DEVELOPING THE SKILLS DEMANDED OF STATISTICIANS BEYOND STATISTICS: A CASE STUDY IN BIOSTATISTICS

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Most of the posts advertised for bio/medical statisticians across all sectors (industry, universities and public sector) in the UK require the following skills in addition to statistical knowledge: specialist knowledge in areas such as clinical trials or epidemiology; ability to manage and analyse large data sets; working knowledge of statistical analysis package; ability to work effectively in a team and individually; ability to work under pressure; excellent planning and organisation skills; excellent communication skills including the ability to write scientific reports and deliver presentations. Some of the methods used to develop these skills during a master's course in biostatistics will be described including online interactive questions, peer review, group work and presentations, consultancy skills workshops and statistical programming tasks.

INTRODUCTION

It is recognised that students, whilst at university, should develop skills for life as well as the subject knowledge skills. To secure employment graduates should have subject specific skills, abilities and knowledge but they also need to demonstrate other transferable skills, such as communication, individual and team work, problem solving and working under pressure, through the application process and at interview. To enable students to develop a range of skills, behaviours, attributes, and attitudes for work and life, universities need to make key skills explicit to students to enhance their self-awareness, and develop self-confidence in their own skill set. Staff also need to be engaged with this process. Students should be able to recognise their own personal, academic and career development achievements and needs (Cole & Tibby, 2013). It is often the generic skills that have the greatest influence on employability (Sigma, 2017).

Graduate employability is high on the agenda and a key subject of debate for UK Higher Education (HE) and most universities are becoming more engaged with the notion of embedding employability and employability skills in curriculum (HEFCE, 2011; Yorke, 2004). There are lots of definitions, approaches and practices associated with employability that relate to all the different stakeholders (government, employers, students, universities, etc). The Higher Education Academy's *Framework for embedding employability* (Higher Education Academy) summarises good practice and the report *Employability: A review of the literature 2012 to 2016* (Artress, Hooley, & Mellors-Bourne, 2017) summarises patterns in the literature. Some of the key points include: embedding employability into the curriculum; co-curricular and extra-curricular opportunities; building links with employers; supporting students to increase their confidence, self-belief and self-efficacy through their studies; encouraging reflection and increasing students' capacity to articulate and communicate their learning to employers.

Statistician posts require graduates from quantitative backgrounds, in particular mathematics degrees. Mathematics degrees in the UK vary considerably in how far they develop statistical skills beyond probability theory, hypothesis testing and linear modelling, with some focussing on statistical theory and others taking a more applied approach. Assessment tends to be exam based and there are often limited opportunities for students to develop a wider range of skills. In addition, mathematics students are often surprised to see emphasis placed on the acquisition of transferable skills and lack presentation and communication skills, pragmatism in the real problem solving, social skills and commercial awareness (Challis, Gretton, Houston, & Neill, 2002).

Medical/Bio-statistician posts are advertised in the pharmaceutical industry, university research groups and clinical trials units and in the UK NHS. Most positions require a master's level qualification as feedback from employers states that mathematics undergraduates do not have the subject knowledge or the transferable skills required. A review of 68 job descriptions was undertaken of entry level medical statistician roles advertised in the UK, these included jobs advertised on the AllStat mailing list 2016-17 and jobs for which references had been written for MSc students in 2016/17. Most of the jobs were advertised by university employers as the person specifications were

In M. A. Sorto, A. White, & L. Guyot (Eds.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS10, July, 2018), Kyoto, Japan.* Voorburg, The Netherlands: International Statistical Institute. iase-web.org

not always available for other employers. 80% of the 68 roles stated that a master's degree in statistics was essential (69%) or desirable (12%) and 29% stated that a PhD was essential but it is known from experience that employers often have to recruit at master's level to these positions due to low numbers of applicants at PhD level. The most common person specification skills required have been summarised in Table 1.

