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THE CDIO BASED SURVEY AS A USEFUL TOOL IN THE MONITORING AND EVOLUTION OF THE CURRICULUM IN THE MECHANICAL AND MATERIALS ENGINEERING DEPARTMENT AT QUEEN'S UNIVERSITY, CANADA

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ABSTRACT

The department of Mechanical and Materials Engineering (MME) at Queen's University adapts the curriculum like any other similar department on an ongoing basis with input from students, faculty, alumni/ ae and other sources. Joining the 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 Queen's University Belfast CDIO survey was used to get feedback from alumni/ ae. Some of the suggested changes have already been implemented, and work will continue on other ones. One of the challenges will be to repeat the survey in the future, to see if the changes made a difference.

INTRODUCTION

The expectations industry and other employers have of our 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 have changed what is expected from graduates, apart from the fact that solid knowledge in the technical core subjects is still required.

There are several ways to get feedback about what needs to be changed in a curriculum. One important method for Queen's MME is the Advisory Council (AC). This is a group of 3-5 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, and how well previous recommendations have been taken care of. The AC visits used to be a mandatory process in the faculty of Applied Science at Queen's, 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, and 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 program. The MME department felt that the CDIO initiative would be a tool well suited to review the curriculum in a more organized way. The work previously done by the other collaborators of CDIO 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.

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 used for the preparation of the documents required by the Canadian Engineering Accreditation Board (CEAB) for a 6 year extension of the MME program. The results of the survey will also be a benchmark for future surveys, and for benchmarking with other programs 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 CEAB. The survey also included questions about mathematics, engineering sciences and additional core subjects, similar to the survey done at Queen's University of Belfast earlier. 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 how the questions can be answered as illustrated below:

Circle one of the level of importance that you believe a newly BSc graduate engineer should have

	1. Considerably less important than the others
Please answer topics	**2.** Less important than the others
on the basis of your	**3.** Of average importance
own personal experience	**4.** More important than the others
	5. Considerably more important than the others

RESULTS OF THE SURVEY

Of the over 3,000 surveys that were sent out, more than 400 responses, or almost 15% percent, were returned and analyzed. Of the ones returned 10.6% were female and 89.4% were male. 37.2% graduated after 1994 and 62.8% were graduates from 1970 to 1993. 38% were still mainly doing an engineering job, 43% had moved to a mainly management activity, 2% had already retired and the remaining 17% were in other positions, such as finance, sales and teaching.

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

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 analyzed. 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. The results about the knowledge in the different areas of mathematics are shown in figure 3.

