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Editorial: Innovations and challenges in the teaching of statistics to non-specialists

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Abstract

Welcome to this special issue of the Journal of University Teaching and Learning Practice. Over the past 50 years, great strides have been taken in the use of technology and distance learning across the disciplines and there has been rising interest in research-informed teaching. Correspondingly, there has been a movement towards greater openness on the part of statistical educators to change their teaching practices in an effort to strive for excellence. In this special issue, a variety of approaches to teaching statistics to non-specialists are presented, all of which have a grounding in the pedagogical literature and involve innovative practices within the authors' own institutions. With the support of a 'ten tips' article involving a book review, consideration is also given to maintaining quality standards. This includes recognising the place of statistics among the sciences and ensuring that making the subject accessible does not lead to compromises in student understanding of statistical inference and the conditions for use of basic statistical procedures. The papers are united in addressing challenges in the teaching of statistics to non-specialists and as such, should assist in supporting communities of practice in this teaching area. In adjusting to the varying social distancing measures presented by the Covid-19 pandemic, we have both observed and participated in new ways of building bridges with students which have unquestionably reshaped the landscape of learning and teaching. Many of us who have found these experiences rewarding will be reluctant to return to status quo as post-pandemic plans unfold, since responding to the need for creativity in distance learning provision has proved beneficial to our own personal professional development in serving the needs of our students. Others may have felt ill-prepared to reconstruct their course content due to a lack of time, training and resources. Either way, I hope that many of the ideas and recommendations provided in this special issue will prove supportive and serve as an impetus to press on in an effort to make the learning of statistics an attractive and rewarding option for non-specialists while maintaining quality standards, particularly where staff resources are limited.

Statistical theory encountered in traditional introductory statistics syllabuses is frequently reported by instructors as having been received by students as nonintuitive or even counterintuitive (Lesser, 2002). From this standpoint, it has the potential to serve as a breeding ground for misconceptions, leading to statistical fallacies and hence, misinterpretation of research findings (Ogbonnaya & Nwankwo, 2019). Clearly, then, there is an argument for spending quality-time at the foundational level in making conceptual learning accurate and accessible. An important concern for educators in achieving this end ought to be that of ensuring that their learners are likely to develop new ways of thinking about problems involving the use of statistics in contrast to simply completing a checklist of course requirements as a means to an end. However, for this to be achieved, instructors must acquire some degree of intellectual empathy towards their learners in the sense of being able to accurately perceive how uninitiated learners may innately frame, and in turn apply, statistical concepts. This process must involve reimagining the seemingly obvious wherever this is necessary in breaking down barriers to effective student learning. Depending on their personal career journeys in statistics, instructors may to varying extents find it challenging to identify where to start in finding the missing links between their own ways of knowing statistics and those of their students.

Through focusing on a German case study involving the implementation of student surveys prior to and at the end of the delivery of a statistics module, **Kruppa et al**. demonstrate how sensitivity to experiential gaps between educators and their students in engaging with statistics can be fostered in communities of statistical educators. The case study involves an exploration of the word associations that learners make with commonly used statistical terms, thus providing a formative basis for reconstructing the content of statistical learning to meet the needs of existing and future students. This work builds on prior research on lexical ambiguity in statistical terms (Kaplan & Fisher, 2010). In providing the details of this approach for use in teaching non-specialists, **Kruppa et al.** raise awareness that familiarity with similar or identical terms in other, such as everyday, contexts can influence the connotations that learners derive from statistical terms, an example of which in their experience is students associating the term ‘decrease’ with the statistical term ‘regression’.

Kruppa et al. favour exploration of this approach to personal development for statistical educators in combination with a range of basic student-centred approaches which they have gleaned from the pedagogical literature. This paper ought to be of general interest to statistical educators at all levels of experience in teaching non-specialists who are challenged by the mismatches between their own and their students’ approaches to interpreting statistical concepts.

The idea of identifying conceptual barriers to student learning can also be understood in terms of the notion of ‘bottlenecks’. Within the literature on student learning, a bottleneck has been defined as a metaphor for referring to “those places in a course or curriculum where the content jumps ahead without explicit description of the mental moves that support, for example, a leap from evidence to conclusion” (Middendorf, 2018). Middendorf (2018) has developed a model which uses such bottlenecks as red flags to identify what needs to be unpacked in the expert’s expertise to break down complicated thinking. This procedure is part of a more in-depth analysis known as decoding the discipline, which is designed with the intention of remodelling student learning. Recognising that statistical educators may find the idea of identifying bottlenecks challenging, **Lemieux and Quiring** demonstrate their approach to decoding statistics specifically within the context of teaching statistics to business students. They do so using a model for educators, where it is may be assumed that educators will use narratives of relevance to the principal disciplines of their learners. Here, narratives take the form of fictional stories involving a problem-solving scenario within the workplace, with dialogues between the characters, such as employees discussing a business contract for the production and packaging of a product and grappling with the underlying statistical concepts. The process of decoding then takes place through discussions between the writer and a critical friend in preparation for delivering each narrative as a motivational tool to support students in engaging with statistical concepts.

