ACCOMMODATING SPECIALISTS AND NON-SPECIALISTS IN STATISTICS COURSES

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Seven upper division Statistics courses in support of a new Minor in Statistics have been developed to be taught by two statisticians at The University of Northern British Columbia. These courses have been designed so that non-specialist undergraduate and postgraduate students can enrol in these courses. Five undergraduate courses are paired with parallel courses for postgraduate credit for a proposed Master of Science to be offered by the School of Business and a proposed Health Sciences doctoral program. Through discussions with the curricula committees for these programs, course prerequisites became calculus and linear algebra courses as taught to non-science majors. This requirement generally exceeds that expected for typical non-specialist courses but is less than the usual for specialist courses. The R statistical software package and the fundamentals of graphical display will be incorporated throughout this new curriculum.

INTRODUCTION

The Mathematics Program at The University of Northern British Columbia (UNBC) in 2004 faced the need to create a Statistics course to meet the professional requirements of a new undergraduate program in Environmental Engineering and a need to deal with declining enrolments in its flagship introductory non-calculus statistics course. As new Statistics courses were offered in September 2008 for the new academic year, inquiries were made for postgraduate statistics courses in support of proposals for a Master of Science degree in the School of Business and a doctoral program in Health Sciences. While joint upper division undergraduate and postgraduate courses had been taught on the topics of survey sampling, experimental design, linear models, and applied multivariate analysis, these had only been offered as special topics courses without the identity bestowed by a course number other than 499 for undergraduate studies and 699 for graduate studies. This led to the proposal for an additional eight courses at the 400- and 600-levels, which were approved to begin implementation in September 2010. Completion of implementation is scheduled for the end of April 2012.

UNBC serves an area the size of France, yet the population numbers only about 285,000 in this region of British Columbia. Although home to the Northern Medical Program, UNBC is a small enrolment university with approximately 3,050 full-time equivalent undergraduate and postgraduate students. There are only two statisticians within the Mathematics Program so a Major in Statistics is likely beyond reach. But with three new upper division (numbered 300 or higher) undergraduate courses available starting in September 2008 and another four starting September 2010, a new Minor in Statistics was created, effective January 2010. Additional to this requirement is a list of courses, from other academic programs, required for accreditation of an individual as an Associate Statistician (A.Stat.) by the Statistical Society of Canada.

To understand the course numbering scheme at UNBC, the typical undergraduate program at UNBC consists of 120 credit hours with one credit hour equivalent to approximately 10 hours of instruction. Such a program can be completed in four years. The normal progression is to take 100-level courses in first year, 200-level courses in first or second year, 300-level courses in second or third year, and 400-level courses in third or fourth year. The 600-level courses are intended for the first year of a postgraduate degree program, but can be taken at anytime. This numbering system for UNBC courses is widely, but not universally, used in Canada, and is used by some universities in the United States. All courses discussed herein are three credit hour courses taught over a semester of approximately 13 weeks duration and 30 instructional hours.

Based on student enrolments at UNBC, it would not be possible to justify even a Minor degree program in Statistics if not for enrolment of non-specialists in the Statistics courses to be offered. The philosophy at the outset of planning was to involve specialists together with non-specialists in the same courses at both the undergraduate and the postgraduate levels. The

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following sections describe the constraints and solutions to issues relating to the development of these new courses.

REVAMPING THE INTRODUCTORY STATISTICS COURSES

For its first decade, UNBC tried to offer four introductory statistics courses. Three of these were to be taught by one statistician in the Mathematics Program and another to be taught by an instructor from the Economics Program. The Mathematics Program offered a pair of sequential three-credit hour courses in mathematical statistics not much different than those taught at other Canadian or American universities. But instead of offering one non-calculus introductory statistics course, two were offered: MATH 242 Statistics for the Social and Health Sciences and MATH 342 Biostatistics. The title of the first of these two courses is self-descriptive. It was for the most part taught in the autumn semester beginning in the month of September. The Economics course ECON 205 Statistics for the Social and Management Sciences was offered alternatively, for the most part, in the winter semester beginning in January. Spring semester offerings of MATH 242 and ECON 205 did not occur every year. The problem with this arrangement was that if students failed either of these courses, they may not be able to repeat until the following academic year. Even though the course content of MATH 242 and ECON 205 was virtually indistinguishable, the Economics Program did not consider the two courses to be equivalent. Although ECON 205 had and still has no prerequisite courses, MATH 242 required a previous course in algebra from the second-to-last year of secondary school, or 30 hours of instruction in algebra at UNBC. The decline of enrolments in MATH 242 was a consequence of uninspired lecturing by non-statisticians who emphasized rote algebraic manipulation and chose textbooks largely devoid of real data for exercises. Mostly, the course was taught without statistical software. Matters were further compounded by closed-book examinations requiring the use of paper statistical tables.

