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Promoting creativity in engineering programmes: difficulties and opportunities

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Abstract

Increasingly more researchers in education and industry have come to recognise the importance of nurturing creativity among engineering students. Since 2000, several engineering programmes in Hong Kong have introduced design subjects aimed at nurturing students' creative capabilities. The structure and content of these programmes have also been revised to cater for practical needs and difficulties. Taking Hong Kong as a case study, this paper first identifies new needs arising in engineering programmes and highlights a number of deficiencies requiring attention. The paper then briefly explains the aims of the new programmes and reviews changes made to design subjects over the past ten years. It identifies the successes recorded and difficulties encountered in implementing the original good intent of these programmes. Based on the Hong Kong case study, the paper then discusses future development opportunities for the promotion of creativity in engineering programmes.

Keywords: Creativity; engineering programme; collaboration; difficulty; opportunity.

1. Introduction

Unlike the situation in the past, when many engineering programmes required that students merely be able to manipulate and apply their skills and knowledge, an increasing number of programmes now expect students to be creative in their overall performance and particular subjects, and to carry this forward in their future career. More researchers in education and industry have also come to recognise the importance of nurturing creativity among engineering students in identifying and solving problems. One of the major reasons for this development is the changing nature of engineering practice making it important to maintain a balance between creative thinking and practical knowledge. Another reason is that society and industry are changing much more rapidly than they have before. Nurturing students' creative capabilities ensures they are able to deal with such changes.

Since 2000, several engineering programmes in Hong Kong have introduced design subjects aimed at nurturing students' creative capabilities. The structure and content of these programmes have been revised over the past decade to cater for practical needs and difficulties, e.g., education reform, new qualification requirements. Design subjects have also undergone various changes in their structure (along with other subjects), content and assessment approach. Taking Hong Kong as a case study, this paper first identifies new needs arising in engineering programmes and highlights a number of deficiencies requiring attention. The paper then explains the aims of the new programmes and reviews changes made to the programmes themselves and individual design subjects over the

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past ten years. It identifies the successes achieved and difficulties encountered in implementing the original good intent of these programmes and design subjects. Based on the Hong Kong case study, the paper then discusses future development opportunities for the promotion of creativity in engineering programmes.

2. Current status of engineering programmes

Engineering education today still places an emphasis on producing students familiar with engineering and technological knowledge and skills. Students are made to adopt a somewhat narrow perspective in their engineering studies. In most instances, students are required to follow a set of rigid steps to solve problems set by their professors and project supervisors. Students generally have limited experience of creative and critical thinking and analysis in, for example, identifying needs to address and problems to solve, and in making critical judgements on current issues (Siu, 2001; Splitter, 1995; Starko, 2000). Although some engineering programmes claim to be oriented towards creativity, many of these programmes are still biased towards training focused on skills such as tracing high-end software in computer graphics illustration. As a result, students lack the opportunity to explore their creative side and cultivate a creative mind (Siu, 2003). Some programmes that purport to develop innovation are biased towards so-called creative thinking, meaning students are not encouraged or required to examine related theories in depth, critically analyse ideas put forward, or develop them for practical purposes. Although the ideas generated are consistently imaginative, they lack theoretical and technological foundations (Siu, 2002).

The following sections of the paper take Hong Kong as a case study to discuss new needs arising in engineering programmes and identify a number of deficiencies requiring attention.

2.1 New needs arising in engineering programmes in Hong Kong

In common with many post-industrial cities, Hong Kong is reacting in a sensitive and dynamic manner to economic, social and technological changes in other cities, countries and regions. After the Second World War, Hong Kong was successively transformed from a fishing port into an entrepôt trading port, a manufacturing-oriented economy, a commercial centre combining manufacturing and service industries, and finally the international financial centre it is today. Hong Kong's education policies have had to be modified time and again to keep pace with the rest of the world and meet the changing needs of society (Siu, 2003). Engineering and product design curricula in Hong Kong have been updated many times to reflect societal changes: this has involved moving from a traditional focus on apprenticeships and techniques to an accent on analysis and technology, before shifting to an approach that emphasises knowledge and creative thinking (Siu, 2009). The current concern is to encourage creativity and innovation so Hong Kong can emerge from economic decline and hold its own against other cities and regions.

Previous studies have examined the job requirements of engineers (including industrial and product designers) and current related curricula in Hong Kong (Siu, 2000, 2002, 2009). The findings of these studies indicate engineers' job requirements have changed over time. In the past, the role of engineers involved more of a focus on generating solutions for problems presented to them. However, to maintain a high degree of competitiveness in today's world, the simple ability to solve problems or follow pre-determined procedures in completing tasks is insufficient. Engineers are increasingly required to perform on a higher level. They also need to have a comprehensive understanding of their profession to enable them to identify needs, initiate design and production strategies, and make decisions (such as on new product lines, efficient and updated production methods and new sales strategies), even if they are not working at the supervisory level. The term "engineering designer" used to be invariably associated with designers with capabilities in particular (narrow) areas, and these capabilities seemed sufficient to allow them to survive throughout their career. The professional engineering designer of today is increasingly required to be a highly capable all-round professional with the ability to meet continuously changing social and industrial needs.

