# HOW YOUNG STATISTICS ACADEMICS LEARN TO TEACH STATISTICS

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*Practicum learning to teach tertiary statistics is a common experience for young statistics academics and plays an important role in the transition from student to inexperienced tutor to confident academic lecturer. We discuss the development of statistics teaching skills and pedagogies through practicum learning in the context of young statistics academics with mathematical statistics backgrounds from a United Kingdom and Australian perspective. Approaches to teaching statistics are described and compared across a variety of introductory to upper-undergraduate statistics courses and for varying student cohorts.*

## INTRODUCTION

Zieffler, Garfield, Alt, Dupuis, Holleque and Chang (2008) view the goal of statistics education research as the improvement of statistics teaching, leading to improved student learning. In concordance with this, we consider the improvement of statistics teaching through the development of teaching skills in young statistics academics.

Whilst literature in statistics education exists on learning to teach statistics, a majority of this literature is focused on primary and secondary school teachers (e.g., Rossman, Medina & Chance, 2006). Texts that consider teaching at the tertiary level are often more general education texts (e.g., Biggs, 2003; Ramsden, 1992) although there are a few, but far less, texts that do address the specific challenges of teaching in the discipline of statistics (e.g., Garfield & Ben-Zvi, 2008; Hulsizer & Woolf, 2009). Whilst the literature provides advice on teaching statistics, there is currently little published on how university statistics teachers learn to teach statistics.

Within the statistics disciplines of research-oriented universities in Australia and the United Kingdom (UK), statistics academics are typically appointed from traditional backgrounds, usually possessing an Honours and PhD degree in statistics but with little, or no, formal education training, and variable teaching experience. However, in universities that also advocate high quality teaching, these academics are often expected to teach statistics, and to teach it well, or to at least achieve high scores in student surveys of their teaching. Given that commencing statistics academics have been trained to develop expertise as statistics researchers, and the purpose of their statistical training was generally not oriented towards teaching, how do they learn to become effective teachers of statistics? Our answer, in short, is through appropriate developmental and mentored practicum learning to teach statistics.

In this paper we provide qualitative comments analysing the development of statistics teaching skills in two young statistics academic staff members through practicum learning. In contrast to a majority of the literature, which focuses on American tertiary institutions, the goal of our paper is to promote research into the development of statistics teaching skills in young lecturers from a more international perspective.

## EXAMPLES OF YOUNG STATISTICS ACADEMICS

Whilst we are both "young" statistics academics, both in the duration of our academic careers and in our ages, over the past 10 years we have been fortunate to benefit from an enriching variety of university teaching experiences, which began as university students and which largely constitutes the development of our teaching skills. Before discussing our suggestions on developing teaching skills in young academic statistics lecturers, such as ourselves, we briefly review our backgrounds as an overview of our practicum teaching experiences.

*Example 1: Australian as a Graduate Teaching Assistant in the UK*

Helen Thompson began teaching whilst an undergraduate mathematics and statistics student at the University of Queensland (UQ), Australia, where she tutored mathematics and statistics classes of 20-40 students to mathematics and statistics majors and service course students. She was subsequently awarded a Graduate Teaching Assistant scholarship to fund her PhD

research in statistics at the University of Glasgow (GU), United Kingdom. As a Graduate Teaching Assistant she was lecturer of an introductory statistics course with approximately 60 first-year statistics majors and tutored introductory statistics courses for both statistics majors and service course students. She then returned to Australia to take up an academic position at Queensland University of Technology (QUT), where, for the past 3 years, she has been teaching a range of statistics courses, from introductory to upper-undergraduate courses, to both statistics majors and service course students and of varying class sizes from 10-350 students.

