LESSONS FROM MEDICINE FOR TRAINING PROFESSIONAL STATISTICIANS

Alison L. Gibbs[1] and Tim Guimond[2]
[1]Department of Statistics, University of Toronto, Canada
[2]Department of Psychiatry, University of Toronto, Canada
alison.gibbs@utoronto.ca

In addition to knowledge of a constantly expanding collection of statistical methods, statistical consultants must have excellent communications skills and the ability to empathize with their clients' practical problems. These characteristics that are expected of professional statisticians by their clients are also expected of physicians by their patients. In the early 1900's, medical education in North America was restructured and standardized. All medical students followed a program of pre-clinical courses, succeeded by hands-on clinical studies. A recent trend in medical education has been to restructure education around key physician competencies. We explore a model of medical education and consider how it applies to a graduate course in statistical consulting. In particular, we discuss how we expose students to a wide variety of clients and problems, and describe the use of consulting rounds, modeled after medical rounds.

INTRODUCTION

In the preface to a collection of papers on medical education, Donaldson (2009, p. iii) wrote "The challenges facing young doctors seem to increase exponentially. Not only does the body of knowledge grow but also the skill set expected of the clinicians is constantly expanding. Patients rightly want their doctor to have breadth of knowledge, depth of compassion, supreme communication skills, and, perhaps above all, plentiful empathy." If we substitute client for patient and statistician for clinician/doctor, this quote applies to the challenges facing young statisticians, and raises the question of how we can prepare them to meet these challenges.

We focus here on the preparation of statisticians for professional work. In our experience, many undergraduate and graduate programs do an excellent job of preparation for doctoral programs in theoretical statistics. However, students with this aspiration and aptitude represent only a small minority of our student body and more consideration to the needs of the majority is needed. In addition to preparing students to carry out complex statistical analysis, our training should not ignore the other phases of the collaborative process that take place before and after the analysis. Future Ph.D. students will also benefit from these innovations (Brown & Kass, 2009).

The ever-growing availability of sophisticated techniques in common statistical software has given non-statisticians broad access to advanced statistical methodology. This can be seen in the growing use of advanced statistical approaches in a multitude of academic areas, at times inappropriately and resulting in erroneous conclusions (Altman, 2002), and suggests that the need for training statisticians in the consultation role is critical.

Medical education has undergone significant changes in the last 200 years in response to similar pressures. In medicine it has been broadly recognized that it is no longer possible to teach the entire lexicon of medical knowledge. Instead, the teaching of problem solving, lifelong learning and critical appraisal of new research is key. Furthermore, it has long been acknowledged that it is necessary to teach a combination of the science of medicine and the art (or practice) of medicine. The traditional strength of statistical education has been in the foundation of the science. More attention to the art of statistical consultation and collaboration is needed and innovative approaches to how to do this can be gleaned by exploring the long history of progress in medical education.

A BRIEF HISTORY OF MEDICAL EDUCATION

In the early 1800s, most physicians in North America received their training from private medical schools that were commercial ventures. Frequently these courses were short (two terms) and involved no hands-on training. Alternatively, an apprentice worked alongside an experienced physician for a year or more. Some physicians with greater financial means sought additional training in Europe where alternative approaches existed. In France and England, medical education focused on clinical skills and in Germany and Austria, laboratory sciences took precedence.

In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the Eighth International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia*. Voorburg, The Netherlands: International Statistical Institute. www.stat.auckland.ac.nz/~iase/publications.php [© 2010 ISI/IASE]

In the early 1900's, these varied approaches were amalgamated in the developing professionalized training programs in the United States and Canada. Abraham Flexner evaluated the medical schools of his era (Flexner, 1910) and he popularized the model put forward by the Johns Hopkins School of Medicine (Ludmerer, 1999). University affiliated schools, with faculty who engaged in both research and clinical practice, were presented as the ideal. The requirement of an undergraduate degree prior to training in medicine, along with a program of pre-clinical scientific laboratory work followed by a clinical clerkship with bedside training became the new standard.

