University-Industry Collaboration: A Must for the Training of Professional Statisticians

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Abstract

Statistical Thinking plays a central role in the Quality Improvement activities of any organization. However, implementation of Statistical Methods in industry requires some broader skills which are not currently provided in university Statistics programmes. In this paper we discuss (i) the current status of Statistics programmes, (ii) the gap between what is offered and what is required, and (iii) a model to bridge the gap. This model involves partnerships between universities and industries and it is suggested that such a collaboration can provide opportunities for a student to improve communication and problem solving skills as well as to gain hands-on experience on real problems. Experience with such a system at the University of Waterloo indicates that it can work successfully and that it is beneficial for all the partners involved.

1. INTRODUCTION

The Quality focus in many North American industries and other enterprises in the recent years brought a renewed awareness to "Data" and "Variation" (Deming (1986). Many managers and leaders of organizations are talking about the importance of (i) Data Based Decisions, and (ii) Understanding and Dealing with Variation. These are the basic concepts in Statistical Thinking and hence Statistics has a central role in the Quality Improvement (QI) activities of any organization. However, many Statisticians who are involved in QI activities face several challenges in implementing statistical methods. They experience (i) the lack of adequate systems to implement statistical methods and (ii) the gaps between what is required in the workplace and what is normally available in a traditional university Statistics programme.

In Section 2 we discuss the needed skills for a professional Statistician, Section 3 gives what is available in current programmes and Section 4 is a discussion of how to bridge the gap. Section 5 suggests University-Industry partnerships as a vehicle for bridging the gap, Section 6 discusses such partnerships at University of Waterloo and Section 7 gives some concluding remarks.

2. NEEDED SKILLS FOR PROFESSIONAL STATISTICIANS

Hoerl et. al (1993) discuss 'survival' skills for Statisticians. An ASA Committee (1980) reported on preparing Statisticians for Careers in Industry. Box (1976), Hoadley and Kettenring (1990), Snee (1990b, 1993) emphasize the importance of communication and problem solving skills for Statisticians. All these discussions revolve around graduate training (Masters and PhD). The current paper highlights undergraduate training in Statistics, with some overlap between these papers.

The background needed for a Statistician depends heavily on the position and the level within the organization. However, we list some minimum requirements for a professional Statistician with an undergraduate background:

a) Technical background

- Applied and Mathematical Statistics background

  - courses in Design of Experiments, Survey sampling, Regression, Statistical Process Control (SPC), Measurement Systems (MS), Mathematical Statistics

- Good Mathematics background

  - Linear Algebra, Advanced Calculus, Numerical Analysis, Differential Equations, etc.

- Good Computing skills

b) Non Technical skills

- Problem solving methodology
- The Scientific Method
- Communication skills
- Ability to work in groups
- Willingness to be involved in adult training

c) Hands-on Experience

- Experience with real problem solving projects

d) Leadership skills

Traditionally, Statisticians performed a support service role. However, in the new environment, Statistics is the nervous system for QI activities and Statisticians often have to be in leadership roles. Thus good leadership skills will be an added advantage.

People with graduate degrees (Masters or PhD) should have additional background as listed in Hoerl et. al (1993) and ASA Committee (1980), including Multivariate Analysis, Time Series, Discrete Data, etc.

3. STATUS-QUO

Currently, most Statistics programmes in universities lead to (i) Bachelors, (ii) Masters, and (iii) PhD degrees. The majority of the PhD Statisticians end up teaching in Universities, while most of the people in (i), (ii) and a small portion of the PhD's end up in non-academic organizations. However, most undergraduate programmes are oriented to students who are going towards a PhD degree.

For effective implementation of Statistical Methods in industry, excellent undergraduate instruction in Statistics is essential because most of these students end up in industrial, governmental, health or other non-academic organizations where they are called upon to implement statistical methods. However there is considerable variation in the undergraduate programmes offered. The technical skills needed are generally met in these programmes, except in some administered by mathematics departments where Applied Statistics courses may not get much importance. Even in those programmes which generally satisfy the technical requirements, topics such as Statistical Process Control (SPC), Measurement System (MS) studies, Planning for Data Collection (PDC) are often not adequately addressed.

The non-technical skills mentioned above and opportunities for hands-on experience in real projects are missing from most programmes. In Graduate programmes (Masters, PhD), the technical skills are generally met; however, the non-technical skills and opportunities for hands-on experience are lacking.