The Statistics course MATH 342 Biostatistics was originally intended to be calculus-based for undergraduate students in biology, forestry, and other natural resource management programs. But calculus-based introductory textbooks in statistics for life science students are nowhere to be found. The legend at UNBC is that the first time the course was taught the students mutinied and the course was never taught with a calculus base again. Had a calculus-based statistics course been integrated into the life science degree programs, this would have been a novel development from the perspective of a North American university.

In 2004, the Mathematics Program at UNBC gained a second statistician. At the same time, a medical program was put in place and an Environmental Engineering Program was proposed. The Canadian Engineering Accreditation Board (CEAB) is responsible for accrediting undergraduate Engineering programs throughout Canada. They are the only body with this responsibility. Each province in Canada has its own association of professional engineers. Each of these provincial associations sets its own standards for accrediting individuals as engineers. The undergraduate degree requirements for Probability and Statistics in the province of British Columbia are set by the Association of Professional Engineers and Geoscientists of British Columbia (APEGBC). While then existing MATH 340 Introduction to Probability and MATH 341 Introduction to Statistics covered the required syllabus, these courses combined required 6 credit hours. Given the tightly packed undergraduate Engineering programs in Canada, this is 3 credit hours too much. MATH 342 Biostatistics looked like an option because as a prerequisite it required 30 hours of instruction in differential and integral calculus. But calculus was not being used in the instruction of MATH 342. This was not to the liking of the CEAB.

The decision was made to scrap MATH 242, 340, 341, and 342. It was also decided at the same time to scrap MATH 440 and its postgraduate counterpart MATH 640. These two courses were entitled Advanced Probability and Statistics. The diverse topics covered in this pair of courses were: strong and weak laws of large numbers, Markov chains, martingales, extreme value theory, and order statistics. The list of deleted courses is given in Table 1. In the place of these courses, four new courses were created. These are listed in Table 2.

MATH 240 Basic Statistics arose from the ashes of MATH 242 and MATH 342 to become the introductory non-calculus statistics course. There is no prerequisite course for MATH 240. MATH 240 has three computer laboratory streams (General Interest; Health and Human Development; Natural Resources and Environment) with weekly assignments tailored to each

stream. There is, however, a common lecture component for the three streams with common term tests and final examinations. Over a thirteen-week semester, each week there are three 50-minute lectures and one 50-minute laboratory with emphasis on the use of statistical software. MATH 240 was created to align with the six reform guidelines endorsed by the American Statistical Association in 2005 for the assessment and instruction of introductory college statistics courses (Everson, Zieffler & Garfield, 2008).

Table 1. Statistics courses deleted at The University of Northern British Columbia (Equivalent postgraduate course given in parentheses)

Number	Description	Prerequisite
MATH 242	Statistics for Social and Health Sciences	30 hours of instruction in algebra
MATH 340	Introduction to Probability	60 hours of instruction in calculus
MATH 341	Introduction to Statistics	MATH 340
MATH 342	Biostatistics	30 hours of instruction in calculus
MATH 440 (MATH 640)	Advanced Probability and Statistics	MATH 341

Table 2. Statistics courses to replace deleted Statistics Courses at The University of Northern British Columbia (Equivalent postgraduate course given in parentheses)

Number	Description	Prerequisite
MATH 240	Basic Statistics	None
MATH 371	Probability and Statistics for Scientists and Engineers	60 hours of instruction in calculus
MATH 372	Mathematical Statistics	MATH 371
MATH 441 (MATH 641)	Nonparametric Statistics	MATH 240 or MATH 371

There was enough material in the calculus-based MATH 340 and MATH 341 to create three courses of three credit hours apiece. These new courses were based on an older model in use 30 years ago at Simon Fraser University, also in British Columbia, when it was a small university of 10,000 students and only 10 years old. The needs of the Environmental Engineering students were met by the new MATH 371 Probability and Statistics for Scientists and Engineers (APEGBC, 2004). This course also meets the greater requirements of Geoscientists in the province of British Columbia (APEGBC, 2006). It need be noted that a course in probability and statistics is merely an elective course for a Professional Geoscientist.

The new MATH 372 Mathematical Statistics was developed solely to meet the requirements for accreditation as a Professional Statistician, which is granted in Canada by a national body: The Statistical Society of Canada (SSC, 2007). MATH 372 covers the “why” not taught in MATH 371 which is jam-packed for the “how” needed by Professional Engineers. With the old MATH 340 and 341, UNBC students were not exposed to Bayesian methods or likelihoodist philosophy. MATH 372 Mathematical Statistics is essentially a course in comparative inference. The third course to be created from the ashes of MATH 340 and MATH 341 was MATH 441 Nonparametric Statistics. A postgraduate counterpart MATH 641 Nonparametric Statistics was created at the same time.