Using a more indepth and broader coverage of statistics, Field has already taken a lead in the narrative approach to teaching statistics through use of fictional characters engaged in dialogue. (Field, 2016) However, **Lemieux and Quiring** also focus on preparing the narrative for their learners. In particular, they demonstrate how collaborative work between colleagues, involving the narrator “making their hidden assumptions and mental operations explicit” to a non-statistician could be used a means of anticipating student bottlenecks within the narrative in advance of delivering statistics teaching. This Canadian case study involves a partnership between the two authors in decoding statistical narratives specifically in preparation for teaching business statistics, and could in principle be adapted for use in the teaching of statistics across a wide range of disciplinary settings.

Addressing the challenge of teaching statistics at scale

The above innovations for addressing conceptual challenges in the teaching and learning of statistics are transferrable to a wide range of disciplinary areas where statistics is taught as a service course. The additional challenge remains, however, of maintaining equity in meeting the statistical learning needs of students where teaching is delivered at scale. The Open University (OU) in the UK is recognised as a world leader in delivering flexible distance education to the masses. It is fitting, therefore, that we should look to this institution for ideas in addressing the above challenge. With a focus on statistics courses, **Hilliam and Vines** report on how the OU has developed its teaching modules at scale. This includes meeting the statistical distance learning needs of students progressing towards different qualifications across a variety of disciplines and home countries. Within this context, the use of narratives is taken to refer to the design of formal statistical problems that are contextualised within "everyday life settings" which all students should be able to relate to. As the modules are required to be available both for mathematics and statistics students and as service courses for students in other disciplines, they have a unique role to play relative to modules traditionally offered at other UK universities. On account of the disciplinary diversity, the students commence their courses with an unusual degree of variability in prior learning in statistics and statistical apptitude. However, due to resource constraints, the case scenarios for their teaching cannot be tailored to meet individual course preferences. Through providing detailed accounts of a range of online learning resources that they provide for their students for consolidation of learning and for assessment purposes, the authors illustrate how student learning is supported and managed within this diverse setting. Given the large element of online learning that is involved in these modules more generally, these resources should prove particularly inspirational to statistical educators who have had to reconstruct their courses for distance learning in response to the COVID-19 pandemic and are keen to derive greater returns from this effort through upscaling the reach of their new courses in the longer term.

The challenge of scale in teaching and learning statistics exists in catering for, not only a diversity of audiences but also, large class sizes. In both cases, a key limiting factor can be availability of human resources for the delivery of courses to meet bespoke student learning needs. Where data analysis skills are being developed and there is a need to assess a large cohort of students, educators may see group assessment as the only manageable option, both in terms of fulfilling marking needs and delivering unique datasets. Within the context of large-class teaching for a business decision-making course, **Weir et al.** discuss use of the open source e-assessment system, Dewis. This system is used for random generation of datasets and construction of key skills e-assessments in statistics with automated marking and feedback. Used in this way, Dewis can widen the scope of assessment opportunities within courses and allow students to obtain rapid feedback based on their individual performance and using their personalised datasets. Furthermore, through outlining their integration of the design of question content with use of the statistical package SPSS, the authors illustrate that e-assessment need not be limited to the theoretical aspects of statistical learning. This paper may be of particular interest to statistical educators who are seeking to grapple with the challenge of producing and delivering manageable innovative assessments in statistics to large cohorts of online learners.

Equipping learners for their existing or future professional careers

Developing student awareness of the relevance of their learning in statistics to their professional aspirations is challenging in undergraduate professional courses where entry is restricted to the highest performing students. This is particularly evident in the case of medicine, where student intrinsic goals for achieving a place in medical school are unlikely to involve the opportunity to study statistics. Relatedly, there is a growing literature on the topic of teaching statistics to medical students and students in allied health sciences (Bland, 2004; Kiliç & Çelik, 2013; MacDougall & Cameron, 2019; Oster, 2018). However, lesser consideration has been given to the topic of teaching statistics specifically to dental students. **Leary et al.** discuss the delivery of statistics teaching in a research methods course, involving a range of teaching methodologies, to undergraduate dental students. Despite the focus on dental students, the methodologies outlined in this paper ought to be of interest to statistical educators in search of a case study exemplifying a blended learning approach. The methodologies outlined include use of PowerPoint slides with voiceover and pop-up questions for elearning and use of an audience response system to gauge student understanding in face-to-face sessions. While the emphasis in this course is on concepts of statistics and epidemiology, course teams who favour the inclusion of data analysis skills in their intended learning outcomes may find it beneficial to combine some of the tried and tested methologies from this particular course with those discussed by **Hilliam and Vines** and **Weir et al.**

