STATISTICS: YOUR TICKET TO ANYWHERE

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ABSTRACT

"We have too many first-year statistics students but too few who choose to major in statistics" is a common complaint among academics in the discipline of statistics, and our department is no exception. Many non-statistics academics appreciate the value of statistics to their discipline and include at least one statistics unit in their required units. However, students in such units often do not see the use of statistics within their discipline or the importance of learning statistics or quantitative skills in general, despite the current shortage of statisticians and deluge of data to be analysed. Our student numbers decline sharply by years of study, from first to second and from second to third. A handful of students who decide to major in statistics or decision science find themselves in high demand. In early 2016, just before the first semester started, we ran an event for the previous year's successful first-year statistics students to encourage more students to choose statistics or decision science as a second major in addition to their existing majors. We worked with our alumni so that the second-year students heard talks mainly by people like them instead of like us – their lecturers. We called this event 'Statistics: Your Ticket to Anywhere'. In this paper, we describe how we structured the event, its outcomes for the department, and how it helped us to "unveil the curtain" and to show the value of statistics to the students in their chosen fields of study.

Keywords: *Statistics education research; Student engagement; Awareness raising; Future generation of statisticians*

1. INTRODUCTION

Nowadays, everyone in the world relies on statistical interpretations for decision making. The recent outbreak of Novel Coronavirus (COVID-19) is an example of how people, organizations and governments make their decisions based on statistics. At the time of writing this article, it was unknown how coronavirus was spreading and there was no cure or vaccine; therefore it can easily be assumed that some people altered their travel plans to avoid the risk of being infected by coronavirus. Universities in Australia had to decide how to help students coming from China. For example, Macquarie University in Sydney set up a web page to provide the latest information and University guidelines to its staff and students (Macquarie University,

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n.d.). Similarly, government departments such as the Department of Health (Australian Government, n.d.) keep Australians informed about the daily changes. The Prime Minister of Australia, Scott Morrison, like heads of other states, made decisions to protect citizens from the risk of COVID-19 infection. One such decision was a travel ban, stopping anyone other than Australian citizens or permanent residents and their immediate families from travelling from China to Australia (ABC News, 2020). A trusted source of information in such a life-threatening disease outbreak is the World Health Organization (WHO). With this responsibility, WHO created a web page to communicate the best current understanding of the coronavirus to fight against misinformation (WHO, n.d.). It is obvious that such situations require statistics to be communicated to people. However, it is not sufficient to communicate this information to people if statistics is a language they do not understand. Therefore, everyone needs some statistical literacy. But how can we equip students who do not consider statistics an interesting or attractive subject with this literacy?

Many articles, books, and conference presentations document the importance of statistics in the modern world. With bigger data collections and heightened efforts to analyse "big data" and make sense of data for decision making, the urgency to educate more people in statistics is increasing. "Statistical literacy is a necessary precondition for an educated citizenship in a technological democracy" (Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, & Woloshin, 2007, p. 53). Gigerenzer et al. (2007) document how highly educated citizens such as doctors, journalists and politicians can make poor decisions due to statistical illiteracy. We are surrounded with data that can help us to make evidence-based decisions in our life and work; however, understanding uncertainty and variation are not easy and almost impossible without statistical knowledge (MacGillivray, Utts, & Heckard, 2014).

The last decade has seen a shortfall of people with adequate statistical training (Cameron, Iosua, Parry, Richards, & Jaye, 2017) who can deal with "big data" (Manyika et al., 2011; Puang-Ngern, Bilgin, & Kyng, 2017). Other research papers documented the importance of gaining students' interest and engagement in statistics classrooms (Howley, 2008), assuming they have already chosen or been required to study statistics. The importance of educating primary and secondary teachers before they face their students and how we can help them to be statistically literate have also been investigated (Bilgin et al., 2017). More than a decade ago, Google's chief economist, Hal Varian, said "I keep saying the sexy job in the next ten years will be statisticians. People think I'm joking ..." (McKinsey & Company, 2009). On the one hand, the alarm bells are ringing due to the shortage of statistically literate professionals and citizens. On the other hand, the opportunities to be highly employable because of the statistical skills are increasing. Are the universities experiencing increased number of students in their statistical classroom? The expected, logical answers would be "yes." Unfortunately, that is not the case. So what can we do?

