Capstone Course Assessment Approaches and Their Issues in the Engineering Programs in Taiwan

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Abstract — *Capstone courses have been increasingly offered in Taiwan. This paper explored their assessment approaches and issues. Authentic assessment and project competition were found widely adopted and the following two issues were identified: (1) The assessment rubrics employed should be enriched and improved; and (2) Assessment fairness on the extent of student participation should be increased.*

Index Terms — *capstone project, course assessment, assessment approach, engineering education, Taiwan*

Capstone Courses Have been Increasingly Offered in the Engineering Programs in Taiwan

In the school year of 2005-2006, there were 193,752 undergraduate students major in engineering in Taiwan. This accounts for about 21% of total undergraduate students, 938,648 (see Figure 1). As shown in Figure 2, in the school year of 2006-2007 the top three fields of engineering education based on undergraduate student number are: (1) electrical and electrical control engineering, (2) power mechanical and mechanical engineering, and (3) micro-electronic and electronic engineering.
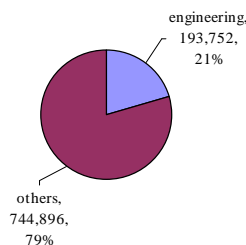

FIGURE 1
The Percentage of Undergraduate Students Major in Engineering in the School Year of 2005-2006
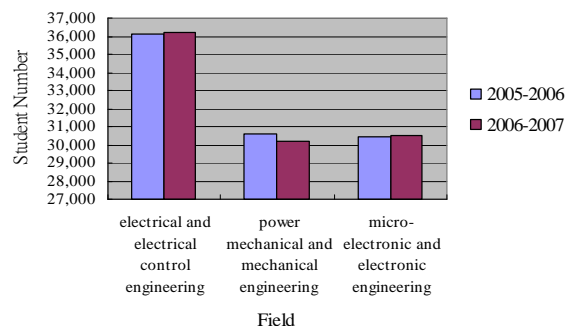

FIGURE 2
Top Three Fields of Engineering Education on Undergraduate Student Number Basis

The field of engineering is strongly expected to put theory into practice. Ten years ago, Chang [1] pointed out that in the field of engineering education in Taiwan students should be given more practical experience, and the utmost importance placed on combining theory with practice. In the last decade, the two problems have been gradually solved. For example, the Institute of Engineering Education Taiwan (IEET), a non-profit and non-governmental organization committed to accreditation engineering and technology education programs in Taiwan, suggests capstone project experience and other measures to engineering programs to help their students to gain practical experiences.

In recent years, capstone courses have been increasingly offered in the engineering programs in Taiwan. A capstone course, typically a part of an upper-level course in line with key learning objectives and in a team environment, provides cumulative experience to students working in real-world projects. The capstone project involves intensive communications with teammates and the faculty adviser.

Authentic Assessment Approaches and Competitions Have Been Widely Adopted

A capstone course is a part of engineering program and involves individuals such as students, faculty advisers and program/department head. Thus, its assessment may be focused on individual, course, or program (see Figure 3). However, more and more position papers put their emphasis on enhancing engineering learning through student assessment. The purpose of assessment can be classified as follows: (1) Assessment for accountability—Assessment of units (individuals, teams, courses or programs) aim to satisfy internal and external stakeholders of units. Results are summative and are often compared with preset objectives and across units; (2) Assessment for improvement—Assessment that aims directly, and often immediately, to improving the operation, course or program to facilitate student learning progress. Results are formative. In addition, the data collection methods for an assessment may include quantitative and/or qualitative approach(es).
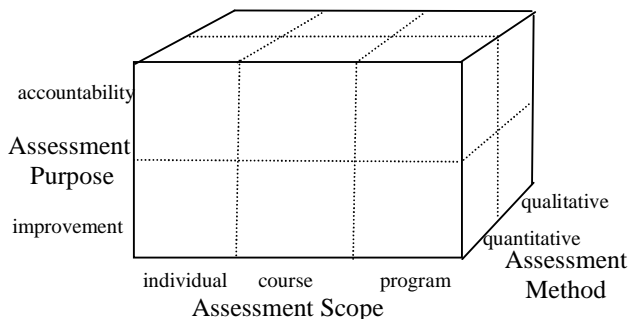

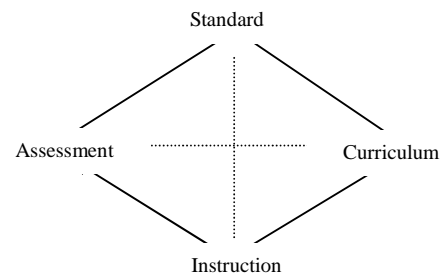FIGURE 3
Assessment Purpose and Scope of Capstone Course

FIGURE 4
The Alignment Expected among Engineering Standard, Curriculum, Instruction and Assessment [2]

In order to meet program accreditation requirements, the engineering programs in Taiwan increasingly become standard-oriented although each program may formulate its standard itself. In this trend, capstone course assessment is anticipated to be aligned within the prescribed program standards and further developed within the course curriculum and instruction (see Figure 4).