There have been some attempts to correct certain aspects of (b) and (c). Some Statistics programmes now require that a Graduate student (Masters or PhD) should spend at least a term (semester) in a consulting laboratory. In certain places PhD students have to take a minor in another area (encouraging them to learn another area) so that inter-disciplinary work can progress. Some institutions have joint Statistics programmes (Masters or PhD) with areas such as Engineering and Business. Though these are commendable, they are not sufficient. Students need to be in a "working environment" to experience real problem solving.

4. BRIDGING THE GAP

Gaps:

In graduate as well as undergraduate programmes, the main gaps are (i) lack of opportunities for hands-on experience with real problems, and (ii) lack of opportunities for developing problem solving and other non-technical skills.

Certain undergraduate programmes lack even traditional Applied Statistics courses such as Design of Experiments, Regression Analysis and Survey Sampling. Many programmes lag behind in addressing topics such as Measurement System Studies, Planning Data Collection and Statistical Process Control.

How to bridge the gap?

We feel that the issues raised should be addressed at two levels:

(i) Changes in curriculum and teaching or delivery methods

- Adopt a problem solving approach
- Project oriented teaching
- Experimental learning (learning by doing)
- Students working in groups
- Systems for proper feedback and course evaluation
- Curriculum should include SPC, MS, PDC, etc.
- Enhance Statistical Thinking

Snee (1990b, 1993), Garfield (1995), Vere-Jones (1995), Hogg and Hogg (1995), Wild (1995), Hoerl et. al (1993) discuss these issues.

(ii) Create a system for developing hands-on experience with real problems. Undergraduate level consulting laboratories are difficult to implement. Even the consulting laboratories at the graduate level are under constant threat of closure because of shrinking resources in many universities. One possible approach which has proved to be somewhat successful is to have a system which provides "work terms" in industry. Such a model requires:

- Co-operation from industry
- University-Industry partnerships
- Long term commitments from the partners
- Recognition that universities and industries benefit from the partnerships

It is important to recognize that during the work term students are to work not only on Statistical Analysis but also to formulate the problem and the plan of approach, and plan the data collection.

5. UNIVERSITY-INDUSTRY PARTNERSHIPS

Industries need graduates with technical and non-technical skills. It is difficult for the universities alone to provide all the skills needed. However, if the universities and the industries collaborate it is possible to provide the student with the necessary opportunities. One such collaboration is to form partnerships..

In such partnerships, an understanding of the needs of each partner and long term commitments are required, and the roles of each partner should be clearly defined. The universities should continue to provide the necessary academic training. They should make programmes flexible so that students can spend some time (work terms) in industry to enhance the non-technical skills and to gain some hands-on experience. Industries should make sure that the students work on real projects in which they can (i) acquire skills to work in groups, (ii) enhance communication skills, and (iii) gain experience in problem formulation, planning of approach and data collection, and problem solving. Universities and their partners should have systems in place to implement the "work terms" effectively — which involves the smooth transfer from university to industry and back. The systems at the industrial partner should have the flexibility to identify project areas for the students and to interact with the university (faculty members) regarding the projects and the progress of the students. Different models or processes may be used for undergraduate and graduate students. The partnerships should be flexible enough to accommodate:

- faculty and student interests
- experience exchange programmes
  - joint seminars or training
- project oriented course work

6. UNIVERSITY OF WATERLOO AND INDUSTRY

University of Waterloo has been involved with industry at several levels:

(i) Co-Operative programmes

The University of Waterloo has a large (probably the largest in the world) co-op programme involving about 9,000 undergraduate students annually. In this programme a student goes to an industry for a four month "work term" after every four month school term. Each student is expected to write a work term report for each work term which will be evaluated by the employer (industry) as well as by the University. Students are expected to finish 4-6 successful work terms during their degree programme. The Engineering Undergraduate programme at Waterloo is only available through the co-op option while other undergraduate programmes including Statistics are available by co-op

as well as regular routes. Each "faculty" (college) has its own special requirements. However, all co-op placements in industry are administered through the Department of Co-Operative Education, a large administrative group on campus. In general, placement rates in Engineering and Mathematics are well over 90%. During recession periods, some difficulties in placing first year students were experienced, prompting some adjustments to the timing of work terms and academic terms.

