

## The CDIO-based survey as a useful tool in the monitoring and evolution of the curriculum in the Department of Mechanical and Materials Engineering at Queen's University, Canada

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**ABSTRACT:** The Department of Mechanical and Materials Engineering (MME) at Queen's University, Kingston, Canada, adapts the curriculum like any other similar department on an ongoing basis with input from students, faculty, alumni/ae and other sources. Joining the *Conceive – Design – Implement – Operate* (CDIO) Initiative and working with colleagues from around the world has been very helpful to set priorities for curriculum changes. A slightly modified version of the CDIO survey conducted at Queen's University Belfast in Belfast, Northern Ireland, UK, was utilised in order to obtain feedback from alumni/ae. Some of the suggested changes have already been implemented and work will continue on other ones. One of these challenges will be to repeat the survey in the future in order to determine if the changes have made a difference.

### INTRODUCTION

The expectations that industry and other employers have of engineering graduates are changing with time, partially due to changes in society, but also how industry adapts to new developments in technology. In particular, communication, teamwork and the enormous advances in Information Technology (IT) have changed what is expected from graduates, apart from the fact that solid knowledge in the technical core subjects is still required.

### FEEDBACK

There are several methods to gain feedback about what needs to be changed in a curriculum. One important method for the Department of Mechanical and Materials Engineering (MME) at Queen's University, Kingston, Canada, is the Advisory Council (AC). This is a group of three to five former students who have been working in industry for several years. They visit the Department once per year, talk with students, staff and faculty, and write a report about the issues that need to be addressed, as well as how well previous recommendations have been taken care of.

The Academic Council visits used to be a mandatory process in the Faculty of Applied Science at Queen's University; however, even after it was no longer required anymore, the MME Department decided to continue these annual assessments. There is also an anonymous University Survey of Student Assessment and Teaching (USAT) that provides feedback to individual instructors, plus a summary with the ratings to the Department Head.

Engineering education meetings and journals, as well as talking to colleagues at conferences, is another source for input about possible improvements in the programme. The MME Department felt that the *Conceive – Design – Implement –*

*Operate* (CDIO) Initiative would be a tool well suited to review the curriculum in a more organised way. The work previously undertaken by other collaborators of the CDIO Initiative on curriculum, teaching and learning, assessment and workspace was convincing enough for the faculty in the Department of Mechanical and Materials Engineering to unanimously join the initiative in December 2003.

### ENGINEERING CURRICULUM SURVEY

In the summer of 2004, a survey about the engineering curriculum was conducted with alumni/ae from 2004 graduates and going back as far as 1970. The goals of the survey were to ensure that students are taught what is required today from graduating engineers by industry. The results from the survey were already utilised for the preparation of the documents required by the Canadian Engineering Accreditation Board (CEAB) for a six-year extension of the MME programme. The results of the survey will also provide a benchmark for future surveys and for benchmarking with other programmes in Canada and abroad.

The survey was based on the CDIO version looking at *personal and professional skills and attributes* and *operating systems in the enterprise and societal context*, or the so-called *soft skills*. Question 3.3 about communications in a foreign language was omitted as there is no such requirement from the Canadian Engineering Accreditation Board. The survey also included questions about mathematics, engineering sciences and additional core subjects, similar to the survey conducted earlier at Queen's University Belfast in Belfast, Northern Ireland, UK. The survey was tested and modified with the help of a small number of faculty, graduate and undergraduate students before it was mailed to the alumni/ae. Based on this initial feedback, it was concluded that there should be only one simple way of answering questions, as listed in Table 1.

Table 1: Potential survey answer selections.

Circle the level of importance that you believe a new BSc graduate engineer should have.	
Please answer topics on the basis of your own personal experience.	1. Considerably less important than the others;
	2. Less important than the others;
	3. Of average importance;
	4. More important than the others;
	5. Considerably more important than the others.

- 38% were still mainly doing an engineering job;
- 43% had moved to a mainly management activity;
- 2% had already retired;
- The remaining 17% were in other positions, such as finance, sales and teaching.