Table 1. Summary of Personal Specifications listed on 68 Medical Statistician Jobs 2016/17 (RCT – randomised controlled trials, HTA – Health Technology Assessment)

Personal Specification	Essential n (%)	Desirable n (%)	Total n (%)
Experience			
Significant statistical experience	38 (56)	9 (13)	47 (69)
Specialised experience, e.g. Epidemiology or RCTs	19 (28)	28 (42)	47 (69)
Knowledge			
Statistical Knowledge	50 (74)	4 (6)	54 (79)
Specialised knowledge, e.g. RCTs, Epidemiology, HTA	27 (40)	14 (21)	41 (60)
General IT skills (e.g. Microsoft Word, PowerPoint, Excel)	35 (51)	3 (4)	38 (56)
Statistical Software (Stata, R, SAS)	46 (68)	9 (13)	55 (81)
Skills			
Problem solving skills	23 (34)	2 (3)	25 (37)
Communication skills (oral or written, e.g. writing reports)	60 (88)	0 (0)	60 (88)
Communication to non-statisticians	60 (46)	5 (7)	46 (53)
Presentation skills	23 (34)	2 (3)	25 (37)
Organisational skills (e.g. time management, projects)	53 (78)	0 (0)	53 (78)
Teamwork skills (e.g. independently and part of a team)	55 (81)	1 (1)	56 (82)
Personal Attributes			
Interpersonal skills	24 (36)	3 (4)	27 (40)
Personality traits (e.g. positive attitude, uses initiative)	45 (66)	0 (0)	45 (66)

CASE STUDY: MSC IN MEDICAL STATISTICS, UNIVERSITY OF LEICESTER, UK

Our MSc in Medical Statistics is an applied and vocational course that enables students when they graduate to work as practising medical statisticians in an industry or research environment. The entry requirement is a strong mathematics background developed on a quantitative degree. The course covers statistical methods and modelling whilst enabling students to develop other transferable skills. At the start of the course most students have little experience in searching for or reading research papers, many have not written a formal report, and most have limited experience in group work and oral presentations. Many lack confidence in answering verbal questions and communicating their results both orally and in writing.

Below describes some examples of how we have tried to develop transferable skills in students on the course; some successful, others not so. A survey of graduates working as medical statisticians from two previous cohorts (2014/15 and 2015/16) was conducted to get their opinion of how the course prepared them for work and some of the comments from the nine respondents (4 working in the pharmaceutical industry and 5 in research posts) are presented.

Oral and written communication skills: developing skills, building confidence and reflection

During the induction week there are introductory sessions on report writing, reading research papers, group work and presentations. These are fairly ineffective as there is no practice at this stage of the course; often student feedback stated that they were not taught these skills. The sessions are now recorded and students are encouraged to revisit them when required. During the course there are formative and summative assessments to practice and develop communication skills. The range of assessment methods include statistical computing, mathematical statistics, statistical analysis with guided questions, research paper critique and two mini-projects assessed by formal written reports.

Although we have a relatively small number of students only a few answer class questions so we have tried a number of ways to increase their confidence. Voting cards are useful to get students to answer simple questions, e.g. "*which of the plots on the screen has the highest*

correlation?". We have used the personal response clickers and the students were generally positive about their use but the form of the questions was restrictive and it was time consuming to set up before and during the class. In the last two years we have been using Top Hat, an interactive, cloud-based teaching and learning platform that students can use via an App on their smartphones and tablets (Wi-Fi allowing) or online in the computer lab (Top Hat, 2018). Questions can have multiple choice, word, numeric or click on target answers. It is particularly useful for computer lab feedback to assess the level of understanding and students can then reflect on where they need further support.

When they submit assessments, students are given the opportunity to reflect on previous feedback by completing the following question on the assessment cover sheet "*Are there any specific aspects of this assignment that you would like additional feedback on from the marker?*" and they are later encouraged to discuss their feedback with lecturers. Very few students ask for further feedback but still comment that they do not get enough feedback. They often request examples of perfect 100% reports, particularly on statistical modelling, although we stress that there is no such thing. At the start of the course while we are revising basic statistical methods students are given the results of a two-sample t-test from statistical software and are asked to write a conclusion on a piece of paper. These are then folded up and put into a box. A few solutions are selected at random and anonymously presented so we can discuss how they could be improved; student usually focus on p-values, do not give effect sizes and confidence intervals, etc. Later in the course the solutions are returned to the students and they are asked to reflect on their writing; this allows them to see how they have improved and many students express embarrassment on what they originally wrote.