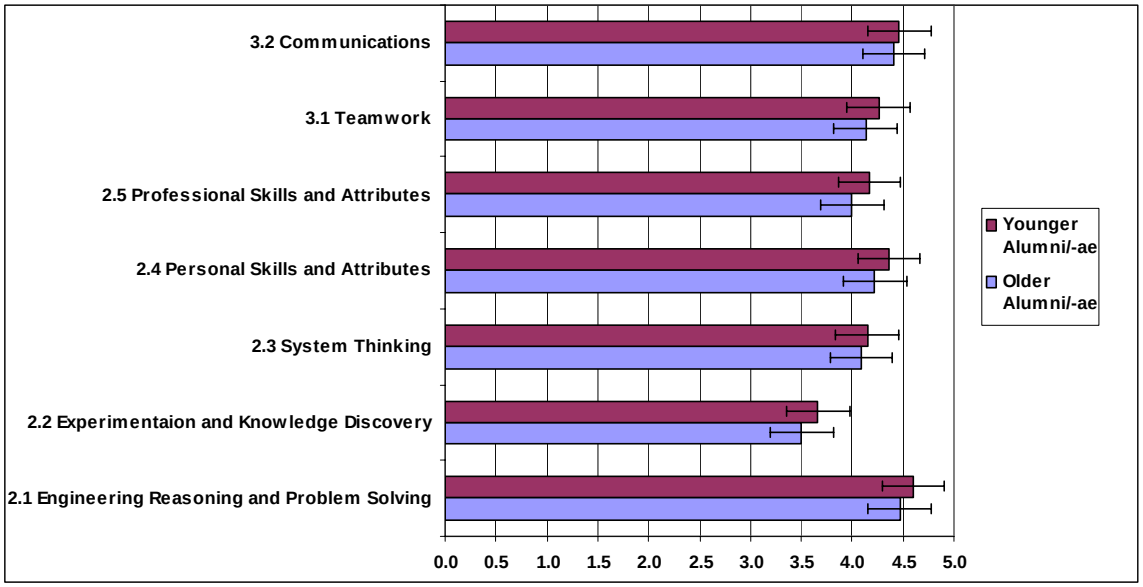

Figure 1: Personal and Professional Skills and Attributes (+/- 1 S.D.).

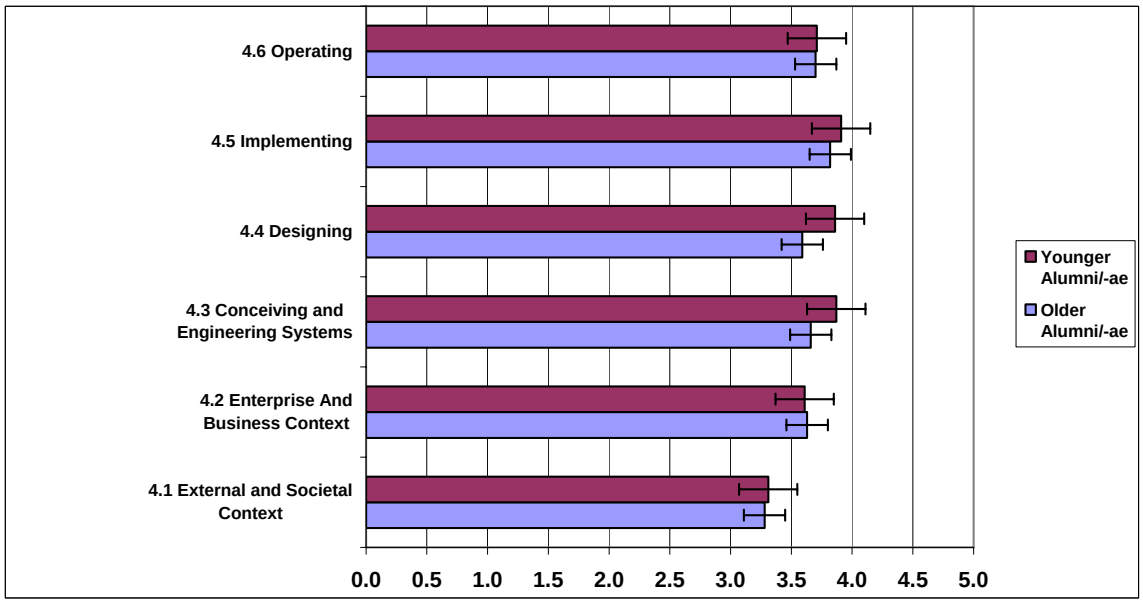

Figure 2: Operating Systems in the Enterprise and Societal Context (+/- 1 S.D.).