The results of the section on *personal and professional skills and attributes* of the CDIO survey is shown in Figure 1 for the more recent graduates and those who graduated before 1994. The results for *operating systems in the enterprise and societal context* are shown in Figure 2. The data was also analysed for male/female differences, but no significant differences were found.

## RESULTS OF THE SURVEY

Of the over 3,000 surveys that were sent out, more than 400 responses, or almost 15%, were returned and analysed. Of the ones returned, 10.6% were female and 89.4% were male; furthermore, 37.2% graduated after 1994 and 62.8% were graduates from 1970 to 1993. The respondents' careers were comprised as follows:

In addition to the so-called *soft skills* from the CDIO survey, aspects of the core curriculum that were part of the survey were also analysed. The answers in the areas of thermodynamics, fluid mechanics, engineering dynamics and kinematics indicate that teaching the principles and how to apply them is clearly more important than deriving the principles. Figure 3 shows the

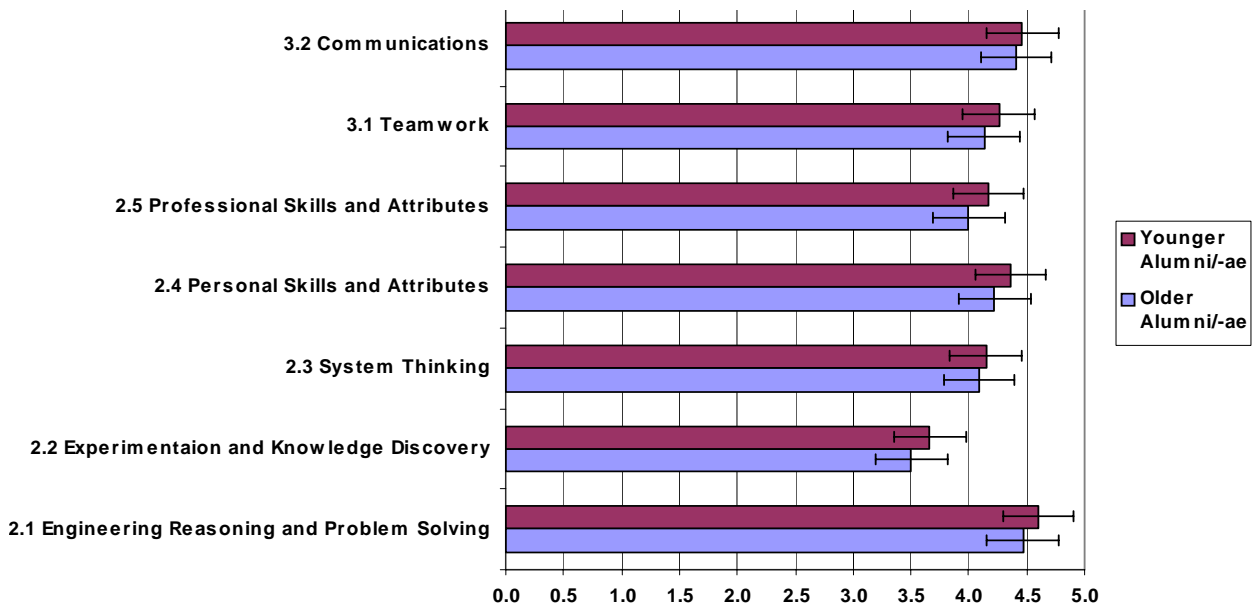


Figure 1: Personal and professional skills and attributes (+/- 1 SD).