In this paper, we describe how we structured an event, which we called "Statistics: Your Ticket to Anywhere!" We relate its outcomes for the department, and how it helped us to "unveil the curtain" and show students the value of statistics in their chosen fields of study. The aim of this event was to inform and enthuse the successful first-year service statistics students about further studies in statistics (in the second and third year) and about the future job opportunities that a deeper knowledge of statistics could unlock.

2. BACKGROUND

In 2016, the Statistics Department at Macquarie offered four units at first-year level, all of which continue today in some form. Three are general introductions to statistics, tailored for different cohorts, while the fourth is a general education unit. These are all seen as service courses, with the majority of their students not enrolled in either of our majors, Statistics or Decision Science.

Business Statistics is a core requirement in the Bachelor of Commerce, Bachelor of Applied Finance and Bachelor of Economics degrees. All unit guides are available from Macquarie University (n.d.). The learning outcomes are similar to any other first-year statistics unit: to organise and summarise data graphically and numerically, use appropriate techniques to analyse data, use Excel to manipulate and analyse data, draw conclusions from the results of data analysis, apply statistical techniques to problems arising from diverse fields of research, and demonstrate foundational learning skills including active engagement in their learning process. Students are introduced to descriptive statistics, sampling distributions and confidence intervals, one- and two-sample population mean tests, population proportion and χ^2 independence tests, and simple linear regression. Concepts and methods are taught using examples from commerce and finance. Annual enrolment in this unit is approximately 2,500.

Introductory Statistics is an alternative to *Business Statistics* aimed at science and engineering students, with examples drawn from those disciplines. This unit is an elective in the Bachelor of Science and other science degrees. Annual enrolment is approximately 1,500.

Statistical Data Analysis is a core unit in the Bachelor of Actuarial Studies, covering similar material to *Business Statistics and Introductory Statistics*, but in more rigour. Macquarie's actuarial program is the oldest in Australia, dating from 1968. It is very challenging, and accredited by the Institute of Actuaries of Australia (n.d.). The stated learning outcomes are to understand the concepts of populations and samples, and be able to apply suitable statistical techniques for different types of variables; to understand basic probability concepts, and be able to apply these to both discrete and continuous variables; to understand application of the scientific method through estimation and statistical inference for means, proportions, categorical data, and linear regression; and to demonstrate foundational learning skills including active engagement in their learning process.

In Australia, especially in NSW, until recently secondary-education (high school) mathematics classes only included very basic statistics, with none in the last 2 years of school. As in many countries, these classes are taught by mathematics teachers, who we believe often underestimate the differences between the disciplines of mathematics and statistics, and fail to convey the interesting side of statistics. In addition, teachers' attitudes (especially pre-service) to mathematics and mathematics teaching is a well-researched area, showing that pre-service teachers have a high level of mathematics anxiety and a negative attitude towards mathematics (Hill & Bilgin, 2018). We argue that when they teach statistics, a discipline that they often have not studied, the teachers would have even greater negative feelings toward the subject. This is exacerbated by shortages of qualified high-school mathematics teachers, causing some high schools to employ science teachers to teach mathematics and statistics to their students (Weldon, 2015). Therefore, we believe that students rarely get a fair view of statistics before studying it at university, and are then able to re-evaluate the discipline.

3. OUTREACH TO RAISE AWARENESS

In our experience, it is extremely rare for students to arrive at university intending to study statistics. On the other hand, for many years we have observed a steady trickle of students discovering sufficient interest in the subject after taking one or more required or elective statistics units to consider changing majors. We believe that by achieving good grades these students overcame their fear of statistics, "statisticophobia" (Dillon, 1982), and their statistical anxiety (Chiesi, Primi, & Carmona, 2011). Therefore, in this outreach, we targeted the students who had achieved high grades in first-year statistics service units. By achieving high grades, these students have begun to see the scope, power, and conceptual underpinnings of the subject, and usually still early enough in their studies that they could alter their study programs to accommodate second-year statistics units as electives or even consider an additional minor or major in Statistics with their prior chosen field of study.