*Example 2: Briton as a Casual Tutor and Lecturer in Australia*

In contrast, Helen Johnson completed her undergraduate mathematics degree in the United Kingdom at the University of Manchester (MU) prior to commencing her PhD program at the Australian National University (ANU), Australia. She was employed on a casual basis, rather than as a Graduate Teaching Assistant, to supplement her PhD program. As a tutor and then casual lecturer, she commenced her teaching by tutoring first-year statistics to classes of up to 30 biology and psychology students. A year later, she was asked to lecture a first-year course in quantitative business methods to approximately 100 commerce students. During her PhD, she continued to teach a range of different courses, including introductory statistics, survey design and market research methods to a variety of students, from first-year statistics to third-year commerce students. Subsequently, she was offered a position as a Lecturer at QUT where, for the past 5 years, she has taught a variety of statistics courses, from introductory-level statistics for large classes of both statistics majors and service course students (both in the same class) to second-year and third-year courses for statistics majors.

All of the Australian universities (UQ, ANU, QUT) and UK universities (GU, MU) discussed above have well-regarded research focused statistics disciplines that additionally encourage high quality teaching. It should be noted that within these, and similar, universities in Australia and the UK, it is not common practice for PhD students to take up appointments as Graduate Teaching Assistants, since typical funding of the 3 year PhD research program does not pose any teaching obligations on students.

Having taught together collaboratively at QUT for the past 3 years, we perceive our strengths in teaching to derive from our theoretical and applied statistical backgrounds, our exposure to a variety of teaching experiences, significant interaction with students, adoption of cooperative teaching practices, collaboration with peers and mentors, and reflection on our experiences, particularly comparisons of differing experiences in Australia and the UK. We discuss these key factors in the development of statistics teaching skills in the following sections.

STATISTICAL BACKGROUND OF TEACHERS

Petocz, Gordon and Reid (2006), in their study of 36 tertiary statistic educators, found that the most commonly mentioned requirement of a "good teacher of statistics" is a solid knowledge of statistical theory and practice. Whilst our traditional undergraduate statistics educations were invaluable in providing us with a sound basis of statistical theory, in our experience, traditional statistical courses often do not emphasise the practice and application of statistics. We have found that real research – academic, Government or commercial – and practical experience as expert data analysts has led us to a greater understanding of applications in other disciplines. Such applied statistical knowledge enhances student learning by being able to put data and problems into real-world contexts and additionally "legitimises" teachers' statistical expertise to students.

EXPOSURE TO A VARIETY OF TEACHING EXPERIENCES

The development of statistics teaching skills and pedagogies arises through exposure to, and experience with, a number of different ways of teaching, in collaboration with peers and collegial mentors. Furthermore, exposure to a variety of experiences, including different cohorts of students and different class sizes, should be a progression that facilitates teaching development.

*Progression of Skills and Experience*

Many early academics in statistics begin their teacher development through undergraduate tutorial or practical classes. MacGillivray (2008) advocates that part of the learning process for

developing statistics teachers is tutor preparation and training, which form part of practicum learning to tutor. MacGillivray (2008) advises that the training of tutors should progress their skills by commencing with one-to-one tutoring, advancing to small group tutoring and tutoring in tandem with more experienced staff, before teaching larger classes. Such training, provided within the statistics discipline, naturally progresses both the skills and confidence of tutors allowing ease of progression into lecturing, where a steady and manageable increase in skills can continue through practicum lecturing. Over time, young statistics academics should experience: a variety of class sizes – progressing from small to large classes; a variety of types of classes – progressing from tutorials and computer laboratories to lectures; and varying cohorts of students. Experience in tutoring service courses is particularly beneficial in gaining understanding of student perceptions, attitudes, skill-level, how to engage students in different disciplines and in using different teaching styles to cater for these differences. After aspiring tutors gain experience in one-to-one tutoring a training course can introduce them to theories and practice of teaching statistics, to their obligations and expectations, to assessment principles, and to enable them to practise their teaching and marking with their peers in a collegial environment.

In comparison, formal higher education teaching training is often too generalised to be informative, and sometimes poorly timed, occurring after the inexperienced teacher has commenced lecturing. Postgraduate Diplomas in Higher Education, or other similar professional development courses offered by universities, are often too broad and theoretical to assist with teaching statistics. However, some online courses designed specifically towards statistics teaching have, more recently, become widely available, such as the *Royal Statistical Society Certificate in Teaching Statistics in Higher Education* (Davies & Barnett, 2005) and *Preparing Teachers of Statistics: A Graduate Course for Future Teachers* (Garfield & Everson, 2009).