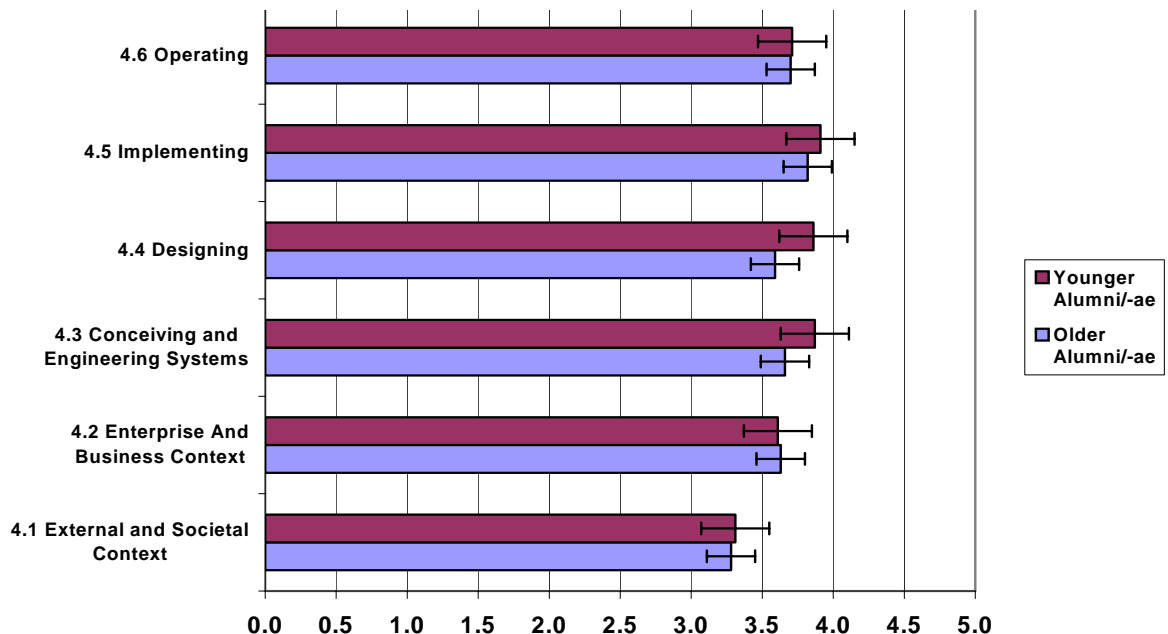


Figure 2: Operating systems in the enterprise and societal context (+/- 1 SD).

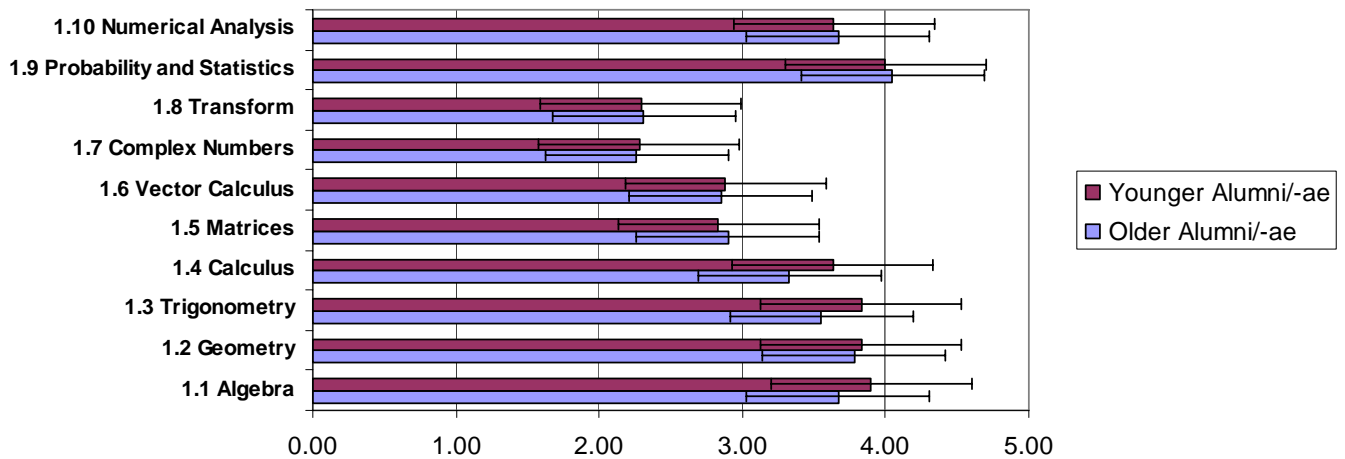


Figure 3: The importance of the different subjects in mathematics (+/- 1 SD).

results about the knowledge in the different areas of mathematics.