In Australia, the tertiary academic year is aligned with the calendar year. In many universities, the first semester starts towards the end of February. So, we organized our event in the Orientation Week (the week before classes begin). We sent invitations to all students who had achieved good grades in the previous academic year.

We called our outreach activity "Statistics: Your Ticket to Anywhere!" (Figure 1). We invited the chosen students to the event, initially with a postal invitation and later via the web service Eventbrite (the details are documented below). As well as individual invitations, we posted flyers in various places on campus and the department's web page.

Figure 1. Statistics: Your Ticket to Anywhere! Invitation flyer

We structured the event so that at least half of the talks were given by recent graduates. In the first half of the event, we showed options for adding a minor or major in *Statistics* to their current degree without derailing their study plans. We also gave examples of previous work-integrated learning projects undertaken by statistics capstone students (Bilgin, Bulger, & Petocz, 2018) to raise students' awareness of where they could use their statistical knowledge.

The alumni who came to talk about their experiences had various backgrounds and pathways leading them to major in Statistics during their university studies. For example, the initial degrees ranged from accounting, finance and biology to actuarial studies. Some previous graduates added Statistics into their degree plans as a second major or minor, while others decided to transfer into a new degree allowing a major in Statistics or Decision Science. To supplement the alumni talks, we also collated information about some of our previous graduates, and presented one slide for each graduate, showing their graduation year and degree, where they were working, and what message they would like to give to our potential statistics

major students. A recent graduate, employed by a government organization after completing an internship for a capstone project, wrote, “There is a growing demand for data professionals in the public and private sector. A major in statistics opens a wide range of career opportunities.” Another one, working for a marketing agency, wrote, “If you love numbers and want skills that truly stand out, Statistics/Decision Science is for you!”

At the end of the presentations, before giving out lucky door prizes to randomly chosen students, we obtained attendees’ feedback on two questions. These two questions were designed based on the pedagogical principles (Angelo & Cross, 1993, p. 154–8). They were:

- “What was the most interesting thing you learned about during today’s session?”
- “What are you still confused about after today’s session?”

It was quite surprising to see the answers to these questions (Figures 2 and 3). Information about each of the points raised by the students is publicly available, both at the University’s website and on the wider internet. However, this event seemed to help students navigate the deluge of information by giving them ideas about what to look for.

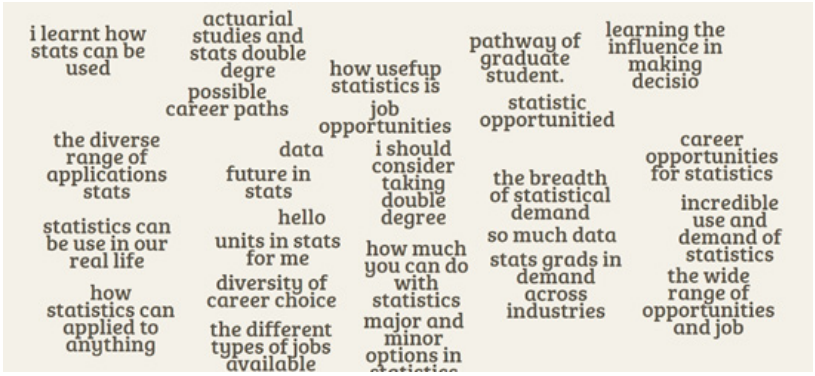

Figure 2. Students’ answers to “What was the most interesting thing you learned about during today’s session?”