*Development of Teaching Material*

One of the challenges of teaching, at any stage in an academic's career, is designing teaching materials, and associated supporting techniques and tools, in order to help students develop skills and understanding, whilst nurturing a positive attitude and approach to statistics. Moreover, students need well-structured notes and confident, well-prepared teachers. Often, existing course notes are a valuable starting point for young academics. However, just as students need to own their learning, so too teachers need to *own* their materials so that they can deliver it effectively to suit their teaching style and also incorporate their own experiences. A corollary is that, in order to effectively use or adapt existing course notes, a teacher needs to have been involved with the course previously or to collaborate closely with teachers on similar courses.

From a university perspective, it is assumed that from year to year, cohorts of students may be similar for a particular class, yet in reality, the personalities, life experiences and attitudes of students can mean that there is a substantial difference each year, which brings with it an extra need to modify material and teaching approaches to suit. Again, this emphasises the need to interact with students. Class material is not static; the theory has not changed but it is constantly evolving. For example, in recent years, there has been a greater demand from students to have more electronic material accessible to them. This requires further thought to develop and make available material that encourages participation and engagement rather than letting students be passively "entertained" by the teacher. Consequently, it is becoming more and more important to remain informed on how new technologies and pedagogies can successfully be integrated for the learning benefit of the students.

*Introductory Statistics Service Courses*

Structuring classes appropriately for different cohorts of students is imperative to ensure that students see statistics as significant for them. Examples in classes and throughout all teaching materials must be designed to actively engage students and to keep their interest. Therefore, examples, contexts and data must be meaningful to the students, whether linking with prior experience, contexts relevant to their current lives, or to their future interests.

*Introductory Probability for Statistics Majors*

Working or researching as a statistician requires modelling and problem-solving skills with probabilistic thinking. Development of these can start at the introductory level in a constructivist way that links with familiar contexts and data. In one of QUT's first-year statistics courses for statistics majors, preliminary exercises are designed to allow students to use prior knowledge and skills to solve a problem before seeing extensions and generalisations to theory. These exercises also serve as a mechanism for encouraging participation in class (MacGillivray, 2006). The principle of building, from simple to complex, permeates the course. As well as preliminary exercises, class activities and lecture notes, the workbooks for each section include simple problem-solving exercises and their answers. Simple exercises give students more confidence to attempt more challenging questions so they build their problem-solving skills gradually. Analysis of student performance indicates that the combination of preliminaries that capture prior knowledge, with group problem-solving class activities, can be deemed successful (MacGillivray, 2006).

*Introductory Courses for Combined Cohorts*

Providing stimulation to such a mixed cohort of students within the same class and at the same time is a challenge. Separating cohorts and delivering material in a way that depends on the student's major is often proposed. Considering the advantages and disadvantages in our theoretical and applied backgrounds allows an impartial view. Although it is important for students to see statistics in this way, all students, including mathematics and statistics majors need the same foundations in statistical thinking and data investigations, and to see applied statistics in action.

*Upper-Undergraduate Courses for Statistics Majors*

Once teaching proceeds to the upper-level undergraduate courses, it is important to incorporate current research and to incorporate examples and material that is relevant to students, for example, problems that they might come across in the jobs they ultimately go on to, such as financial-based questions or health-based questions. Therefore, incorporating examples related to these areas into the course materials enables students to see statistics in the real world. Other ideas, such as bringing in external lecturers from industry, allows students to see how the statistical methods they are learning are used in real life and that what they are learning has a point to it.

COOPERATION AND COLLABORATION

Wild (2006) stresses the importance of cooperation in the improvement in quality of statistics teaching. Robinson and Schaible (1995) also discuss the benefits of collaborative teaching. A collaborative teaching team, whether on one course or across courses, ultimately reduces the workload in design and production of material, and in improving the quality of teaching. Collaboration with interdisciplinary colleagues, especially for service course teaching, is essential to ensure course content is focused towards their students' needs and, where required, to ensure that the content and standards meet the requirements of accreditation boards in regulated disciplines such as optometry, pharmacy and medical science. Young lecturers can draw from the experiences of members of their teaching team and make use of shared resources that they otherwise may find difficulty in sourcing, such as good real data sets and real world applications of statistics.

