A new assessment and evaluation system for an engineering course, based on the CDIO model

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ABSTRACT: A traditional engineering curriculum was analysed to determine the suitability of its assessment methods for an application-oriented course. A new curriculum, with a performance evaluation and examination system suited for the CDIO (Conceive, Design, Implement, Operate) teaching model was developed. The CDIO method emphasises practical and innovative teaching, which was reflected in the new assessment system. Practice shows that the new performance evaluation system improves the teaching. The new evaluation system also can serve as a model for project performance evaluation.

INTRODUCTION

An application-oriented engineer requires a solid foundation of theoretical knowledge, but also the practical ability to deal with operational and production issues [1]. The assessment process is an aim to measure student learning against learning objectives. However, with the deepening of education reform, assessment by the traditional closed book examination is no longer adequate [2]. This is especially so when, to meet the needs of industry, there is an emphasis on students' practical abilities.

Current engineering assessment procedures must be reviewed to ensure they adequately assess practical ability, as well as students' theoretical knowledge [3].

The CDIO (Conceive, Design, Implement, Operate) model is project-oriented and task-driven so that students acquire the necessary knowledge and skills to complete tasks in solving practical problems [4]. Currently, the implementation of the CDIO model of teaching is still at an exploratory stage. This is especially so in the evaluation of student performance [5]. Therefore, the CDIO teaching model must be implemented with a suitable performance evaluation system. Introduced in this article is a CDIO teaching mode for an engineering curriculum, including a suitable evaluation system.

TEACHING EVALUATION

The functions of teaching evaluation are:

- Measurement of the effect of teaching. Teachers can determine student learning deficiencies and, hence, improve the teaching.

- Reasonable assessments that incentivise students to learn by providing guidance as to what to learn. To pass the examination, students must engage in targeted learning.

- Provision of a focus on developing practical abilities and quality, which is especially important for engineering courses. Students should be able to use theoretical knowledge to solve practical problems and this should be assessed.

- Providing feedback to students and teachers through assessment. Students then understand their strengths and weaknesses, which can guide their further self-development. Teachers understand students' grasp of the material, which can lead targeted teaching to overcome deficiencies in students' knowledge.

Table 1: The indicators of assessment methods and the requirements.

First-level evaluation indicator	Second-level evaluation indicator	Assessment content, form and requirements	Appraiser
The process of assessment	Test	Urge timely review, examination of knowledge, comprehension, application of memory	Teacher
	Homework	Check the preview, review the situation; assessment on the basic concepts and principles	Teacher
	Experiment	Operational assessment and assessment of combining operability assessment: the completion of an independent machine/experimental task	Teachers and students
	Speeches and discussion	Reflect on students' classroom participation; examine student skills and adaptability; assessment of students' knowledge, understanding and ability to apply	Teachers and students
Achievement evaluation	Final examination	Assessment of students' memory knowledge, understanding and mastery; appropriate arrangements for open-book examination to test students applied knowledge, access to information and the ability to analyse problems, problem-solving skills	Teacher
	Curriculum design	Lead students to academic activities as soon as possible, for further study and professional knowledge, develop a spirit of culture and innovation, practical ability and team co-operation, which has a great role in self-promotion, and is an excellent means of combining theory and practice	Teachers and students
	Papers, projects	Let the students individually or in small groups use knowledge and skills learned to complete a project and evaluate the work	Teachers and students
	Competitions, certification	Various training competitions; certification examinations at all levels of government and industry organisations are included in the scope of the examination, such as: published papers, conference attendance, college students' innovative pilot scheme, Challenge Cup Entrepreneurship Competition; participate in vocational certification examination to test their knowledge of industry requirements and operational requirements, employment	Industry experts
Quality assessment	Engineering quality	To guide students on strengthening attitude, behaviour, awareness of becoming good engineering, technical and scientific research personnel: to have the basic ability to analyse and solve practical problems	Teachers and students
	Attendance and attitude	To work on time and finish the task	Industry experts
	Collaboration communication	Communication ability, team co-operation ability	Industry experts

Skills requirements for professional positions are diverse, and students, in acquiring these diverse skills, will need to be assessed in diverse ways [6]. It needs to be not only diversity of assessment, but also diversity of assessors. In addition to teacher evaluation, there can be peer assessment by other students and self-assessment.

Also, industry might be involved in the teaching process, in which case experts from the industry would be involved in the assessment. Authoritative industry-certified examinations should be introduced, so that students understand industry requirements as an aid to future employment.

