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Teaching industry-based intensive short courses and its significant effects in keeping up with current industrial trends and practices

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ABSTRACT: In this article, the authors strive to contextualise their thoughts on how teaching intensive short courses, which were tailored to cater for the needs of industrial practitioners, can be an effective approach in keeping abreast of, and maintaining relevance to, present industrial trends and practices. The authors detail the mechanism involved in their preparation, organisation, and delivery of the courses, which were pertinent activities in achieving the authors' own objectives of gaining insights into the current developments of the local industry. Participants' feedback in the course evaluation provided partial evidence to this end that the authors sought to achieve, based especially on the usefulness of the course materials, particularly the industrial case studies and examples that were incorporated.

INTRODUCTION

There is an ongoing debate on the role of academia in providing appropriately and sufficiently trained engineers who will meet the demands of industry. The crux of the issue centres on the need to bring *real world* experience and insights into the classroom. Several measures have been proposed to address this issue. Noble suggests sabbaticals, consulting activities, graduate research and the hiring of adjunct faculty members as possible approaches to keep up with current industrial needs and developments [1]. He advocates, in detail, the anticipated benefits of having an adjunct faculty position and its effects on professor(s), industrial employers, the university and students. It is further noted that students appreciate courses that feature adjunct professors as guest lecturers, especially years after graduation when they have been through similar experiences of working in industry.

Actively conducting research is another approach to keep abreast of industry developments. In attaining a more direct experience, one can work on applied research problems that are of industrial relevance in addition to undertaking basic research. Further, Wankat advocates the synergism between research and the other core academic function of teaching, relating several examples on how research has helped in his teaching [2]. Sabbaticals spent at companies and consulting work are also clearly beneficial to a professor vis-à-vis exposures to industry and their practices. In this article, the authors attempt to describe another approach in maintaining relevance with current advances in industry by relating their experiences in teaching intensive short courses to industrial practitioners and by explaining how this has improved their teaching activities in the academic setting.

INDUSTRIAL-BASED INTENSIVE COURSES

Every company that is serious about becoming a market leader in their core business area ought to consider human resources as their primary asset. As a result, many companies are compelled to devote a dedicated budget to developing and improving their people through training courses. There are generally two types of such courses: those that are taught by individuals within the company itself (ie company's internal or in-house courses) and those that are handled by instructors engaged from outside of the company. The latter are either conducted in-house, ie the course instructors are invited to the company's site and utilises company facilities, or at an external location, ie the company sends its participants over to the training venue, typically the instructor's institution or a hotel.

There is a great number of firms offering training programmes to companies, indicating the thriving state of this business line. Universities also offer such programmes. Several universities in the USA and other countries have an office dedicated to organising and scheduling short courses offered to industry. The Office of Consultation and Career Development (OCCD) at the College of Engineering of Kuwait University is probably typical. The main function of the OCCD is to encourage and maintain ongoing interactions between the College and local industry. It provides consultation services to local firms to solve their particular problems and assist in improving their productivity. Furthermore, the OCCD arranges in-house trainings to various government and private agencies. On average, the OCCD organises more than 55 public short courses every year in various fields of specialisation. Each department in the College has a committee that is responsible for identifying areas in which a short course could be offered.

The OCCD also conducts surveys to determine areas in which professional training is needed and can thus be offered. Most faculty members contribute by participating in one or two intensive courses per year. Clearly, there are financial returns in undertaking such initiatives, but the educational and institutional benefits are even greater, as will be highlighted in this article.

PREPARATION IN CONDUCTING INTENSIVE COURSES

Teaching a short course to industry comes automatically with high expectations. After all, participants, who were once students, are now professionals; some are even managers and are unlikely to settle for anything less than the best teaching and instruction that can be offered. Therefore, in preparing to conduct a short course, the professor has to constantly keep his/her potential audience in mind. The course participants might previously have taken a similar course in their undergraduate or graduate education. Typically, they will have signed up for a particular industrial short course with the following intentions: to refresh their understanding of the fundamentals of the field, especially pertaining to knowledge areas that are more scientifically-grounded; to stay updated with new breakthroughs and innovations in the discipline; and to discuss, with the faculty member, some of the problems that they are facing in their work related to the course material. Thus, the professor has to ensure that he/she can and will be able to meet these expectations.

To ensure satisfying students' needs, it was decided to teach courses only in the areas of expertise. In this way, current developments in the field are already familiar to the presenters. Additionally, in preparing for lectures, multiple sources were consulted on a subject to see different methods in which the material could be presented. The lectures were supplemented with a number of practical local examples too. Discussions with former students of the same courses helped in the formulation of these examples. Various articles in journals (especially trade journals) were also beneficial in this respect. Every possible effort was made to prepare good overheads or presentation slides to be used for the course delivery.