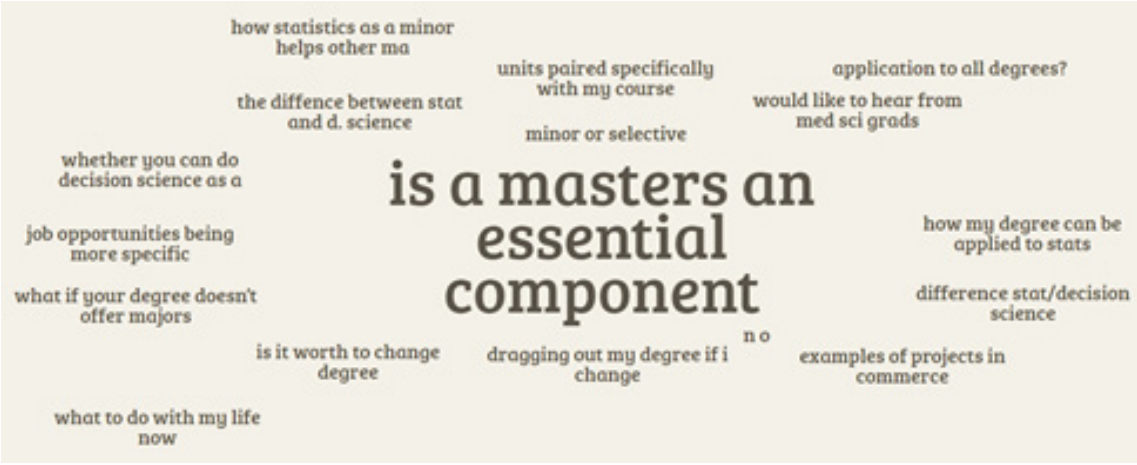

Figure 3. Students’ answers to “What are you still confused about after today’s session?”

The most interesting thing students learnt through the event can be summarized as the usefulness of statistics and the career opportunities it presents. This is an indication of how the discipline of statistics is not known outside the small circle of statistically educated people. We

as statistics educators should aim to reach out to inform more people, starting with our students, about the statistics and its impact on the society.

Students were mainly confused about what they need to do to restructure their studies to include more statistics either as a minor, a major or further study at postgraduate level. From their answers to the second question (Figure 3), it is clear that they were convinced that studying further statistics would benefit them.

A light lunch with academic staff and higher-degree research students allowed us to address any remaining questions in a friendly, less structured environment. One-to-one academic advice following the event was also undertaken to help the students to restructure their study plans. A side effect of the invitation was increased demand for academic advice, not just by the students who came to event, but by the students who got the invitation but did not come to the event.

4. INVITATION PROCESS – PROCEDURES – RELATED ACTIVITIES

In terms of the organization of the event, we are faced with a few potentially labour-intensive logistical challenges. Specifically, we need to find an efficient way to invite and promote the event to over two thousands students; to organize their registration for catering purposes; and to have an accurate record of attendees on the day of the event so that prizes can be given away based on a random draw. Our solution was to use Eventbrite (n.d.) to manage the event for us.

Eventbrite is a U.S.-based event management and ticketing website that allows event organizers to offer online ticketing services for their events. Eventbrite meets all of our needs, and is free to use when hosting a free event.

The service allows us to send personalized email invitations to our students by simply providing their name and email address in a spreadsheet format. The site then allows tracking and analysing how many students had opened and responded to our invitation.

At its core, Eventbrite is an online ticketing website, so obviously students can register for the event with a few simple clicks once they have received the invitation. A ticket would then be generated and sent to them (Figure 4). It also allows you to create a form for students to fill in during registration if you would like to collect their background information. If students want to cancel or change their registration, the site will take care of that for us, too, and provide us with a real-time registration count for catering purposes. A few days out from the event, the site will automatically generate a reminder to all registered students.

