Informatics to all undergraduate students who are taking the Bachelor of

Civil Engineering Degree Programme and the Bachelor of Building Engineering Degree Programme in the Department of Civil and Structural Engineering and the Department of Building and Real Estate at PolyU. Under the new OBE curriculum requirements, the curriculum, teaching, learning and assessment for the subject are described here by answering the questions of 'what are the intended learning outcomes (ILOs)', 'how to align the curriculum, teaching, learning and assessment with the ILOs', and 'how to implement the curriculum, and evaluate the learning outcomes'.

What are the ILOs? According to the programme document, in satisfying the requirements of knowledge and professional skills of the subject, students who complete the subject should be able to:

(1) Master the elementary theory and techniques of engineering surveying including the establishment of control points, topographic mapping, cogo computations and geometric modelling, setting-out, as-built surveys, deformation monitoring and total quality management (TQM) of the aforementioned survey operations for the design and construction of roads, drainage systems, buildings, railways and tunnels.
(2) Operate and calibrate precise surveying instruments such as steel tape, electronic total station, auto-level, levelling rod and GPS receiver.
(3) Collect, analyse and report basic survey data for the design and construction of the aforementioned civil and building infrastructures.
(4) Communicate with other professionals such as real estate developers, architects and engineers concerning the survey requirements in construction projects.

How to align the curriculum, teaching, learning and assessment with the ILOs? Focusing high-status knowledge, high-value skills and real-world applications and the ILOs [9], textbook [12], videos of survey operations, reference readings, and other teaching materials are produced or chosen for the curriculum (Table 1) and learning and teaching activities. Before the commencement of the session, syllabus and teaching schedule of the subject are distributed to students providing them with the learning objectives, curriculum content, assessment scheme and items (e.g., Table 2 and Figure 2), academic policy, available resources, and planning and self-management skills to initiate self-controlled study. The learning, teaching and assessment activities comprise of twenty-eight hours of lectures (two hours per week), twelve hours of field instruction, one survey project, one phase test, one three-hour written examination, and unlimited hours of practicing surveying computers and instruments within the semester.

How to implement the curriculum? Teaching-oriented activities include the design and planning of teaching and learning activities (lectures and field practicals), teaching materials and schedule, criterion-referenced formative and summative tests, remediation and enrichment activities (e.g., tutorials in small group), and facilities management for the session. Learning-oriented activities include implementation of the instructional activities, monitoring and improving students' mastery of learning, obtaining feedback from all parties involved, and evaluation and continual improvement of the curriculum. These activities are demonstrated in below. Before attending the lecture, students are required to read the particular chapter(s) of the textbook or watch the video-record to prepare themselves for the scheduled topics. After the lecture or field instruction, PowerPoint® slides and lecture notes will be placed in PolyU's WebCT® and SMILE® e-learning systems to facilitate independent learning among students.

How to evaluate the learning outcomes? During the session, formative and continuous assessments are frequently organized in the form of oral presentation, quiz, phase test and progress reports by which Subject Lecturer communicates expectation and standard of learning performance to the students. Remedial or revision lessons may be needed if students' learning outcomes are below expectation. A portfolio of assessment resulting from students' performance is recorded. In the end of the semester, revision of all the topics is given to reinforce students' understanding so that they have confidence of sitting at the final examination. Summative assessment in the form of written examination is then organized to assess the effect of the completed program and compare the performance of students. The learning outcomes are graded by the criterion-referenced levels of the Structure of the Observed Learning Outcome (SOLO) Taxonomy published in [13. 14]. The assessment result will also be used for selecting successful learners to receive awards and scholarships. Teacher performance is assessed by the overall student performance, Student Feedback Questionnaire (SFQ), teaching portfolio, In-class Peer Evaluation (IPE) by colleagues or academic advisor, Members of Student-Staff Consultative Meeting, and Programme Committee Members.