The former MATH 242, MATH 342, and MATH 340 were precluded from being jointly held for credit. This was unfortunate because it blocked upward progression in Statistics. The new MATH 240 Basic Statistics is virtually algebra-free without any secondary school Mathematics prerequisite. MATH 240 is a nonmathematical course in the sense of Higgins (1999). Unlike Higgins’s (1999) prescription, which is for specialist courses, MATH 240 was conceived to be taken by specialists and non-specialists alike. But like Higgins (1999): this course discusses the planning and design of sample surveys and experiments; includes use of the R statistical software system (with the `Rcmdr` package) for data visualization and analysis; encourages active collaborative learning through small groups, which in part helps to develop management and communication skills in our students.

Because MATH 371 is jam-packed with methods and theory needed by our Environment Engineering program, students, whose academic program permits, are encouraged to enrol in MATH 240 Basic Statistics before taking MATH 371. Because of the curriculum requirements placed on MATH 371 by the Engineering profession, there is insufficient time to follow the approach of Romero *et al*. (1995), which reduces time spent in lectures and uses statistical software. The pedagogical philosophy of the Engineering profession in Canada is that theory is taught and calculus applied in the introductory course in probability and statistics. The applications of statistics are left to the laboratory courses taught by Professional Engineers. The approach of Bisgaard (1991) with emphasis on experimental design, which is better suited to an industrial engineering program, was also not an option. The UNBC teaching ratio of 40 students to 1 instructor, however, is better than 115:1 at the Polytechnic University of Valencia (Romer *et al*., 1995). There is simply no time to incorporate statistical software in MATH 371. Moreover, the National Examination on Probability and Statistics as of May 2006, as agreed by the various provincial professional associations of engineers, permits only basic scientific calculators—with paper statistical tables provided in the examination booklet. Although the syllabus for MATH 371 is influenced by the professional requirements and approaches to testing by the APEGBC, it is not a course for specialist engineering students only. For one, a number of substantive subject areas are mined for examples and exercises. For another, MATH 371 is a required course at UNBC for a student considering a career as a Professional Statistician (P.Stat.). One aspect of training future professional statisticians at UNBC is exposure to other disciplines, and students from other disciplines, in both MATH 240 and MATH 371. In so doing, the comprehensive approach of Wild (1994), towards the teaching of specialists in Statistics, has been adopted. It is important that all UNBC students in introductory Statistics courses become educated consumers of statistical methodology. All those students who might follow a career path to becoming an A.Stat., and thence a P.Stat. after more training and guided practice, need to be able to communicate well with non-statisticians.

POSTGRADUATE STATISTICS COURSES

In September 2008, it was clear that the proposal for a doctoral program in Health Sciences at UNBC would require students to have a reasonable degree of proficiency in statistical methods. The courses MATH 641 Nonparametric Statistics, MATH 671 Linear Models, MATH 672 Survey Sampling Design and Analysis, MATH 673 Experimental Design and Analysis, and MATH 675 Methods for Multivariate Data were developed, in part, to meet this requirement. These courses, with their undergraduate counterparts, and prerequisites are listed in Table 3.

Table 3. New Statistics courses at The University of Northern British Columbia
(Equivalent postgraduate course given in parentheses)

Number	Description	Prerequisite
MATH 471 (MATH 671)	Linear Models	30 hours of instruction in calculus and one of MATH 240 or MATH 371
MATH 472 (MATH 672)	Survey Sampling Design and Analysis	30 hours of instruction in calculus and one of MATH 240 or MATH 371
MATH 473 (MATH 673)	Experimental Design and Analysis	30 hours of instruction in calculus and one of MATH 240 or MATH 371
MATH 475 (MATH 675)	Methods for Multivariate Data	20 hours of linear algebra and MATH 471 (MATH 671)

Even before the ink was dry on the proposals for these new courses, UNBC's statisticians were approached by the School of Business to teach a postgraduate course in linear models and another course in applied multivariate analysis to support a proposed Master of Science program. Distinct from a Master of Business Administration, the M. Sc. Program is intended to equip its graduates for research.