The new engineering programmes initiated in Hong Kong during 2000 are aimed at overcoming the deficiencies of existing engineering programmes and put more of an emphasis on nurturing students' creative capabilities. One

of the critical changes introduced in these new programmes is the addition of a number of design subjects not forming part of the traditional curriculum. Instead of offering these subjects through the engineering department alone, they are provided through a design school partnership. Close collaboration among engineering departments and the design school is expected.

2.2 Deficiencies of current engineering programmes

Although engineering programmes that meet changes in society are encouraged, many programmes currently available have been unable to nurture students with the flexibility required to meet new needs (Fan, 1996; Siu, 2000, 2001, 2002):

- Student knowledge and experience are invariably biased. Under the common engineering training methods currently adopted, some students acquire good knowledge and skills but are weak in critical thinking (Siu, 2009). For example, many students (and graduates) have good computer engineering and graphics skills. They are able to utilise high-end software to produce exceptional illustrations. However, they are weak in such areas as identifying needs, taking the initiative and making decisions (Siu, 2001, 2002). Engineering graduates of this type find it difficult to differentiate themselves from those in neighbouring regions who are also highly skilled but command lower salaries;
- Some students are able to think creatively, but have very limited experience of putting their imagination into practice. For example, Hong Kong employers are consistently disappointed with so-called creative engineering graduates who cannot bring practical benefits and constructive contributions to the workplace. Such graduates usually need a lot of time and help from their senior colleagues to adapt to the work environment. Some employers comment that given a choice between employing this type of graduate or one with good technical skills rather than strong creative abilities, they prefer the latter;
- Today's engineers are expected to perform well in different areas of their profession. In practice, individuals are not supermen and are subject to practical limitations and constraints. All-round performance cannot be interpreted simply as demonstrating expertise in all areas; rather, it is more appropriately understood as the ability to work as part of a team to compensate for individual limitations (Adair, 1990; Beyerlein, 2000). In other words, teamwork has become a crucially important aspect of the engineering profession (Cleland & Irelend, 2002; Humphrey, 1997; Sekine & Arai, 1994; Shonk, 1992; Smith, 2000; Stevenson & Whitmore, 2002; Wright, 1998). However, no particular emphasis is placed on teamwork learning activities in current engineering curricula. Most such activities are provided on a may or may not be needed basis as an element of trendy learning activities;
- Current engineering curricula lack continuity in two ways. First, many are not reviewed and updated frequently. Even when they are, few elements are thoroughly reviewed and modified. The major reasons for this lack of rigour are that many curriculum planners and academic staff in individual universities remain in their positions for many years, and more importantly, fail to update their knowledge and experience. To be frank, the minor revisions made in most cases are superficial and represent a response to outside pressure for change. Second, current curricula do not incorporate a vision for or offer ways to prepare students to continue their studies in future. Some programmes merely prepare labourers, while others do not provide students with opportunities to develop their own interests, widen their perspective to adapt to other new disciplines, or equip them with the psychological and academic skills to face changes in society and industry.

3. New engineering programmes

One of the key changes introduced through new engineering programmes is the inclusion of several design subjects. These subjects are aimed at nurturing students' creative capabilities through industrial and product design studies and practical project experience.

3.1 Original programmes in 2000

When the new programmes were launched in 2000, they each offered two compulsory and four to six elective design subjects. The subjects were offered at several academic levels designed to cater for the varying needs of different students. The titles and contents of the subjects included:

- Fundamental design theories and practices;
- Social and cultural considerations;
- Design humanities;
- Other particular design areas.

Each of these design subjects consisted of two major parts: design theories and practical projects. Unlike conventional engineering design theories, the theories studied in the design subjects included other aspects of design such as historical issues, social and cultures theories, human factors and product semantics. In practical projects, there was a greater expectation that students would go through the whole design process. Instead of aiming only to produce the final solution (problem solving), students were required to perform well in "initiation" and "exploration". For example, students were expected to identify design issues and topics by themselves. They were also expected to work more in groups and collaborate with each other in group creativity activities.

3.2 Programme revisions since 2005

Several revisions have been made to programme objectives and contents since 2005. The reasons for these changes are as follows:

- Changes made to the overall requirements and structure of degree programmes in Hong Kong;
- Changes made to the accreditation requirements of professional bodies, e.g., registered engineer requirements;
- Changes made to the education goals and objectives of departments (programme-host departments in particular);
- New student expectations;
- New enrolment requirements and needs.