3. CONCLUSIONS AND FUTURE DEVELOPMENTS

The transformational or rigorous OBE has been adopted by geomatics higher education in Hong Kong. At subject or curriculum level, the process (Figure 1) comprises: (1) identifying intended learning outcomes for students; (2) the design of the curriculum (e.g., Table 1), teaching, learning and assessment to enable students to achieve the ILOs; (3) outcomes assessment (e.g., Table 2 and Figure 2); (4) continual improvements to the subject and programme. The rigorous approach demands consistent, high expectations of learning outcomes by requiring students to understand the curriculum content much deeper than just finding the correct answer in traditional standard test and written examination [3]. The teaching and learning outcomes emphasize on capacity (i.e., 'what the students are capable of doing') rather than just on content knowledge; and the learning process is capacity building rather than content delivery. It goes beyond structured tasks (e.g. memorization of concepts) by involving students in high-level thinking and seeking for the generic competencies of communication, critical thinking, creative thinking, problem solving and entrepreneurial teamwork through lectures, videos, field practice, assignments, projects, use of instruments, report writing, oral presentation and high challenging tests and examination [3]. At university or programme level, WIE or coop programmes are being offered for all-round development of the students. Its success requires active involvement of stakeholders - students, faculty, employers, parents and others; and anticipates higher educational and social costs than traditional OBE. The research is on-going focusing the curriculum development, teaching and learning activities, educational research, and total quality management (TQM) of OBE. If readers have any valuable comments on all aspects of OBE, it is hoped that they would be brought to the attention of the author.