Emerging from discussions with members of the School of Business was a desire for courses at a higher level of previous preparation not usually seen in non-specialist postgraduate

courses in Statistics. Graduates of the Bachelor of Commerce program are required to complete 30 hours of instruction in differential and integral calculus and 30 hours in discrete mathematics, which includes roughly 20 hours in linear algebra. These graduates are also required to complete 30 hours of instruction in statistics, though this is typically in a non-calculus introductory Statistics course, such as MATH 240 Basic Statistics. These, together with MATH 671 Linear Models, then became the prerequisites for MATH 675 Methods for Multivariate Data. The prerequisites for MATH 671, 672, and 673 are just 30 hours of instruction each in calculus and statistics. This is less than would be required for Statistics specialist courses but considerably more than for typical non-specialist courses.

There will be no initial introductory statistics course at the postgraduate level. This represents a point of departure from the postgraduate non-specialist course model discussed by Brogan and Kutner (1986). Instead, students will have completed an introductory statistics course during their undergraduate degree or enrol in a qualifying year and pick up any missing undergraduate courses from their background.

Paired with MATH 641, 671, 672, 673, and 675 will be undergraduate courses MATH 441, 471, 472, 473, and 475. The four undergraduate courses meet accreditation requirements of the Statistical Society of Canada (SSC, 2007). Unlike the postgraduate model discussed by Brogan and Kutner (1986), MATH 641, 671, 672, 673, and 675 cannot be oriented toward any one discipline. However, other aspects of the model of Brogan and Kutner (1986) were adopted for these courses. This places emphasis on problem solving and providing early and repeated discussion on graphical techniques throughout the curriculum established by these courses. The R statistical software package will be used throughout these courses. As much as possible, these courses will incorporate capstone projects with oral presentations of results as well as written final reports by small groups of students in an intensive active learning environment. Presentation will be an even mixture of lecture and computer lab in the manner of Pollock and Wilson (1976). Tests and final examinations, if any, will be open book as also suggested by Pollock and Wilson (1976).

TRAINING PROFESSIONAL STATISTICIANS

Rather than segregating those who would like to follow an educational path to a career as a Professional Statistician, the preference at UNBC is that they are exposed to non-specialists throughout their undergraduate program. In no way does this pedagogical approach detract from the thesis of Bessant and MacPherson (2002) that Statistics is a "separate discipline." What has been embraced in UNBC's Statistics curricula is the "holistic statistics" notion of Kettenring (1997): an inclusive view of Statistics that celebrates its interdisciplinary character and eclectic origins. The only possible exception to this pedagogical philosophy among the new courses is MATH 372 Mathematical Statistics, which by its nature is not likely to attract non-specialist students given that 6 credit hours of single-variable calculus is required and 3 credit hours of multivariate calculus is highly recommended. Surprisingly, this course has attracted its first non-specialist: a student majoring in Biology.

Three recommendations of Yilmaz (1996) for non-specialist statistics courses have been adopted for students at UNBC intent on a career as Professional Statisticians. These recommendations were again repeated by Swanson and McKibben (1998) for non-specialist statistics courses. They are:

1) the ability to link statistics and real-world situations;
2) the knowledge of statistical concepts; and
3) the ability to synthesize the components of a statistical study and to communicate the results in a clear manner.

It would be short-sighted to think that these would not be effective in educating Statistics specialists.

CONCLUSION

It is asserted that, at UNBC, a viable model has been developed for a Statistics degree program for a small university with just two statisticians. With colleagues in other disciplines

supplementing the courses taught by UNBC's statisticians with their own courses in data analysis, a Minor in Statistics was created, effective January 2010, that will allow graduates to seek accreditation as an A.Stat. by the Statistical Society of Canada (SSC, 2007). These other disciplines include ecology, environmental science, geography, and health science (that is, epidemiology). A commitment has been made at UNBC to offer MATH 240 Basic Statistics every semester, MATH 371 Probability and Statistics for Scientists and Engineers every September semester, and MATH 372 Mathematical Statistics every January semester. The other five 400-level courses (and their 600-level postgraduate counterparts) will be offered every other year.

Adopting the R statistical software system allows a concentration in teaching efforts on a package that is widely used by non-specialist students at the undergraduate and postgraduate level. There was a rather humorous meeting in the spring of 2008 when a number of colleagues inquired of UNBC's statisticians as to whether consideration would be given to the use of R in Statistics courses. Three years earlier, Minitab® and SAS® were dropped from Statistics courses and the switch made to R. There are things for which SAS® is still superior but the drawback for SAS® is a very steep learning curve.

The decision was made to teach statistical graphics throughout the curriculum rather than in a single specialized course. Because of limited resources, there was no other choice. Fortunately, R is the superior package for this approach.

With the planning done, what remains is implementing this novel approach. But as statisticians, there is continuous quality improvement as the ace up one's sleeves (Wild, 1995). As to developing summative measures of success of this Statistics program, this is an open avenue of research to be pursued.

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