On the day of the event, the key challenge is to have an accurate record of attendees so that lucky door prizes can be given away based on a random draw. Instead of checking students' names off a paper list and potentially creating a bottleneck at the entrance, or giving out raffle tickets, Eventbrite has a complimenting app called "Organiser" (available as a free download in both Apple App Store and Google Play Store) that allows the user to reliably and efficiently check attendees in by simply scanning QR codes on students' tickets with the camera on a mobile device. If a student cannot produce the ticket, one can also simply look the student up with a quick search on the guest list. A further advantage is that all check-in data (as well as any other data) is synced in real time with Eventbrite's servers so that multiple devices can be deployed at different entry points while still maintaining a unified and complete list of attendees (for the prize draw).

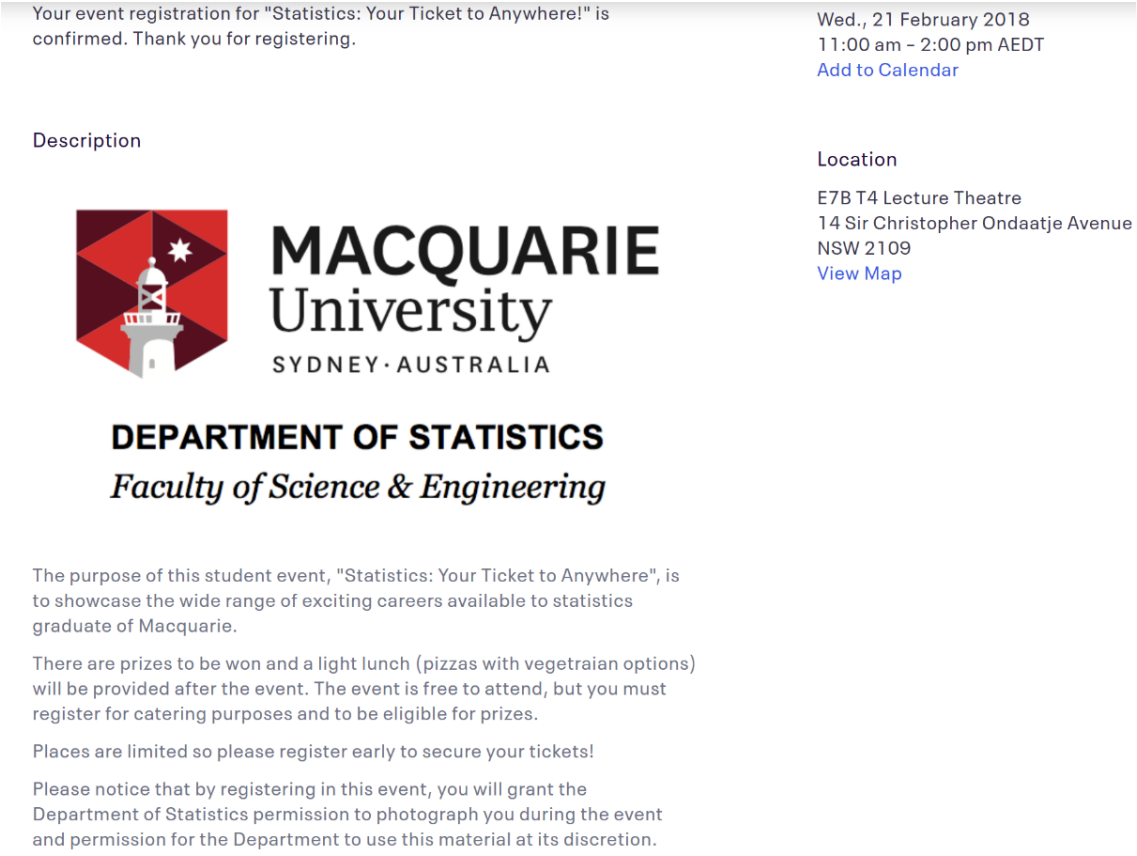

Figure 4. Eventbrite registration confirmation

5. EFFECTIVENESS OF OUTREACH AND IMPLICATIONS FOR STATISTICS EDUCATORS

The number of invitations, registrations and attendees are given in Table 1. The proportion of invitees who attended ranged from 2% to 3%, with about half of registered students attending. At first look, this may seem like a low success rate, but that is more reflective of the wide range of good students invited. And as we shall see, it coincided with a substantial increase in students in our higher-level units.