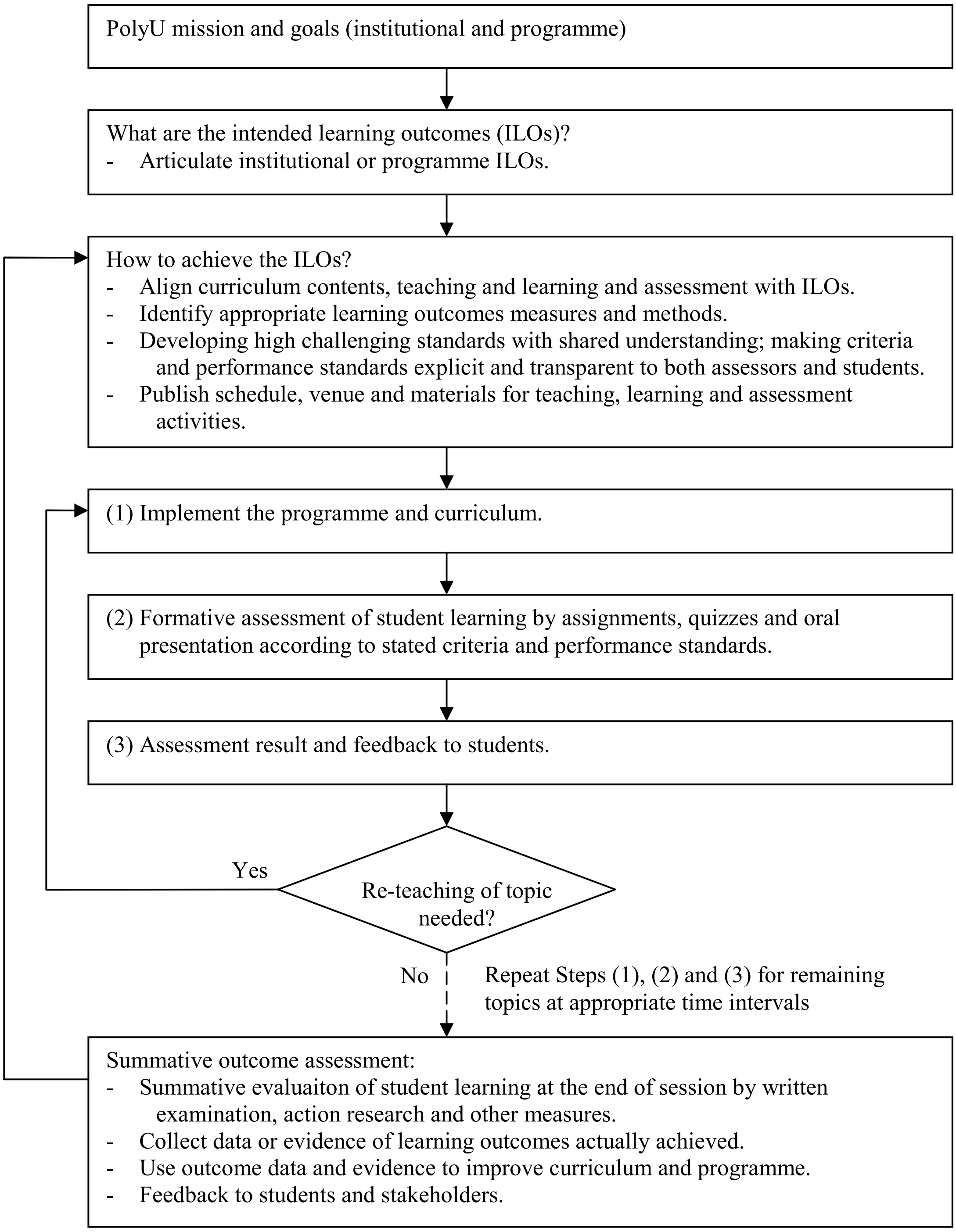

Figure 1: Outcome-based approach to teaching, learning and assessment [6, 7, 11]

	Satisfactory: Yes	Satisfactory: No
Leveling		
1. Calibration of instruments		
2. Leveling (field observation data and reduction)		
3. Manual calculation and automatic system		
4. Quality control against the standards (misclosure)		
5. Field sketches (level lines, bench mark diagrams)		
Traverse Network		
6. Calibration of instruments		
7. Angular measurement (observation and field reduction)		
8. Distance measurement (observation and field reduction)		
9. Manual computation and automatic system (Bowditch Method)		
10. Quality control against the standards (angular and linear misclosure)		
11. Field sketches (traverse lines, station diagrams)		
Spatial Intersection		
12. Field observation and sketches		
13. Cogo computation		
14. Use of automated system (computer programs)		
15. Evaluation of survey measurements		
16. Accuracy of the survey result (coordinates of the required point)		
Final Report		
17. Style (table of contents, format, figures, tables, references)		
18. Contents (objectives, survey methodology, survey records)		
19. Familiarization		
20. Assessment of results and conclusions		

Figure 2: Example of assessment scheme issued to students.

Table 1: Syllabus and teaching schedule of Subject LSGI 2961 - Engineering Surveying [10, Table 2]

Week No.	Topics
1	Introduction to engineering survey operations. World geodetic coordinate systems. Local coordinate reference systems for construction.
2	Geometric modeling and cogo computations. Use of electronic calculators and spreadsheet software in: solving triangles, polar, inverse, intersections, resection, conformal transformation, computing vertical and horizontal curves, and computing areas and volumes.
3	Elementary theory of errors. Analyses and adjustment of survey measurements by equal shift and least squares methods.
4	Distance measurement and corrections using tape, total station, and stadia and tangential tacheometry. Operations, calibrations, quality records, accuracy standards and specifications of instruments.
5	Angular measurement using theodolite and total station. Operations, calibrations, quality records, accuracy standards and specifications of instruments.
6	Vertical control network by leveling. Operations, calibration, quality records, accuracy standards and specifications of instruments. Procedures of differential, trigonometric and reciprocal leveling. Accuracy standards and specifications of ordinary and precise leveling.
7	Horizontal control network by triangulation, trilateration and traversing. Operational procedures, accuracy standards and specifications. Data analysis and adjustment by Bowditch Method, Transit Method, Crandall Method and Least Squares Method using electronic calculator and computer software.
8	Global satellite positioning systems. GPS reference coordinate systems and datums. Operations, calibration, quality records, accuracy standards and specifications of instruments. GPS planning, observation routine and data processing.
9	Detail surveying and mapping by chain survey, stadia-tacheometry, total station, hydrographic instrumentation, aerial and ground photogrammetry, and LIDAR scanning methodology. Data processing and drafting by manual and computer methods. Data formats, standards and specifications of detail plans in CAD and GIS.
10	Survey operations for site formation and road construction. Basic geometric design criteria for roads. Precise 3-D model and digital terrain models for formation and slope stakeout. Survey standards and specifications. Setting-out of horizontal and vertical alignments, automated graders, and slipform pavers.
11	Survey operations for construction of drainage systems. Use of alignment laser and laser level. Procedures, standards and specifications for the setting-out and as-built surveys of pipelines and drainage utility systems.
12	Survey operations for construction of buildings. Procedures, standards and specifications for the control of verticality, setting-out and deformation monitoring of high-rises and deep foundations.
13	Survey operations for construction of railways. Precise 3-D model of railway tracks. Railway survey standards and specifications. Setting-out and as-built surveys of railway tracks.
14	Survey operations for construction of tunnels. Precise 3-D model of tunnels. Calibration and Use of gyro-theodolite, alignment laser, profiler and laser scanner. Procedures, standards and specifications for control network, setting-out and deformation monitoring surveys for construction by shield drive and drill-and-blast methods.