*The role of mentors and peers*

Mentors, peers and even colleagues that are unknown to us personally play many roles in supporting the development of teachings skills and assisting in adding to the arsenal of techniques and knowledge required as high quality teachers. Expert teaching staff are invaluable in providing feedback on development of course materials and assessment. They possess expertise that comes with years of teaching practice and knowledge of the types of students that attend their university and take particular courses. For example, they can aide in the writing of material by advising on the level of difficulty, amount of content suitable for the duration of a class or the entire course and appropriateness of the context given the student cohort.

Usually, mentoring of junior staff is an unrecognised activity in the workload of the mentor. If "voluntary" mentoring is not available, there are still options that take advantage of required processes in the university system. A system of assessment moderation, such as that of the UK, not only ensures consistent and appropriate standards, but also facilitates improved proficiency in assessment by young lecturers. Each stage of the moderation process provides feedback from differing academics, and the differing views and suggestions on the same item of assessment is of great benefit to all staff, but particularly younger academics.

Peer collegiate review of teaching in a supporting environment allows for positive feedback on delivery of material. Similarly, sitting in on any teacher's classes can provide insight into techniques that worked and didn't work, and on methods of delivery that one may otherwise never have considered. QUT advocates young lecturers' participation in *Teaching Squares* as a part of its teaching training, where groups of four young lecturers from different disciplines peer review each others' in-class teaching. This style of non-confrontational interdisciplinary peer review provides young lecturers with a broad view on approaches across varying disciplines.

Young lecturers should also be encouraged to read statistics education publications, such as the *Journal of Statistics Education* and the *Statistics Education Research Journal*, and to attend conferences, such as the *International Conference on Teaching Statistics*, and to apply the research. Much can be learned from case studies of other statistics teachers in higher education (e.g., Garfield, 2005), and from successful and unsuccessful techniques employed by peers and reported in publications (e.g., Larsen, 2006). However, it is important to note that the pedagogies of others should not be blindly employed and due care should be taken in allowing for differing educational cultures and cohorts, as well as personal comfort in delivering or implementing pedagogies.

REFLECTION ON TEACHING AND STUDENT FEEDBACK

Reflection, whether through officially or unofficially collected student feedback, is of extreme importance in developing skills as a statistics teacher, as well as making the experience as fulfilling as possible for the students. Student feedback, through university-collected surveys and direct feedback can provide important information on organisation, teaching materials and aspects of teaching styles. Analysis of class results at the end of semester can give indications of whether the students understood the principles. This is especially relevant when considering the service-course students, who do not need or want to see the theory behind the approaches nor, on majority, want to be there; it is sufficient for them to apply the statistics, albeit correctly and appropriately. Ongoing interaction with students also facilitates informed courses of action in aiding our understanding of how to help students learn. All these approaches allow opportunities to reflect on teaching.

CONCLUSION

The journey to becoming a confident and good academic statistics lecturer is an experience that is unique to each individual. However, there are some common key factors that contribute to a successful journey, which include, a good statistical background and knowledge of the material being taught, training, such as tutor training and professional courses, adoption of collaborative teaching and teamwork, informed reflection of teaching practices, but, most importantly, training through a progression of teaching experiences. Ideally, practicum learning to teach should involve exposure to varying class sizes, varying cohorts, service courses and specialised statistics courses, and courses of differing content and level. Just as statistics students "learn by doing", there is no substitute for practicum teaching in learning how to teach statistics.

Unfortunately, especially at research focused universities, and even in those that advocate high quality teaching, there is little incentive in allocating time to developing good teaching practices. Hence, for a young lecturer to develop into a good teacher of statistics, amongst the skills and knowledge that need to be acquired, there must be the desire to be a good teacher.

In Australian and UK universities, there is a need to address the development of young statistics academics' teaching skills early in their careers as university students. We see this as the responsibility of the individual, the university department that provides their statistical training, the department and university that appoints the young academic, and fellow teaching colleagues.

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