In the clinical clerkship at Johns Hopkins, "under appropriate supervision, students took patients' histories, performed physical examinations, and carried out procedures…. [f]ollowed the daily progress of their patients until discharge, and met three or four times per week with an attending physician" (Ludmerer, 1999, p. 60). Students were 'learning by doing', exposed to real problems and given access to senior physicians to assist them in combining their prior scientific learning with their developing skills in patient care (Atwater, 1992). This tradition remains one of the most common approaches to clinical training and in modern settings the use of clinical ward rounds complements this. On the internal medicine service of Johns Hopkins Hospital, rounds involves all clinical trainees (chief resident, senior residents, interns and medical students) meeting on the ward each morning. Each new patient admitted to the service is introduced by the interns or medical students who obtained the medical history, helping them develop their skills in communication with both patients and colleagues. As the team moves to the bedside, the patient is interviewed, physical findings demonstrated and then the team moves to the hallway to debrief. Medical students are responsible for searching the relevant medical literature and presenting this research to the team, stressing the importance of ongoing learning. These rounds also afford time for the more senior residents to share their knowledge and demonstrate skills. In this setting, learning is a collaborative and social process (Sheehan, Wilkinson & Billet, 2005).

A few medical schools, for example McMaster University (Bussigel, Barzansky and Grenholm, 1988), have designed their entire undergraduate medical training using a self-directed learning approach to better prepare physicians for lifelong learning in response to the constant development of diagnostic and treatment knowledge. McMaster uses a highly innovative problem-based curriculum where didactic training is minimized and students learn and teach each other in small groups under the direction of a faculty mentor.

Post-graduate education (residency), which lasts two to five years post medical school, has also developed as a result of careful scrutiny. The Royal College of Physicians and Surgeons of Canada examined the training needs of physicians, to address the challenges they will face "that will require them to function in a health-care system in a constant state of flux and facing increasing fiscal constraints—while providing the best specialty care" (Frank, Jabbour, Tugwell, et al., 1996). They identified seven important and varied roles of medical specialists. These CanMEDS roles (Medical Expert, Communicator, Collaborator, Manager, Health Advocate, Scholar and Professional) are used in all medical specialty training programs in Canada and have gained respect worldwide.

There are many parallels between the challenges faced in medical education and in statistics education. As in medicine, the discipline of statistics has experienced an explosion of knowledge. Coming from a tradition of apprenticeship, medical education added scientific rigour to clinical training. Coming from a tradition of rigour, statistics students need practical training and would benefit by the addition of experiential learning in collaborative settings to complement their theoretical training. There are many skills needed for statistical practice that not typically taught in traditional statistics courses (see Kenett & Thyregod, 2006, for some examples). The CanMEDS roles can be used as a framework to develop educational innovation to address these needs.

THE CANMEDS MODEL AND THE TRAINING OF STATISTICIANS

Many of the CanMEDS roles also apply to professional statisticians and developing all of these roles can be considered important aspects of training students in statistics. The CanMEDS 2000 Societal Needs Working Group (CSNWG) proposed definitions of each role, key competencies, and specific objectives as they apply to medicine. Here we quote those key competencies (taken directly from the CSNWG report, 2000) and comment on their adaptation to a

statistical framework. Many authors have described the characteristics necessary of effective statistical consultants (for example, Kenett & Thyregod, 2006; Jolliffe, 2006; Committee on Training of Statisticians for Industry, 1980); these are easily classified with the CanMEDS roles. In this model, the Medical Expert role is seen as central who draws on other roles, and this parallels our view of the Statistical Expert as central to the statistical consultant.

Expert: *1) demonstrate diagnostic and therapeutic skills for ethical and effective patient care; 2) access and apply relevant information to clinical practice; 3) demonstrate effective consultation with respect to patient care, education and legal opinions.*

In statistical consultation, clients expect the statistician to "remain current in dynamically evolving statistical methodology," and "present a client or employer with choices among valid alternative statistical approaches that may vary in scope, cost or precision" (American Statistical Association, 1999).

Communicator: *1) establish therapeutic relationship with patients/families; 2) obtain and synthesize relevant history from patients/families/communities, listen effectively; 3) discuss appropriate information with patients/families and the healthcare team.*

The statistical consultant requires excellent communication skills to determine the exact nature of the question being asked and the data available, collaborate on an analytic plan, and to communicate his/her analytic results. Statisticians must guard against prematurely answering questions the client initially asks by obtaining a complete understanding of the project first, thereby uncovering the real nature of the study. Strong communication skills help the consultant avoid errors of the third kind – answering a question that was not asked (Kimball, 1957).