Table 2: Assessment of learning and teaching objectives for the subject [10, Table 1]

Domain	Learning and teaching activities	Types of assessment
Knowledge	Seven engineering survey operations (i.e., geodetic control, detail mapping, geometric modeling, setting-out, as-built surveys, deformation monitoring and total quality management) for the construction of five main categories of civil engineering infrastructures (i.e., roads and bridges, drainage systems, buildings, railways and tunnels).	Multiple choice test on basic facts Written exam on topic knowledge Concept map on discipline knowledge Peer- and self-assessment
Intellectual skills	Able to conduct and apply the survey operations in solving real-world problems.	Phase test and written exam on functioning knowledge Project report
Motor skills	Operation of surveying instruments and computer systems. Presentation of survey results using both manual and computer methods.	Calibration and operation Oral test Survey report
Attitudes	Able to communicate with team members, clients and other professionals.	Observation of behavior Interview Affective questionnaire

REFERENCES

[1] Cummings, W. K. and Williams, J. (2005). International Development Models for Educational Reform. *Asia Pacific Journal of Education,* Vol. 25, No. 2, pp. 125-143.

[2] Ungar, H. G. (Editor, 1996). *Encyclopedia of American Education.* New York: Facts on File.

[3] Spady, W. G. (1994). *Outcome-Based Education: Critical Issues and Answers*. Arlington: American Association of School Administrators.

[4] Spady, W. G. (2003). Outcome Based Education. In Guthrie, J. W. (Editor), *Encyclopedia of Education,* 2nd ed., pp. 1827-1831. New York: Macmillan Reference.

[5] PolyU (2005). *Guidelines for Implementation of Criterion-Referenced Assessment*. Learning and Teaching Committee of The Hong Kong Polytechnic University.

[6] PolyU (2008a). *Guide to Outcome-Based Education.* Learning and Teaching Committee of The Hong Kong Polytechnic University (http://www.polyu.edu.hk/obe; accessed in December 2008).

[7] PolyU (2008b). *Developing a Programme Learning Outcomes Assessment Plan*. Learning and Teaching Committee of The Hong Kong Polytechnic University.

[8] QAC (2008). *Quality Assurance Council Audit Manual.* Quality Assurance Council of The University Grants Committee of Hong Kong (http://ugc.edu.hk/eng/doc/qac/publication; accessed in December 2008).

[9] Biggs, J. (2003). *Teaching for Quality Learning at University: What the Student Does,* 2nd ed. Philadelphia: Society for Research into Higher Education; Open University Press.

[10] Lam, S. (2008). Teaching Engineering Surveying in Civil Engineering Program: Curriculum, Pedagogy and Assessment. *Journal of Professional Issues in Engineering Education and Practice*, Vol. 134, No. 2, p. 173-177, ASCE.

[11] Lam, S. (2006). Development of Business Management Curriculum for Geomatics Education. *Geomatica*, Vol. 60, No. 4, pp. 369-372, CIG.

[12] Lam, S. (2005). *Engineering Surveying for Civil Engineers: an Algorithmic Approach*. Singapore: McGraw-Hill Education.

[13] EDC (2005). *PolyU Policies, Regulations and Guidelines on Teaching*, Educational Development Centre of The Hong Kong Polytechnic University, Hong Kong.

[14] Biggs, J. and Collis, S. (1982). *Evaluating the Quality of Learning: the SOLO Taxonomy*, Academic Press, New York.

BIOGRAPHICAL NOTES

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