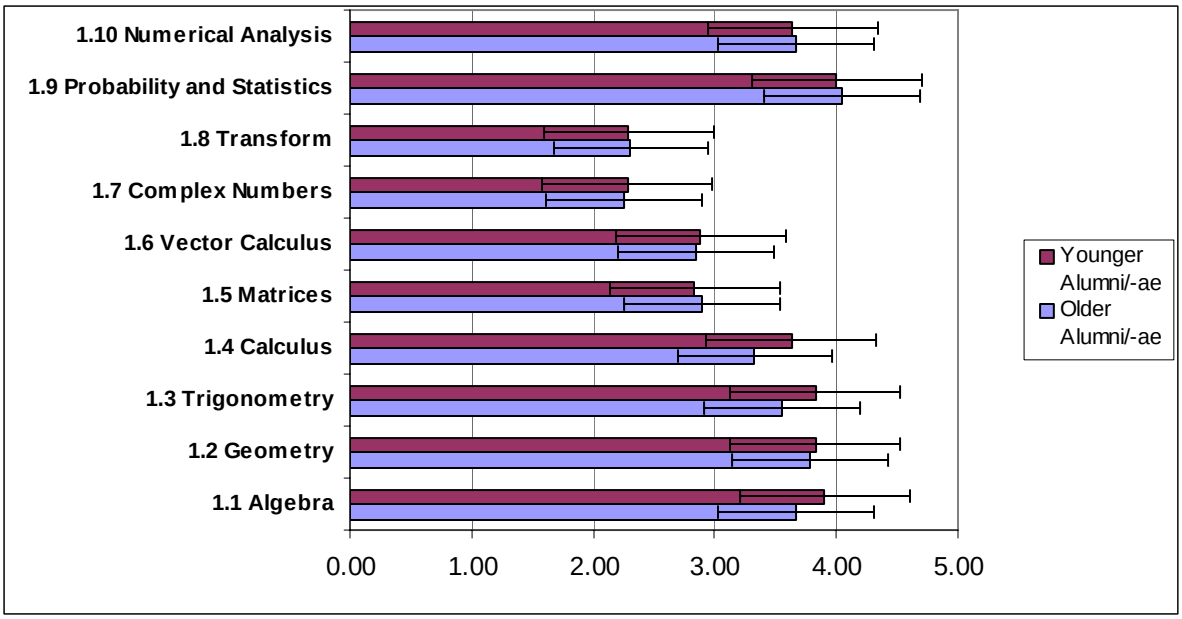

Figure 3: The Importance of the Different Subjects in Mathematics (+/- 1S.D.).

Additional feedback was generated about the importance of other courses taught in the MME program. Project management was the one with the highest rating of 4.1, and the lowest was 2.8 for marketing methods and practices, with the other 17 subjects 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 four following 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 our own graduates between 1970 and 2004. The simplified answers that were adopted in the survey largely eliminated problems 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 system in the enterprise and societal context (Figure 2, 4.1 – 4.6) are between 3.3 and 3.8, with the lowest being external and societal context (4.1). It is interesting to see in figure 3, that probability and statistics was rated high with a score of four by alumni/ ae, while transforms and complex numbers were not rated highly with scores around 2.3.

The MME core program was also benchmarked with the CDIO syllabus as outlined by Bankel et al. (2005). There is no fixed set of technical electives for the areas of specialization in manufacturing and design, biomechanical, mechatronics, aerospace engineering, and thermo and fluids in the MME program at Queen's. Only the materials option has a defined set of courses for specialization, limiting the number of technical electives a student can choose. The scale used at Queen's is not exactly the same as the one used by the Swedish universities Chalmers, KTH and Linkoeping or the MIT in the US, making a detailed comparison difficult. The largest deficit in the core program was found to be in Enterprise and Business Context (4.2), Implementing (4.5) and 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 first, second and third year of the four year program, so that it will be an on-going process. The initial feedback by students and faculty is very positive. A second major change resulted in increased efforts to have industry-sponsored projects in our 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 tools when reviewing the curriculum. It provides hard data from over 400 engineers who graduated from the MME program at Queen's University. It helps to focus the discussion on the issues that matter, rather than getting lost in less important details. It also neutralizes strong opinions by individual faculty members. The mechanical and materials engineering program 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 deign 4^{th} year design capstone course (CD), and the 4^{th} 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 program closer to what is required by industry and other employers.

REFERENCE

Bankel, J., et al., Benchmarking Engineering Curricula with the CDIO Syllabus, *Int. J. Engng. Ed.,* **21**, 121-133, 2005.