The process of evaluation for a CDIO-based curriculum should facilitate independent learning to generate enthusiasm for the course [7]. There is a need to find teachers with experience in this mode of teaching and learning, who can fill the role of teaching the teachers. The curriculum system structure is shown in Figure 1.

DESIGN OF THE CURRICULUM EVALUATION SYSTEM

The evaluation system has three aspects: the process of assessment, the results of the assessment and assessment of quality. The process of assessment should guide the student in learning and be consistent, from the beginning to the end of the learning. Results of the assessment come from getting students to demonstrate their knowledge or accomplish a task, so as to assess their abilities. Quality assessment refers to the quality of the student, including aspects of attitude, participation, collaboration and communication. The examination system should not only assess a student's learning, but also the student's grasp of knowledge and level of competence.

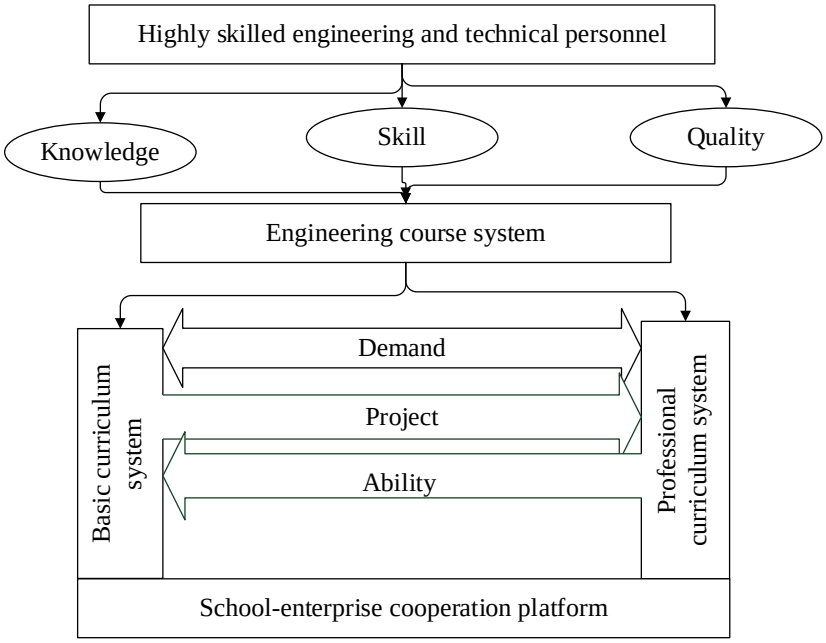

Figure 1: The curriculum structure.

Meanwhile, the curriculum does not just rely on assessment results; as well, there are competitions and certifications. Appraisers include the teachers, industry experts and the students themselves. So the assessment method is diversified. Figure 2 shows the process that was followed in developing the new assessment system.