Additional feedback was generated about the importance of other courses taught in the MME programme. Project management was the one with the highest rating of 4.1, while the lowest was 2.8 for marketing methods and practices, with the other 17 subjects falling in between.

There was space provided for additional comments and about a third of the over 400 respondents added comments. These comments were grouped into the following four categories:

- More practical applications – real world issues: 38%;
- Excellent communication skills: 21%;
- More group projects – teamwork: 27%;
- Other: 14%.

## DISCUSSION

Almost 15% of the surveys mailed were returned, providing an excellent basis for reviewing the curriculum with over 400 *opinions* of Queen’s University’s own graduates between 1970 and 2004. The simplified answers that were adopted in the survey largely eliminated problems when answering the questions.

All the personal and professional attributes and interpersonal skills (Figure 1, 2.1-2.5 and 3.1-3.2) seem to be important with a rating of 3.5-4.5 out of 5. The lowest was experimentation and knowledge discovery (2.2). The attributes in operating systems in the enterprise and societal context (Figure 2, 4.1-4.6) are between 3.3 and 3.8, with the lowest being the external and societal context (4.1). It is interesting to note in Figure 3 that probability and statistics was rated highly with a score of 4 by alumni/ae, while transforms and complex numbers were not rated highly, yielding scores of around 2.3.

The MME core programme was also benchmarked with the CDIO Syllabus as outlined by Bankel et al [1]. There is no fixed set of technical electives for the following areas of specialisation in the MME programme at Queen’s University:

- Manufacturing and design;
- Biomechanical;
- Mechatronics;

- Aerospace engineering;
- Thermo and fluids.

Only the materials option has a defined set of courses for specialisation, limiting the number of technical electives a student can choose. The scale used at Queen’s University is not exactly the same as the one used by the Swedish universities Chalmers University, Göteborg, KTH and Linköping University, Linköping, or the Massachusetts Institute of Technology (MIT) in Cambridge, the USA, which makes a detailed comparison difficult.

The largest deficit in the core programme was found to be in the following areas:

- *Enterprise and Business Context* (4.2);
- *Implementing* (4.5);
- *Operating* (4.6).

The results of the survey have led to a few changes in the curriculum of the MME Department. In particular, the oral and written communication course has been changed to have about half of the material linked to communication requirements in other courses. Furthermore, communication will be taught in the first, second and third years of the four-year programme so that it will be an ongoing process.

The initial feedback from students and faculty has been very positive. A second major change resulted in increased efforts to have industry-sponsored projects in the fourth year capstone course, and also as much as possible in other design-related undergraduate courses.

## CONCLUSIONS

The CDIO-based survey is a very useful tool when reviewing the curriculum. It provides hard data from over 400 engineers who graduated from the MME programme at Queen’s University. It helps to focus the discussion on those issues that matter, rather than getting lost in less important details. It also neutralises strong opinions by individual faculty members. The Mechanical and Materials Engineering programme has already adopted an overhaul of when and how oral and written communication teaching will be provided.

Furthermore, it has helped to strengthen the conceive and design 4<sup>th</sup> year design capstone course (CD), and the 4<sup>th</sup> year

implement and operate (IO) course. Additional changes in the curriculum will be necessary to further decrease the gap between what industry needs and what is being taught. An additional challenge will be to convince more faculty members to introduce aspects of the CDIO Syllabus in their courses.

Benchmarking entering and exiting students, as well as follow-up alumni/ae surveys will indicate if the curriculum changes

provide a programme closer to what is required by industry and other employers.

#### REFERENCES

1. Bankel, J. Berggren, K-F., Crawley, E., Engström, M., El Gaidi, K., Östlund, S., Soderholm, D. and Wiklund, I., Benchmarking engineering curricula with the CDIO syllabus. *Inter. J. of Engng. Educ.*, 21, 121-133 (2005).