Collaborator: *1) consult effectively with other physicians and health care professionals; 2) contribute effectively to other interdisciplinary team activities*

Statisticians are important members of research teams and business endeavours, and being able to work collaboratively with other professionals and team members is essential for the success of the projects.

Manager: *1) utilize resources effectively to balance patient care, learning needs and outside activities; 2) allocate finite healthcare resources wisely; 3) work effectively and efficiently in a healthcare organization; 4) utilize information technology to optimize patient care, lifelong learning and other activities.*

A statistical consultant must be aware of the business aspects of their work, including working "within the constraints of the real world, [becoming] highly involved in the solutions of company problems, produc[ing] high-quality work in a timely fashion" (Committee on Training of Statisticians for Industry, 1980).

Advocate: *1) identify the important determinants of health affecting patients; 2) contribute effectively to improved health of patients and communities; 3) recognize and respond to those issues where advocacy is appropriate.*

While at first this might seem less critical a role for statisticians, the broad use of statistical findings to influence public opinion and the dissemination of research findings in public discourse suggests a need for greater numeracy of the general public. This was recognized in the Statistical Society of Canada Code of Ethical Statistical Practice (2004).

Scholar: *1) develop, implement and monitor a personal continuing education strategy; 2) critically appraise sources of medical information; 3) facilitate learning of patients, housestaff/students and other health professionals; 4) contribute to the development of new knowledge.*

The practice of statistics requires an ongoing commitment to personal professional development and the education of colleagues, clients and collaborators.

Professional: *1) deliver highest quality care with integrity, honesty and compassion; 2) exhibit appropriate personal and interpersonal professional behaviours, 3) practice medicine ethically consistent with obligations of a physician.*

The professionalization of the statistician has been advanced by several statistical associations, through the development of accreditation processes, and the publication of codes of ethical conduct (American Statistical Association 1999, International Statistical Institute 2009, Statistical Society of Canada 2004). These obligations and skills are best learned in a community of practice with role models and mentors, and are shaped in a practice environment.

EXPERIENCE APPLYING CANMEDS TO TRAINING STATISTICAL CONSULTANTS

As noted by Jolliffe (2006) statistical consulting is a "practical activity and has to be learnt by practicing it" just as medical students learn by doing. The graduate course in statistical consulting at the University of Toronto is integrated with the Statistical Consulting Service. Although students receive the credit of a half-course (13 weeks), students are enrolled for two terms to allow them to access a greater diversity of projects, and work within the rhythm of the client flow of the consulting service, rather than the timing of a traditional course.

In order for students to develop their facility in the many roles of statistical consultants, there are several different components to the course. Students in the class participate in several short-term consultations, two longer-term projects, didactic sessions, and consulting rounds. Didactic sessions are convened for discussions of the roles of statistical consultants, goals of client meetings and strategies for reaching them, ethical and professional issues of statistical practice, and, occasionally, lectures on statistical methodology.

Many clients of the Statistical Consulting Service are graduate students from other disciplines who require advice but need to complete their own analyses, and others require ongoing assistance. Students in the course participate in one-hour meetings, along with consulting service staff and, sometimes, faculty. At their first meetings, students participate mainly as observers and over the course of the year they are expected to gradually assume greater responsibility for conducting the session, collaborating with their classmates and consulting service staff. Students observe and develop skills in the roles of expert, communicator, collaborator and scholar.

A key component of the course is bi-weekly consulting rounds, styled after rounds in clinical medical education. McCulloch et al. (1985) noted that on-the-job and internship models of training of statistical consultants have many weaknesses, including the difficulty of exposing students to a wide variety of problems and consulting styles, and it is difficult for novice observers to follow the rapid thought process of the experienced consultants. Our consulting rounds were designed to help overcome these problems. In rounds, each student presents details of client meetings they participated in. Discussion is broad and can encompass: new concepts acquired from the client's discipline, communication problems encountered and how they were overcome, novel statistical methodology that was learned in the solution of the client's problems, and rules-of-thumb about statistical practice and how they were applied. Often this discussion leads to improved solutions for a client, and the presenting student participates in communicating these ideas back to the client. Through rounds, students are exposed to a greater variety of statistical problems, clients, and consulting scenarios; develop skills in oral presentations to peers; learn strategies for dealing with difficult clients, pinpointing where and why breakdowns occurred; and critically evaluate the application of specific statistical methods to problems. It is here that the basis for professional practice is established and we have found that participation in rounds increases student confidence in their ability to take on a larger role in future client meetings.