There is a representative group from industry called the Waterloo Advisory Council which meets with University administration twice a year to exchange ideas on many issues facing the University and industry. Co-op education and University-industry collaboration is often discussed. This is an opportunity for the University to get input from industry regarding curriculum changes, new courses and programs.

(ii) Institute for Improvement in Quality and Productivity (IIQP)

University of Waterloo has many centres and institutes working with industry. Recognizing the prominent role of Statistical Methods in the QI activities the IIQP was established in 1985 as a liaison between the University and industry to implement Statistical Methods in industry. Its mission statement states "The Institute for Improvement in Quality and Productivity at the University of Waterloo is a group of individuals and corporate members committed to the development, communication and application of methods for quality and productivity improvement. The Institute's goal is to serve its members, the University and Business Communities."

Goals and objectives of the Institute are:

- To provide a focus for multidisciplinary consulting and research in technical and managerial methods for improving quality.
- To develop a centre offering courses and seminars for business and industry
- To aid in developing undergraduate and graduate programs in technical and managerial methods for quality improvement
- To facilitate experience-exchange programs between university faculty and industry personnel

- To stimulate development of innovative training methods in quality for the work place.

University members of the Institute include faculty members from approximately ten disciplines, and this enhances interaction among several disciplines which is helpful in carrying out technology transfer activities.

IIQP Activities - Training and Consulting:

The IIQP has an active program of in-company and public courses spanning a range of topics in Industrial Statistics. To encourage rapid implementation of the methods taught in the classroom, work related projects are usually included as part of the courses. Third or fourth year undergraduate, Masters and PhD students have the opportunity of getting involved in these projects with industry, or serving as teaching assistants in the short courses that are offered.

Research:

By promoting closer contact between faculty members and industry, the Institute encourages increased applied research on topics of great interest to business and industry. It plays a direct role in stimulating research in the University community through financial awards for graduate work in areas relating to quality improvement. The Institute also provides direct financial support for faculty research. It publishes a research report series containing the results of current research done in the Institute. Graduate students have benefited from the funding provided but, more importantly, from the problems generated for their research from the industrial collaboration.

Co-op Students:

The IIQP employs one or two undergraduate co-op students (Engineering and/or Statistics) each term. They routinely work with faculty members to help with projects. They have the opportunity of visiting companies initially with and later without faculty members.

Campus course curriculum changes:

Faculty members involved in the partnership gained valuable experience and ideas in working with industry. These have helped them to implement substantial changes to the content of Statistics courses at Waterloo.

The first course (second year undergraduate) taught to Mechanical and Systems Design Engineering students now centres around Continuous Process Improvement. These students are exposed to Experimental Design, Statistical Process Control, etc. and they have conducted experiments at industrial partner facilities during their work terms which have resulted in substantial annual savings. Significant changes have been made to a second year Statistics course in the Faculty of Mathematics. In this course, students conduct experiments in a laboratory in groups, deal with Measurement System issues and write laboratory reports as a team. Major changes have also been made to an advanced course in Experimental Design to reflect the applications in industrial partner facilities.

A wide variety of examples including casting, injection moulding, undercoating, etc. have been collected from partner facilities and these appear as examples in lectures and assignments. Students are excited by the fact that these examples are real and often involve thousands of dollars in savings.

IIQP partnership with industry continues to provide many tangible and intangible benefits:

- Enhancements in content and delivery of courses
- Graduate and Undergraduate student involvement in real projects
- Enhancement of applied research of Faculty and Graduate students
- Professional development of the faculty members
- Enhancement of Statistical Thinking at some industrial partner facilities and modest cultural changes
- Application of newly developed methods in partner facilities
- Savings in real dollars for industrial partners

7. CONCLUDING REMARKS:

We discussed the need for universities to form partnerships with industry to provide opportunities for students to enhance their skills. Some may argue that universities should be a place for education and should not be in the business of training. It is important to keep the balance, and all such endeavours should be motivated by "academic excellence with relevance". In the past some universities have shied away from training for professional status such as Chartered Accountant (CA or CPA) and Professional Engineer (P.Eng.) while producing accountants, engineers, doctors, etc. More recently some universities have started offering courses leading to CA (CPA), P.Eng., and professional status in Actuarial Science.

It is important that the professional Statistician is equipped with good technical and non-technical skills. This is a challenge the universities have to face and one model for success is to form partnerships with industry as suggested. There is no need to compromise on academic excellence, however building in "relevance" to the programme enhances its value.

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