Online learning can also provide professional development opportunities to enhance existing career prospects. In this setting, the challenge of convincing students of the relevance of statistics to their careers may not seem immediately obvious. However, where statistics is situated in a more general research skills course, mature

learners may experience some degree of anxiety regarding their personal capabilities to keep pace with peers who have stronger or more recent backgrounds in the mathematical sciences. **Davies** discusses a possible approach to addressing this challenge through the delivery of a series of online seminars for a quantitative research module for working professionals. These learners pursue research while enrolled as distance learners on the part-time Doctorate Programme in Professional Practice at the University of Wales Trinity Saint David. The online seminars are both problem-based and discursive and are embedded in a flipped learning model, involving the use of real-life datasets. The authors report student feedback which could prove instructive in fine-tuning their approach to delivering these seminars and serve as ideas for statistical educators who are at the early stages of planning the development of online distance learning courses for professionals.

The value of exploring the above teaching methodologies and those of **Leary et al.** in adapting to the uncertainties that have emerged from the COVID-19 pandemic is implicit from the following remarks recently made in response to employer research carried out at the OU:

> *By providing continuous opportunities for progression and recognition of skills development, employers can retain crucial contact with their people, to keep them motivated and engaged.*
>
> *A strong commitment to flexible, online learning, could prove absolutely crucial to employers looking to keep abreast of the radically shifting COVID-19 situation over the weeks and months to come, and give their employees the chance to drive future success* (Patel, 2020).

Fostering sound practice in the interpretation and analysis of data

As the above contributions illustrate, within higher education, there is not a one-size-fits-all approach to teaching statistics to non-specialists. Educators have contrasting perspectives on the teaching methodologies and content that are best suited to their learners, and this can be influenced by a range of factors, including the emotional and intellectual maturity, career aspirations and competing interests of the learners. In all of these conditions, there are many common factors, however, including the challenges of meeting individualised student learning needs in statistics and managing staff resources and time realistically to meet these needs. Within these contexts, there is also a need for maintaining standards in the teaching of statistics so as to train students to recognise and prevent the misuse of statistical procedures and the misinterpretation of research findings. Within higher education, there can, however, be systemic barriers to achieving this goal.

The desire for university schools and departments to expand their teaching profiles to gain a competitive edge increases opportunities for early career researchers, including postgraduate students, to take up paid teaching opportunities in statistics, where their own backgrounds in the discipline are lacking. Similarly, experts in non-statistical fields who are themselves researchers may feel pressurised to take up the challenge of teaching the statistical components of their more generic research methods courses. While this can lead to a shared empathy between educators and their learners regarding the complexitites of statistics and its nonintuitive nature, there is also potential for over-simplifying statistics to the detriment of the quality of future research. These barriers are likely to grow where institutions seek to expand student intake based on recent initiatives to create online courses in response both to the COVID-19 pandemic and the inevitable uncertainties regarding future use of social distancing measures. Indeed, it has already been suggested that:

> *For many higher education chief financial officers, offering students a choice to study either on campus or remotely will provide an opportunity to change outdated business models and create a roadmap for future financial stability* (Dennis, 2021, p. 3).

These predictions serve to intensify the long-term challenge to be met in ensuring ongoing professional accountability in the presentation of statistics as a science. This includes presentation of models with testable assumptions and ensuring that the application of statistics is not taught in the absence of a core grounding in statistical theory. This is particularly evident in the application of statistical hypothesis testing, where abuse of the ubiquitous *p-value* has caused consternation among professionally trained statisticians for over 50 years. I, **MacDougall**, provide a preliminary review of the Pocket Study Skills book *How to Analyze Data*. Building on this work, I also provide ten tips primarily to support statistical educators who are themselves non-specialists in statistics and would appreciate quality standards for evaluating the plethora of published resources designed to make statistics less mystifying to non-specialist learners. However, hopefully, these tips will also make a contribution to supporting editors and reviewers in providing feedback to authors on their academic work in teaching and learning, where statistical expertise is lacking.

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