Including experienced consultants at rounds creates transparency of their approach allowing student observers to clarify the various roles the statistical consultant assumes and internalize some of the skills that are necessary to adopt these roles. Experienced consultants share the reasoning and purpose of their actions, examples from previous experiences to illustrate the lessons learned from practical experience including what statisticians can and cannot contribute to a project, parables they have learned from other statisticians, and rules-of-thumb acquired through experience including accepted standards of practice in different fields. This explication of the process reveals elements of the hidden curriculum and helps develop a professional identity in students.

Through two large projects, students learn how to collaborate with each other and the client. There are pragmatic limitations in selecting suitable clients for student projects; ideal clients do not have tight deadlines, understand the pedagogical contribution they are making, and are given the benefit of free services. In discussions of these considerations, we are able to explore the manager role including issues of time management, team division of tasks and communicating expectations with clients. The first long-term project is typically taken on by the entire class which builds a strong basis for collaboration and communication among peers. The second project is carried out in small teams, who are more personally responsible for their own time management and building team dynamics.

DISCUSSION

The commonalities and shared difficulties between medical and statistical education can provide us with a framework for developing new teaching methods and innovations in medical education can serve as an inspiration for both our graduate and undergraduate training. Some of the most prominent innovations have addressed the explosion of knowledge.

Pallie and Carr (1987) identified four problems with the conventional medical school program: 1. formal medical education has become too long and detailed; 2. too much teaching (too little critical thinking) and learning in lockstep fashion; 3. continuing obsolescence of medical knowledge; and 4. inclusion of social problems and any other innovative topics is excluded by inertia and inflexibility of the system. Similar problems are present in statistical education: 1. statistical training now requires a master's degree for most employment; 2. statistical courses are designed to progress rigidly from probability and univariate statistics to theory and multivariate statistics; 3. advancements supercede the older methods which are the basis of the curriculum; and 4. important and innovative topics such as ethical practice, visual display of data, collaboration, and communication need to be included.

Recent reforms (Whitcomb & Nutter, 2002) in medical education have blurred the line between the two-year pre-clinical followed by two-year clinical education. Clinical work is integrated earlier, to allow students to appreciate the importance of basic science to their future work. Moreover, departmental divisions among pre-clinical courses have disappeared, with courses integrating knowledge from various clinical departments into a coherent course on all aspects of a subject, for example, material from cardiology, pathology, and radiology is integrated into a single course on cardiac function and diseases of the heart. Recent calls for reform in statistics education (see, for example, Weldon, 2009; Brown & Kass, 2009; Meng, 2009) have echoed those of medicine, emphasizing the need for experiential learning, immersion in real problems as the driving force for the curriculum, and a re-examination of the order in which concepts are taught.

The quality of learning of the consulting students in our program is directly related to the quality of their engagement with the course. Some students express concern with the perceived lack of content (by which they mean advanced statistical methodology), and find it difficult to embrace a different approach to learning. Some do not recognize the professional development that takes place through their participation in a process of consultation accompanied by reflection and discussion. The training model presented here demands students be self-directed, willing to take risks, and willing to expend effort in thinking about or researching an issue for which there is no direct or immediate reinforcement as is typically given in graded assignments and exams. To prepare students to excel in consultation and develop a professional identity as a statistician, we need to motivate students to expend effort in setting learning goals, locating needed educational materials, and creating networks of colleagues who assist them in achieving their educational objectives. This should begin earlier in their education, preferably during their undergraduate program, and will likely require rethinking the incentives we use to motivate students in their educational activities.

Other authors have described approaches to teaching statistical consulting that include discussion sessions with similar goals as our consulting rounds. McCulloch et al. (1985) describe the use of "Case Conferences" for discussion of difficult or unusual statistical problems. Shuenemeyer (1990) utilizes "Lab review" sessions for staff, including graduate student assistants, of the consulting service. However, in order to fulfill the statistical competencies modeled in the framework of the CanMEDS roles, we believe that we need to expand the scope of these types of curricular changes to undergraduate education. Statistical students need to be exposed earlier to models of self-directed and experiential learning to develop the skills necessary to participate in meaningful professional development activities throughout their lifetimes. One such model is the "community of practice" which students in our course have been introduced to through the use of rounds.