The modules are taught in week long blocks and during each teaching week students have to participate in some form of group work: appraising a research paper; analysing a set of data; describing a study design. The groups present their findings to students and lecturers. Students must peer review and ask questions on other groups' presentations. These presentations are not assessed but almost all students participate. The repeated use of group work and presentations improves their teamwork and builds confidence in presentation skills. When they have to give their independent project presentation towards the end of the course they have increased confidence and they comment that presenting in interviews is easier. Employer feedback also reflects this.

The Graduate Survey feedback comments on communication and teamwork skills included: "*My communication skills were definitely developed on the MSc through lots of reports and presentations. This is a strength of the MSc, as it has prepared me for report writing and giving presentations in my job. ..I think being able to critically review a paper has been essential so far in my job, and the MSc helped me develop the skills I need for this*"; *"..the frequent presentations we had to give in groups ..helped build my confidence for when I presented at work, chaired meetings and actively participated in team meetings. Also the written communication skills especially helped with interpreting results and the best way to present data in my external reports*"

IT Skills

Students usually have skills in Word and PowerPoint or Latex when they start the course and are given links to documents detailing more advanced use. Two statistical software packages, Stata and R, are used throughout the course and SAS programming is part of an optional module. Students are given self-learning booklets containing example code and practical exercises mainly on data handling and manipulation. After an introductory session, they work through the booklets in their own time and can get support if required. Students can learn at their own pace based on their prior knowledge. There is a data management assessment in both software packages requiring clearly annotated code so that analyses can be replicated. Students have to submit their code for many assessments. In modules they are guided to the relevant commands but also have to look up the detail of the code. By the end of the course the students are very competent at coding evidenced from the Graduate Survey comments: *".. when I started my job I was confident I'd be able to pick up another programming language (SAS) as I had done so on the MSc*"; *".. I did find the SAS booklet really helpful and I do still refer to it*"; *"..the course well prepared me for a job using Stata frequently*".

Career development

An industrial placement is the ideal opportunity to develop career awareness but difficult to fit in a one-year course. We run subject specific careers events with graduates speaking about their

roles and invite visiting speakers during modules who are working in the field so the students get some contact with employers. Some projects have options to work with external supervisors. In the past students were able to observe statistical consultancy sessions but as these sessions are no longer offered we developed a consultancy skills workshop combined with careers information on applications and interviews. As part of this students are asked to complete a personality test and they have to reflect on how their personality affects their performance and how they are perceived. Role play is used as a substitute for a real consultancy session but is not ideal. Some, but not all, students were engaged in the role play. Feedback on the workshop reflected this and included: "*Very good session, more helpful than I expected. The role play was good and the lectures were interesting*"; "*Role play - very useful*"; "*Found the session very helpful*"; "*Role play - not useful at all*".

CONCLUSION

It is important to embed employability within the curriculum of any course and we have tried to do this in our master's course. Students need to be aware of the skills that they will require beyond the subject skills and appreciate that most statisticians have to think about solving problems but do not work alone and will have to communicate their findings to other statisticians and non-statisticians both orally and in written form.

Problem-based learning and formative and summative assessment are core parts of the curriculum. Through lots of group work and oral and written presentations of their findings, the students gain confidence through the year. The course is very intensive so there is constant pressure to learn new statistical techniques and students are reluctant to spend time reflecting on their skills development through personal development planning with their personal tutors or reviewing assessment feedback. At the Consultancy Skills workshop students can reflect on how they can convey their skills to an employer and use them in a statistician role and is timetabled at the time when they start to apply for jobs. Most assessments are linked to a specific topic and until the Consultancy Skills workshop students do not have to think about giving advice more generally. We need to think about whether we can give more experience beyond the role play as comments on the Graduate Survey included "*Going into work a skill I have had to develop is deciding what is best approach for data or study that is being planned*".

Student feedback from our graduate survey shows that student's appreciate the skills developed on the MSc when they start work but that there are still things that we could improve on. The Graduate Survey feedback included: "*The course helped a reasonable amount with communicating (with non-statisticians), however I feel like it could have gone a little further, for example practice verbally explaining results to non statisticians rather than just writing a section of a report for non-statisticians*"; "*Communicating with non-statisticians ..you get this with experience, do not think in can be taught on MSc*".

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