These courses often require a laboratory component and practical sessions, which are conveniently carried out at the College's facilities. To stimulate discussions and provide more links between theory and practice, a guest speaker is sometimes invited from industry to present more practical examples and case studies. At the end of a course, participants are asked to apply what they have learned to a small project or provide solutions to an existing unsolved industrial problem encountered in their work.

Another aspect that the teaching of a short course requires is integrating computing technology within the course. Previous experience has often revealed that participants like to have some hands-on experience with the material imparted to them. They want to see real world examples that, in many cases, cannot be illustrated without the help of a computer. Equation-solving packages are particularly useful in some demonstrations by assisting in solving large-scale mathematical-based problems, answering *what if* questions in sensitivity analysis and plotting the results directly. Various instructional software is also available as aids to teach courses in different engineering fields, eg the work by Reklaitis et al present comprehensive simulation models of various industrial chemical engineering processes [3]. Each model was developed in collaboration with an industrial sponsor and designed to illustrate a real-world process. In addition, Fogler et al offer standalone interactive teaching modules for various fundamental courses in chemical engineering [4].

IMPACT ON REGULAR TEACHING ACTIVITIES AT THE UNIVERSITY

Subsequently, when returning to teaching regular courses at the university, the material assembled for teaching the short courses provides excellent supplements to lectures. The practical examples and case studies collected for teaching industrial courses serve to relate the theories and concepts taught in class to real world problems. The authors have also noticed an improvement in classroom teaching. All the hard work in meeting higher standards in conducting intensive courses has certainly enhanced their teaching. The authors are now accustomed to preparing for university courses in very much the same way they did for industrial courses. As emphasised throughout, in teaching the latter, it is almost a must to relate theory to practice. Now, even when teaching university courses, the authors feel compelled to adopt a similar approach.

ADDITIONAL BENEFITS IN TEACHING INDUSTRY-BASED COURSES

There are many other benefits derived from teaching industry-based short courses. Discussions and conversations with the participants help in identifying the specific needs of industrial practitioners that should be included in such courses. Further, the authors are privy to current issues faced by local industry that could potentially be translated into research ideas, whose solutions could potentially be of benefit to industry.

Teaching these intensive courses also enhances networking with local industry and helps in fostering new relationships. For instance, while teaching a short course last year, one of the attendees, who was a senior engineer, caught the presenters' attention as he appeared to possess all the ideal qualities that industry looks for in a fresh graduate, ie someone with good communication and interpersonal skills, self-confidence, is a clear thinker and has a strong understanding of the fundamentals. It was decided to invite him to give a talk to students. He opted instead to lecture students on computer modelling and simulation, and their roles in process engineering applications. All in all, this event served two purposes: first, students learned a great deal from the talk and second and more importantly, they obtained a glimpse of a real life model engineer. Besides that, an opportunity was also gained to solicit feedback on the quality of the University's recent graduates and whether there are particular weaknesses that should be remedied.

COURSE ORGANISATION

An opportunity presented itself to organise two industry-based intensive courses, with each organised on two separate occasions (altogether, several courses have been offered to industry). The courses were: *Professional Development Skills with Creative Problem Solving for Engineers* (Course 1) and *Elements of Applied Process Engineering and Optimisation* (Course 2). Each time, they managed to attract an average attendance of about 15 participants. These five-day courses typically consisted of five six-hour modules (including hands-on computing sessions), with each scheduled over a day. The general contents and structure of these courses are provided in Tables 1 and 2, respectively.

For Course 1, the objectives kept in mind were to help the participants shape an effective and efficient method of approaching their daily responsibilities by providing specific training in the development of the following attributes: creative problem solving; competitive yet collaborative thinking; professional development skills with an emphasis on oral and written communication; interpersonal skills; and decision-making skills. In this course, the allocation of time was just sufficient to introduce the participants to the basic concepts of problem-solving, providing them with the opportunity of applying these newly-acquired skills, in addition to expanding their confidence in analysing and solving new problems independently. Essentially, the targeted audience was engineers keen on learning and acquiring various tools to nurture professional development skills. Past participants encompassed a very wide range of backgrounds, including industrial specialists, managers, ministerial personnel, consulting/ services executives, engineers and technicians.

Table 1: Contents of Course 1.

Part I: Effective Writing
- The Six Principles of Clear Writing;
- Measuring Your Clarity;
- Practical Tips on Organising;
- Outsmarting the Deadline;
- Elements of Formal Reports;
- Writing a Progress Report;
- Writing Good Memos.

Part II: Oral Presentation
- Handling Difficulties;
- Signs of Closed Communication;
- Presentation to Different Levels of Audience: the Manager, the Agency, the Manufacturers and Colleagues.