REFERENCES

Altman, D. G. (2002). Poor-Quality Medical Research: What can journals do? *JAMA, 287*(21), 2765-2767.

American Statistical Association. (1999). Ethical Guidelines for Statistical Practice. Online: www.amstat.org/committees/ethics/index.cfm

Atwater, E. C. (1992). Clinical Education Since Flexner or Whatever Became of William Osler? In B. Barzansky & N. Gevitz (Eds.), *Beyond Flexner: Medical education in the twentieth century*. Westport, CT: Greenwood Post.

Brown, E., & Kass, R. (2009). "What Is Statistics?" *The American Statistician, 63*, 105–123.

Bussigel, M. N., Barzansky, B. M., & Grenholm, G. G. (1988). *Innovation Processes in Medical Education.* New York: Preager Publishers.

CanMEDS Societal Needs Working Group (2000). CanMEDS 2000: Extract from the CanMEDS 2000 Project Societal Needs Working Group Report. *Medical Teacher, 22*(6), 549-554.

Committee on Training of Statisticians for Industry (1980). Preparing Statisticians for Careers in Industry: Report of the ASA Section on Statistical Education Committee on Training of Statisticians for Industry. *The American Statistician, 34*, 65-75.

Donaldson, L. (2009). Foreward. In Y. Carter & N. Jackson (Eds.), *Medical Education and Training: From theory to delivery* (pp. iii-iv). Oxford: Oxford University Press.

Flexner, A. (1910). *Medical Education in the United States and Canada: A report to the Carnegie Foundation for the advancement of teaching.* New York: Carnegie Foundation for Higher Education.

Frank J. R., Jabbour M., Tugwell P., et al. (1996). Skills for the New Millenium: Report of the Societal Needs Working Froup, CanMEDS 2000 Project. *Annals of the Royal College of Physicians and Surgeons of Canada, 29*, 206-216.

International Statistical Institute. (2009). ISI Declaration on Professional Ethics. Online: isi.cbs.nl/ethics0index.htm

Jolliffe, F. (2006). Practice Improves Presentation. In Rossman, A. and Chance, B. (Eds.), *Proceedings of the Seventh International Conference on Teaching Statistics*, Salvador, Bahia, Brazil. International Statistical Institute. Online: www.stat.auckland.ac.nz/~iase/publications.php

Kenett, R., & Thyregod, P. (2006). Aspects of Statistical Consulting Not Taught by Academia. *Statistica Neerlandica, 60*(3), 396-411.

Kimball, A. W. (1957). Errors of the Third Kind in Statistical Consulting. *Journal of the American Statistical Association, 57*, 133-142.

Ludmerer, K. M. (1999). *Time to Heal: American Medical Education from the Turn of the Century to the Era of Managed Care*. Oxford: Oxford University Press.

McCulloch, C. E., Boroto, D. R., Meeter, D., Polland, R, & Zahn, D.A. (1985). An Expanded Approach to Educating Statistical Consultants. *The American Statistician, 39*(3), 159-167.

Meng, X.-L. (2009). Desired and Feared–What Do We Do Now and Over the Next 50 Years? *The American Statistician, 63*(3), 202-210.

Pallie, W. & Carr, D. H. (1987). The McMaster Medical Education Philosophy in Theory, Practice and Historical Perspective. *Medical Teacher, 9*(1), 59-71.

Schuenemeyer, J. H. (1990). Training Statisticians to be Consultants. In *Proceedings of the Third International Conference on Teaching Statistics*, Dunedin, New Zealand. International Statistical Institute. Online: www.stat.auckland.ac.nz/~iase/publications.php.

Sheehan, D., Wilkinson, T. J., & Billett, S. (2005). Interns' Participation and Learning in Clinical Environments in a New Zealand Hospital. *Academic Medicine, 80*(3), 302-308.

Statistical Society of Canada. (2004). Code of Ethical Statistical Practice. Online: www.ssc.ca/accreditation/documents/ethics_e.pdf.

Weldon, L. (2009). Experiential Learning in Statistics: Expanding its Role. Seminar, Department of Statistics, University of Toronto, October 29, 2009. Online: www.stat.sfu.ca/~weldon/.

Whitcomb, M. E., & Nutter, D. (2002). Learning Medicine in the 21st Century. The Carnegie Foundation for the Advancement of Teaching. Online: www.carnegiefoundation.org/sites/default/files/Learning_Medicine.pdf.