Table 1. Invitations, registrations, and attendees

Year	*Type of response*		
	Invitations	*Registrations*	*Attendees*
2016	1,703	98	54
2017	1,991	86	35
2018	2,426	91	45

For many years prior to the introduction of this event in 2016, our department's only marketing directed to students in our first-years units was to send a letter or email to high-achieving students, congratulating them and providing information about possible future statistical studies. Unfortunately, this way of encouraging students had a very low impact on students' future choices of statistics units. The number of students who chose to study further

statistics units in the second- and third-year level for nine years (5 years before the event and 4 years after the event) shows that the event has encouraged more students to choose higher-level statistics units (Table 2 & Figure 5). While it appeared that the second-year student numbers followed a decreasing trend from 2011 to 2015, the student numbers started to increase after the event. The increase in third-year enrolments is also gratifying (though it is harder to know how much of that to attribute to the event since enrolments were already on an upward trend).

Table 2. Number of students in selected second- and third-year statistics units (before and after the event)

	2011	2012	2013	2014	2015	2016	2017	2018	2019
First Year (3 units)[a]	2,416	2,548	2,985	2,946	3,367	4,576	4,395	3,655	3,983
Second Year (2 units)[b]	153	132	121	107	108	166	293	342	373
Third Year (2 units)[c]	19	21	26	33	41	50	71	84	99

[a] Business Statistics, Introductory Statistics, Statistical Data Analysis
[b] Applied Statistics, Introduction to Probability
[c] Linear Models, Consulting in Statistical Sciences (Capstone)

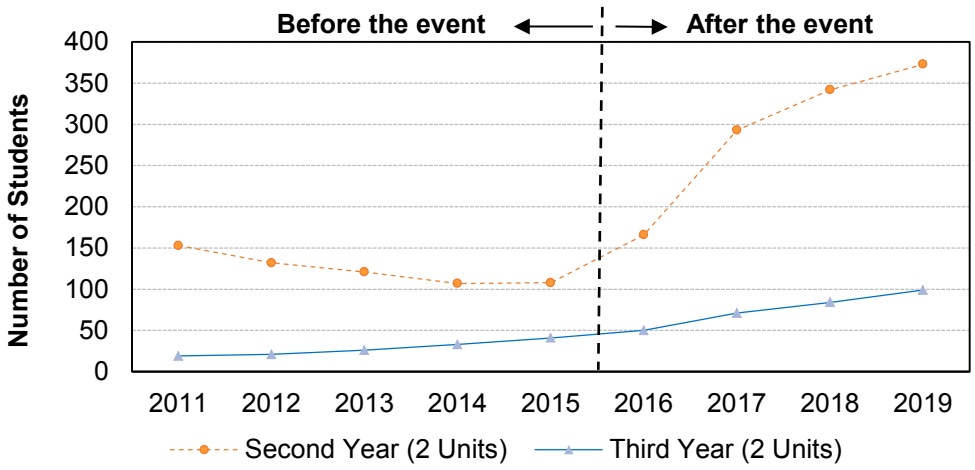

Figure 5. Number of students in selected second- and third-year statistics units before and after the event

We believe if many institutions run such events, we can help to change the complaint from *"We have too many first-year statistics students but too few who choose to major in statistics"* to *"We have too many statistics students but too few academics who can teach them."* Working together as a community and helping each other to reach out to more people are important for the future.

Increasing the student numbers in second-year statistics units is the first step toward educating more future graduates with required skills for their future work and life. Regardless of the profession they choose, they will be better equipped to make evidence-based decisions that are beneficial to society. Statistical numeracy is as important today as literacy was a century ago. Targeted marketing or outreach events like ours can encourage students to include more statistics units in their study plans or even major in Statistics, this way we can help to build a better future. It is important to *"unveil the curtain"* and show the beauty of statistics and its value to their chosen professions. Who could do this best, their lecturers (us) or young ones like themselves who went through the same path?

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