Part III: Creative Problem Solving
- Enhance Your Creativity;
- Group Dynamics;
- Methods for Idea Generation;
- Creative Ideas Evaluation and Judgement;
- Solution Implementation and the Selling of Ideas;
- The Pugh Method of Creative Design;
- Case Studies and Open Discussion.

Part IV: Patents
- Basic Principles of Patents;
- Usefulness of Patents;
- What a Patentable Invention is;
- Obtaining a Patent;
- Patent Application and Specification.

Part V: Computers and Professional Productivity
- Roles of Computers;
- Computers as a Thinking Tool;
- The Internet;
- Computer-Aided Report Preparation.

Part VI: Decision Making
- Structural Elements of Decision Problems;
- Payoff Tables and Decision Trees;
- Decision-Making Under Uncertainty;
- Value of Information;
- Multistage Decision Problems;
- Case Studies.

Part VII: Interpersonal Skills
- Clarifying and Confirming;
- Constructive Criticism;
- Managing Differences;
- Crediting;
- Applications: Influencing Behaviour; Influencing Attitudes; Supporting Positive Contribution; Building Teamwork.

Part VIII: Economic Evaluation of Projects
- Engineering Projects;
- Time Value of Money;
- Profitability Indicators;
- Project Selection.

The primary objective of the technically-oriented Course 2 was to familiarise participants with a wide array of mathematical modelling tools for applications in chemical process plant design, planning and scheduling in process operations, energy conservation, and parameter estimation. The tools introduced chiefly comprise methods for solving linear and nonlinear optimisation problems. The application of several well-established reliable and readily available microcomputer software packages was illustrated and a large variety of industrial case studies and examples were discussed.

Table 2: Contents of Course 2.

Part I: The Nature and Organisation of Optimisation Problems
- What Optimisation is All About;
- Why Optimise?
- Scope and Hierarchy of Optimisation;
- Examples of Applications of Optimisation;
- The Essential Features of Optimisation Problems;
- General Procedure for Solving Optimisation Problems.

Part II: Optimisation Methods

1. Basic Concepts of Optimisation.

2. Introduction to Linear Programming and Model Formulation:
- The Structure of Linear Programming Models;
- Solution Techniques and Postoptimality Analysis;
- Transportation and Assignment Problems;
- Computer Applications and Software.

3. Overview of Nonlinear and Integer Programming:
- Constrained and Unconstrained Optimisation of Nonlinear Programs;
- Pure and Mixed Integer Programs;
- The Branch-and-Bound Method;
- Practical Session: Hands-on experience and application of state-of-the-art modelling and computational software.

Part III: Applications of Optimisation

1. Fitting Models to Data:
- Classification of Models;
- The Method of Least Squares;
- Factorial Experimental Designs;
- Case Studies and Examples from the Petrochemical Industry.

2. Artificial Neural Networks (ANN):
- The Essence of ANN;
- Fundamentals of Neural Computing;
- Applications of ANN: Empirical Modelling; Process Control; Fault Diagnosis; Process Modelling and Forecasting; Computational Software.

3. Heat Transfer and Energy Conservation:
- Optimising Recovery of Waste Heat;
- Optimum Shell-and-Tube Heat Exchanger Design;
- Optimisation of Heat Exchanger Network.

4. Separation Processes:
- Optimisation of Liquid–Liquid Extraction Processes;
- Optimal Design and Operation of Staged Distillation Columns.

5. Fluid Flow Systems:
- Optimal Pipe Diameter;
- Minimum Work of Gas;
- Economic Operation of a Fixed-Bed Filter;
- Optimal Design of a Gas Transmission Network.

6. Chemical Reactor Design and Optimisation:
- Alkylation Process Optimisation;
- Formulation of Chemical Reactor Optimisation Problems;
- Use of Differential Calculus in Reactor Optimisation;
- Use of Linear Programming in Optimising Reactor operations;
- Nonlinear Programming Applied to Chemical Reactor Optimisation;
- Chemical Equilibrium.

7. Optimisation of Large-Scale Plant and Operation:
- General Methods for Meshing Optimisation Procedures with Process Models/Process Simulators;
- Equation-Based Large-Scale Optimisation;
- Large-Scale Optimisation Using Sequential Modular Flowsheeting;
- Large-Scale Optimisation Incorporating Simultaneous Modular Flowsheeting Strategies;
- Conclusions Regarding Combining Optimisation with Flowsheeting Codes;
- Treatment of Large-Scale Problems with Integer-Valued Variables.