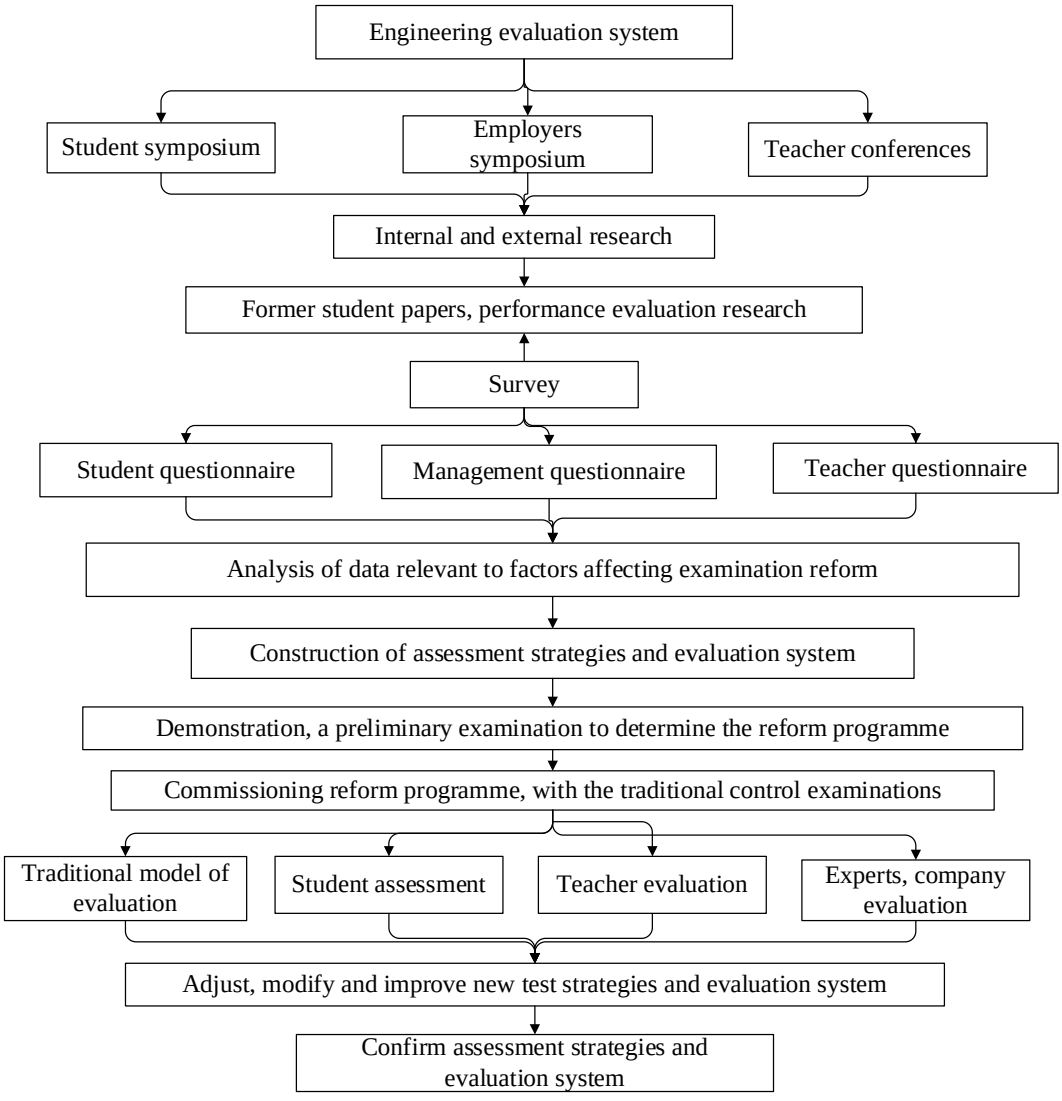

Figure 2: The process for developing the new curriculum evaluation system.

Table 2: CDIO standards and curriculum requirements comparison.

Course assessment vs. CDIO standard	C1 Basic science knowledge	C2 Core engineering	D1 Engineering reasoning	D2 Experiment and knowledge	I1 Team work	I2 Communication	O1 Design	O2 Operation
The process of assessment	√	√		√				
Achievement evaluation			√				√	√
Quality assessment					√	√		

Table 1 contains the assessment indicators, type of assessment and appraisers. The first-level indicators are divided into second-level indicators. For each second-level indicator, the content of the assessment and the appraiser are indicated. Table 2 shows how the assessment system in Table 1 would be used to assess teaching using the CDIO mode, e.g. in Table 2, C1 and C2 refer to the *Conceive* stage of CDIO, and so on.

THE IMPLEMENTED ASSESSMENT SYSTEM

The curriculum evaluation system shown in Figure 3 was built for a CDIO model curriculum using the assessment system in Table 1.