Generally speaking, the assessment approaches to capstone courses are various and controversial—different faculty advisers employ different approaches. In recent years, the following guidelines have been increasingly mentioned in the student assessment of capstone course in Taiwan:

1. The purpose of assessment is to realize and facilitate students' learning and serve as the basis of improving instruction, curriculum as well as standard.
2. Assessment should take in course goals and objectives as its reference, and understand if students have been equipped with core competencies in both general and major areas.
3. Assessment should not be limited in one way, and students' self assessment and peer assessment should also be adopted as well as faculty assessment.
4. Assessment should include cognitive, psychomotor and affective domains.
5. Both formative and summative assessment should be emphasized together.

Authentic assessment (AA) is a form of assessment in which students are required to perform real-world tasks that demonstrate meaningful application of essential knowledge and skills. Student performance on a task is typically scored on a rubric, a scoring scale used to assess student performance along a task-specific set of criteria, to determine how successfully the student has met specific standards. A rubric serves as a guide and gives students a clear picture of the strengths and weaknesses of their tasks [3]. Thus, a capstone project itself can be considered as an authentic assessment.

Obviously, the capstone courses in Taiwan increasingly follow the above assessment guidelines and adopt authentic assessment approaches. However, authentic assessments typically are criterion-referenced measures. That is to say, a student's learning progress and outcome on his/her capstone project is determined by matching his/her performance against a set of criteria. In order to encourage programs and individuals to value capstone project experiences, more and more capstone competitions has been held. For example, every year the Ministry of Education (MOE) entrusts a university of technology to host a nation-wide capstone project competition and exhibition for the students in universities/colleges of technology and junior colleges of technology.

The Capstone Course at the Department of Electro-Optical Engineering, National United University, As A Case

Located in mid-Taiwan, the National United University (NUU) is a comprehensive university. Founded in 1988, the Department of Electro-Optical Engineering (DEOE) at NUU is to prepare students with integrated optics, mechanics and electronics capability in order to meet the professionals needed in the emerging and fast growing photonics industry in Taiwan. The DEOE requires all undergraduate students in its four-year programs to take capstone courses in their sixth and seventh semesters. Most of these capstone projects are sponsored by faculty advisors, who provide initial project specification and mentoring. Each project team includes three to five students. At the end of the seventh semester, a department-level capstone project competition is held. The following three components are assessed in the competition: (1) project display with posters and operations, (2) paper report, and (3) oral presentation with PowerPoint slides.

A 360-degree feedback was employed to collect opinions from course instructors, students and program heads at NUU, especially at DEOE. It is found as follows:
1. The assessment approaches to capstone course at NUU meet the assessment trends mentioned earlier.
2. The assessment rubrics employed at NUU should be enriched and improved to purse relevance.
3. Students are satisfied with assessment measures but expect to increase assessment fairness on the extent of participation.

The Possible Solutions to Solve the Two Issues Raised in NUU

The possible solutions to solve the above two issues—assessment rubrics and assessment fairness—may be suggested as follows:
1. Templates of analytic and holistic rubrics should be developed for promotion.
   Analytic rubrics articulate levels of performance for each criterion so the adviser can assess student performance on each criterion, while a holistic rubric assigns a level of performance by assessing performance across multiple criteria as a whole. Analytic rubrics are more common because advisers typically want to assess each criterion separately, particularly for assignments that involve a larger number of criteria. Holistic rubrics tend to be used when a quick or gross judgment needs to be made [3]. Templates of analytic and holistic rubrics should be developed for promotion.
2. Types of knowledge and various cognitive, psychomotor and affective processes should be simultaneously assessed.
   In the relevant assessment rubrics to be developed for capstone courses, types of knowledge and various cognitive, psychomotor and affective processes should be assessed. Table 1 indicates a match of "types of knowledge" and "cognitive processes".

TABLE 1

A Simple Cross Table to Match Activities and Objectives to the Types of Knowledge and to the Cognitive Processes [4]

The Knowledge Dimensions	Cognitive Processes					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
Factual						
Conceptual						
Procedural						
Metacognitive						

3. The approaches employed in cooperative learning should be adopted.
   Cooperative learning is a teaching strategy in which small teams, each with students of different levels of ability, use a variety of learning activities to improve their understanding of a subject or unit. Each member of a team is responsible not only for learning what is taught but also for helping teammates learn, thus creating an atmosphere of achievement. Students work through the assignment until all team members successfully understand and complete it [5]. Normally, individual and group performances are emphasized in a cooperative learning team. In addition, cooperation is emphasized among team members while competition among teams. In order to increase assessment fairness on the extent of team members' participation, the approaches in cooperative learning such as heterogeneous team building, cooperation within a team and competition across teams, should be adopted.

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