The changes made to design subjects include the scrapping of some elective subjects and the addition of other subjects. These changes are mainly due to new educational needs and student expectations. Instead of being taught by design school staff, several design subjects are co-taught in conjunction with staff from the engineering departments. This new arrangement is aimed at fostering better communication among departments (i.e., the design school and engineering departments) and achieving a balance between creativity and practical considerations in engineering. The weightings of elements covered in some design subjects have also been changed. For example, some subjects involve more of a focus on design thinking, whereas others are aimed at promoting implementation considerations and the ability to generate creative ideas.

In addition, through practical projects undertaken in individual subjects, students are encouraged to participate in external design competitions and work with the industry to execute their ideas. Students are also provided with additional forms of financial and technical support to motivate them to transform their ideas into reality.

4. Successes and difficulties

The inclusion of design subjects (creative elements) in engineering programmes has been continuously evaluated since 2000. In addition to obtaining regular feedback through student questionnaires and student-staff consultation meetings, studies have also examined the quality of planning, implementation and evaluation work for such subjects. These studies have included semi-structured interviews with students and teachers, continuous classroom observation of performance (classroom participation and assignment performance) and reviews of project outputs. They show the inclusion of design subjects has led to the following successes:

- Students gain more experience in the design process (creative process);

- Students have a greater opportunity to exercise their initiative in both design thinking (e.g., problem identification) and problem solving;
- Students have more freedom to propose ideas and put forward their views on projects (i.e., learning elements and process);
- Students gain wider experience of the design process;
- Students can see design issues (or other learning matters) from a wider perspective, e.g., not only from engineering and technological angles, but also from social, cultural, human and ideological viewpoints;
- Students have the opportunity to bring ideas through to practical implementation. They are also able to apply the skills they learn to new concepts and areas;
- Students are more highly motivated to participate in design projects;
- Students and teachers have more opportunities to work together, particularly through their involvement in projects;
- Students gain more work experience in a wider range of industries with different levels and forms of support (e.g., resources and technical support);
- Teachers have greater involvement in students' projects (i.e., more active involvement throughout the design process);
- Teachers have more of an opportunity to work with others from other departments (e.g., co-teaching in the same subject; co-supervision of students' projects);
- Curriculum planners and programme coordinators have flexibility to develop programmes and subjects that reflect changes in society and new education goals.

On the other hand, the planning, implementation and evaluation of programmes presents quite a large number of difficulties:

- Curriculum planners face more difficulties in planning and coordination, particularly in administering curriculum structure and the weighting of different subjects (and learning content);
- Curriculum planners face more difficulties in planning and revising curricula and subjects to meet changes in the outside world; in particular, design subjects are required to be more dynamic to meet social changes;
- Programme coordinators encounter more difficulties in resource allocation, particularly among different departments (e.g., physical space, manpower allocation);
- Programme and subject coordinators must deal with additional problems in the overall administration of programmes (e.g., coordination among different departments);
- Programme and subject coordinators need to organise a more flexible timetable for students from different programmes and teachers from different departments;
- Subject coordinators need to spend more time searching for suitable teaching staff, including those working with staff from other departments in different disciplines;
- Teachers need to cater for students with different academic backgrounds and expectations of the overall programme and individual subjects;
- Teachers need to establish more flexible assessment schemes for students with more varied backgrounds;
- Students are required to be more self-motivated and display greater initiative in their learning;
- Students from engineering disciplines need to familiarise themselves with the learning modes and methods of design disciplines;
- Teachers and students need to familiarise themselves with new assignment requirements and assessment criteria;
- Students need to handle the expectations and requirements of subjects with different natures (within the same programme).

5. Opportunities for future programme development

As discussed above, nurturing creative capabilities among engineering students has become a more important aspect of their education, particularly in preparing students to face changes in society and industry. The case study

described here shows the incorporation of design subjects into engineering programmes has led to some successes and advantages. However, curriculum planners, programme and subject coordinators, teachers and students alike face quite a number of difficulties in programmes of this type. The Hong Kong case study demonstrates three aspects of engineering programmes in which creativity development opportunities exist.

Regarding the planning aspect, engineering programmes are becoming more flexible in terms of learning objectives and curriculum content. Added to this is that fact that professional bodies in the engineering field no longer impose such strict education and accreditation requirements. Thus, curriculum planners have greater flexibility in planning curricula that include more design subjects and elements. In terms of implementation, interdepartmental and interdisciplinary collaboration is encouraged to a greater extent. Engineering (and design) department teaching staff are more open-minded than before in working with others. Experience also tells them they must work with others in teaching key elements of their respective disciplines. This change in mindset has eliminated many barriers to collaboration among teaching staff. Moreover, learning and teaching reference materials are provided through engineering programmes to nurture students with creative capabilities, and more resources are provided at the university and departmental levels. Regarding the evaluation aspect, quality assurance schemes for engineering programmes are different from those previously adopted. Society, educators, employers, parents and students themselves are more open to the idea of engineering students learning not only how to manipulate and apply conventional engineering skills and knowledge, but also to be more creative in the face of social and industrial changes. In short, all of these mindset changes in different sectors of society present opportunities for engineering programmes to nurture creative students.

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