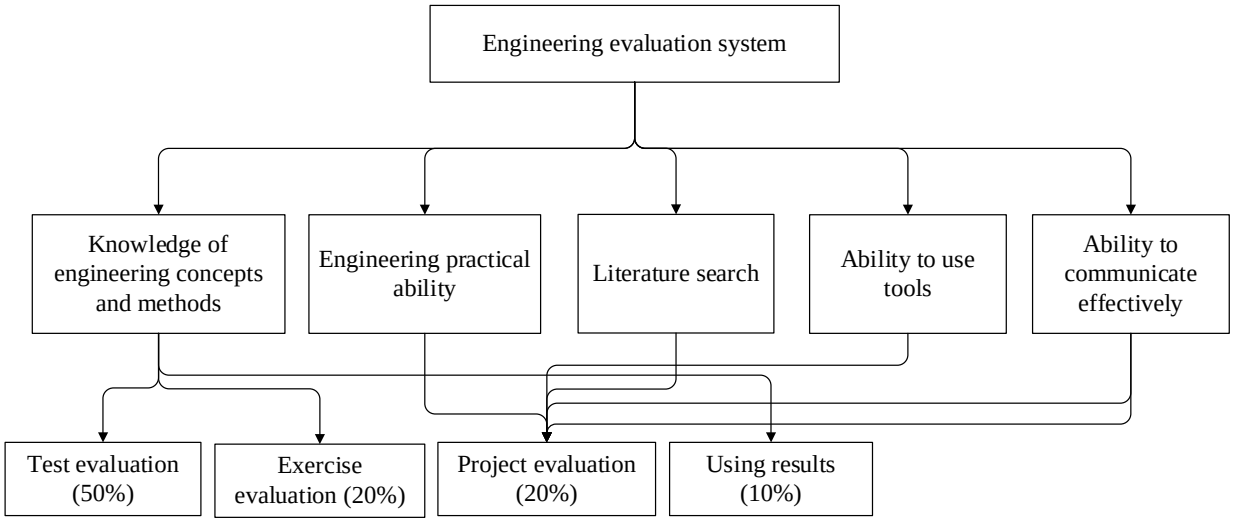

Figure 3: Curriculum evaluation system.

Assessment is out of 100%. The paper examination (40%) questions include false questions, multiple choice questions, short-answer questions, problems requiring calculations and case study questions. The comprehensive ability of the students is to grasp the main theories and methods of assessment of the project. Chapter exercises (10%) demonstrate students' mastery of engineering theory and methods. The project design (30%) requires students to design their own project working in groups of five. Each group has a group leader. Subject may not be repeated. The daily record is 20%. The composition of the evaluation is shown in Figure 4.

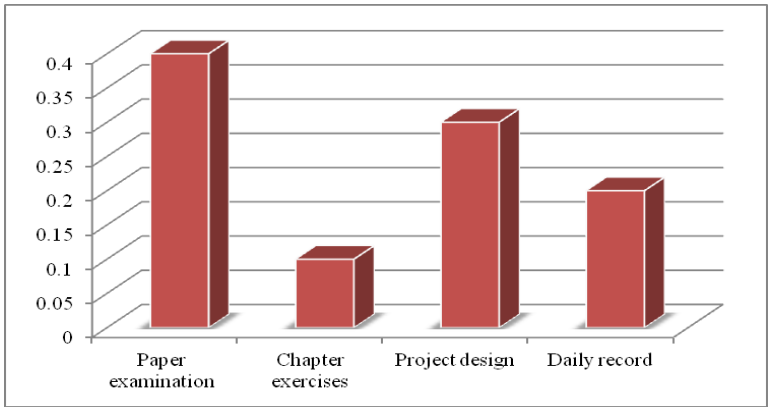

Figure 4: The composition of the evaluation.

PRACTICAL EFFECTS

Students were surveyed to find out their opinions of the reform proposals. On visits to management, assessment methods to improve teaching were discussed. At a symposium for teachers, curriculum evaluation was discussed, as well as the method of improving teaching quality and promoting the ability of students. The survey results are shown in Table 3.

Table 3: Student survey results.

Question	Options	Per cent (%)
What is your course content?	a. It is the content of textbooks b. Most of the content is from textbooks, with some extra-curricular content c. The content of the textbook is a minority, most is extracurricular content	34 54 12
How do you learn?	a. Listen carefully in class; after-school review b. Do not listen in class; rely on self-study after class c. Listen carefully in class; do not study after-school d. Do not go to class	27 39 30 4
Should your teacher highlight the major course examination topics?	a. Yes b. No	66 34
Should there be more experimental classes?	a. More b. Same number c. Less	19 65 16
Are you satisfied with the current experimental classes?	a. Satisfied b. Not sure c. Dissatisfied	23 55 22
What should the assessment be based on?	a. Focus only on the theory examination b. Only pay attention to practice c. The combination of theory and practice	46 23 31
What form do you expect a course assessment to take?	a. Open-book examination b. Closed-book examination c. A combination of theory and practice	12 61 22

It can been seen from Table 3 that 54% of people think that most of the content of the curriculum is in textbooks, with just a small extra-curricular content. Most (88%) regard textbooks as the main source of information. Thirty-nine percent do not listen in class and mainly learn by self-study.

Moreover, 66% think the focus of teachers should be on the examination. Sixty-five percent think that their experimental classes are all right. Fifty-five percent are neither satisfied nor dissatisfied with experimental classes. Forty-six percent believe the assessment should be based on the written examination.

CONCLUSIONS

The study, as described in this article, concerned curriculum evaluation system requirements suitable for the assessment objectives of the Conceive, Design, Implement, Operate method. The evaluation process is through the ongoing and summative assessment of students' knowledge, learning ability and professional skills. It can accurately reflect the effect of the project teaching, in terms of knowledge, ability and quality. But, it also promotes students' learning initiative and practical abilities. The evaluation weights were obtained through interviews and surveys. The reasonableness of the evaluation process and evaluation of the results require practice in the use of the system, which will be the focus of future research.

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