COURSE EVALUATION AND PARTICIPANT FEEDBACK

At the end of a course, the University distributes standard questionnaires for course evaluation to elicit participants' responses, on a scale of 1 to 5, on 12 criteria related to various aspects of the course. The questionnaire also includes space for participants to provide anonymous written comments. The mentioned criteria are as follows:

1. Clarity of course objectives;
2. Adequacy of course contents in meeting the outlined objectives;
3. Practicality of course contents and outcomes to real world industrial practices;
4. Adequacy and usefulness of course handouts and materials (eg course notes, computer program files for hands-on sessions and summary sheets);
5. Effectiveness of audiovisual aids employed in the course delivery;
6. Understandability of instructors' delivery/presentation of information;
7. Demonstration of instructors' knowledge on subject matter;
8. Suitability of training methods adopted by instructors (eg discussion, case studies, hands-on practice sessions);
9. Adequacy and comfort level of classroom facilities;
10. Satisfaction with miscellaneous course services (eg meals and breaks);
11. Suitability of course duration with respect to course contents and objectives;
12. Overall satisfaction with the course programme.

Figures 1 and 2 display the mean score of each of the criteria for Course 1 and Course 2, respectively.

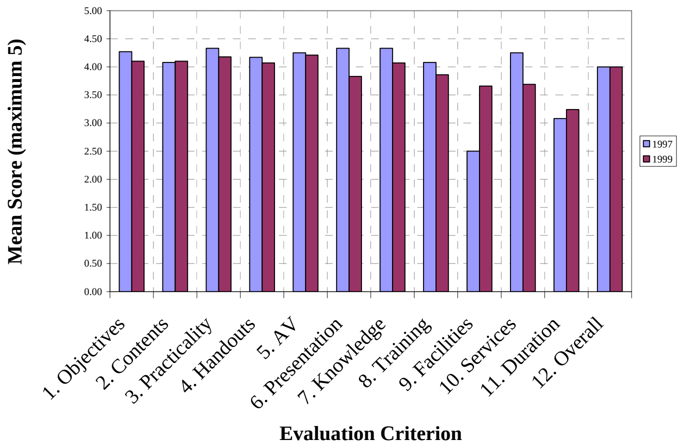

Figure 1: Participants' responses to the 12-criterion course evaluation questionnaire for Course 1.

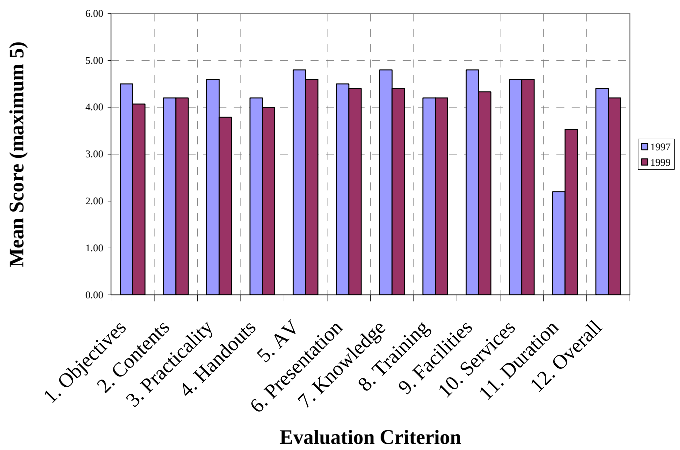

Figure 2: Participants' responses to the 12-criterion course evaluation questionnaire for Course 2.

As depicted by the graphs, the participants' rating consistently indicated positive responses of above-average to excellent (ie a score of more than 4 in general) for most of the criteria. It was also evident that a similar standard, if not better, was maintained in the second offering of both courses. The notable exceptions to this highly-encouraging trend were with regard to the course duration (for both courses) and classroom facilities (for Course 2); but the latter recorded significant improvements the second time around.

Some examples of general feedback and comments from the participants include the following for Course 1:

- *The course contents are relevant to what I do in my work*;
- *Everything was excellent including the lecturers (instructors) and course material handouts*;
- *I especially enjoyed the many discussions and case studies that were real life examples of what I actually encounter in work*;
- *The use of audiovisual aids was effective*;
- *The course duration should be made longer to enable better coverage of the materials.*

Feedback and comments for Course 2 include the following:

- *The objectives of the course were very clear and informative*;
- *The lecturers' delivery was very good and they were knowledgeable*;
- *I particularly liked the material and delivery on engineering economy, management, optimisation and cost estimation with the aid of computer programs*;
- *My favourite sections of the course were on quality control, location* (site) *selection and linear programming*;
- *The course duration should be extended to two weeks, instead of the present one week, to accommodate the intended contents.*

CONCLUSIONS

It goes undisputed that our three main roles as academics are research, teaching and scholarship in the field of engineering. These entail the need to keep abreast of present industrial trends and practices, as we are in the business of producing graduates that meet the needs of industry. In this article, the authors advocate the active involvement in organising and teaching industry-tailored intensive short courses as another effective approach towards achieving this goal.

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