

## ENGAGING STUDENTS AND TEACHERS THROUGH STATISTICS TOWARDS GREATER CONNECTION AND SOCIAL RESPONSIBILITY

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*Arresting statistical anxiety and connecting students with statistics is critical in the big data age and for future generations to be socially responsible citizens. This paper outlines a national project-based learning activity, which facilitates interdisciplinary projects, engages students from varied backgrounds with varying areas of interest, and develops key communication, research and statistical skills aligned with national school curriculum outcomes. Allowing students to take the lead, determine the context and self-diagnose are powerful motivators. A mentoring model connecting industry, primary, secondary and tertiary educators has been invaluable to the project's success. Australian school teachers are saying "21st Century learning at its best", "motivates and engages students". Mentors are saying "I was inspired by their keenness", "provides students a unique opportunity". Students are saying "engaging, educational and enjoyable". Over 1000 students engaged with the competition in 2016.*

### INTRODUCTION

Statistics and the interpretation of data are ubiquitous in the knowledge society and consequently statistical literacy is assuming an increasingly prevalent role in education at all levels. However, the perceptions and general appeal of statistics, requires measures to keep students interested and overcome initial hurdles to gain their interest or engagement (Howley, 2008; Howley, 2009). Further, statistical anxiety is increasingly a major issue which has been identified as a deterrent for young people to access and succeed in university degrees (Onwuegbuzie & Wilson, 2003; Williams, 2010). In particular, statistical anxiety seems to affect females and students from diverse backgrounds (Bui & Alfaro, 2011; Onwuegbuzie & Wilson, 2003). Early intervention for improving access to university is crucial, particularly for low socio-economic status (SES) students (Tai, Qi, Maltese & Fan 2006; Barnett, 2011; Maltese & Tai, 2010). A significant body of research also indicates that mathematical and statistical unpreparedness is a major factor affecting entry to and persistence in the traditional Science, Technology, Engineering and Mathematics (STEM) disciplines for students from low SES regions and culturally diverse backgrounds (Bonous-Hammarth, 2000; Clewell, 1992; May & Chubin, 2003). Despite this research dating back decades, and the proliferation of resources to teach *mathematics* available through digital media and the internet, data worldwide shows that *statistics* is also considered a significant roadblock for many low SES students (Bell, 2003; Petocz et al., 2007).

There are additional reports identifying the relative shortfall of adequately skilled individuals in the new Big Data age (Manyika *et al*, 2011; Puang-Ngern, Bilgin, & Kyng, 2017). Students need to engage with and become more greatly interested in the analytical, statistical and machine learning aspects needed to fill the increasing need for such Big Data skills. Although universities are introducing new degree programs to address this issue (Kyng, Bilgin, & Puang-Ngern, 2016), earlier appreciation of and engagement with statistics is lacking.

Australia's former Chief Scientist has commented that "when they do study them (the sciences) at school...the best way to teach inspirationally is to teach it the way it's practised." (Chubb, 2015). However, school teachers have rarely if ever experienced statistics in practice. Nor do they understand the varied and wide reach of statistical thinking, techniques and applications, and its importance to study design and inference. Their knowledge about the practicing statistician is at best limited, their focus has been on the many other topics and aspects of teaching. When it comes to teaching statistics, teachers usually concentrate on the theory but not the practical applications of statistics; supposedly it is easier to teach and assess the theory compared to practical aspects and applications of statistics.

## AUSTRALIAN SCHOOLS' POSTER COMPETITION

The National Schools Poster Competition is a project-based learning activity. It involves teams of 2 to 5 school students creating an informative poster presentation (akin to a conference poster) addressing a practical question on an area of interest to the students, from any field, and utilising the collection, presentation and interpretation of data. There are five divisions, namely Grades 3-4, 5-6, 7-8, 9-10, and 11-12 (aged from 8 to 18 years); the first two divisions are primary school, and the remainder are secondary school in the Australian education system. Within each division, small cash prizes (\$50 to \$200) are awarded to winning teams and their schools.

The competition is a fun and engaging activity that develops students' critical thinking, investigation, collaboration, communication, reporting and creative skills. It nurtures awareness of how statistics, quantitative and scientific skills can help us better understand the world, no matter the field of interest. It enables students to understand the interdisciplinary nature of investigations, and maps to National and State Boards of Studies' curriculum outcomes.

Winners may progress to the International Statistical Institute's international competition, the International Statistical Literacy Project (ISLP), with which it is aligned albeit with many key distinctions. One of the unique aspects of the national competition is the strategy of building an Australia-wide network of mentors. Mentors attend schools to facilitate the activity's delivery and engage students with discussions of the practical importance of statistics. Providing mentors for the activity is an invaluable contributor to the competition since many secondary school teachers of mathematics or science classes are not trained to teach such disciplines.

Mentors are trained and supported nationally, guided by the national coordinator and the resources he has produced surrounding how to engage teachers and students and facilitate the activity. Mentors include undergraduates with experience in statistics, pre-service teachers (training to be a secondary school mathematics teacher), current and retired industry practitioners and practicing professionals.

## STAKEHOLDERS' REFLECTIONS ON THE COMPETITION

Within the context of an open invitation welcoming thoughts on the competition and how it may be improved, comments received after participation in the project-based learning activity have complemented other unsolicited comments volunteered from teachers and students. Participants provided positive feedback about the help the project-based learning activity gave them in developing statistical foundations, connecting the many disparate topics surrounding statistics, providing an overall confidence in their ability to understand the power of data, and a sense of statistics being accessible and comfortable for them. They also reported a sense of achievement and/or improved academic self-efficacy.

Mentors have found the experience enriching and reported how eager the students have been to engage in the activity and how impressed they were with the students' enthusiasm. They have referred to their experiences as "*highly rewarding*" (senior data administrator, Department of Health) and how the competition "*provides a unique opportunity to combine the skills they have learned in Science, Mathematics and English to investigate a real world problem*" (Biometrician, Crop and Food Science), and that "*the results are very interesting*" (Finance Systems Specialist). In addition to mentors, teachers and students also provided unsolicited feedback and were later recorded in wrap-up sessions following the activity. An indicative sample of the quotes from such feedback, and summaries, are presented in the following sections.

### ***Teacher reflections on the competition***

The teachers' reflections on the competition covered many aspects but the most important points were the interdisciplinary nature of the activity, giving students the opportunity to work collaboratively in a practical project and allowing students to choose an area of interest to them. The teachers were happy with the help they got from the mentors and they all agreed to recommend the activity to their peers. We provide the teacher's voice by the following quotes.

A male secondary school teacher who worked for five years in regional and rural areas with low SES students commented: "*It's definitely a project I'd get involved with if I was teaching out there again. You've got a lot of students who are interested in sport, they've got strong views on cultural and environmental issues. Giving them the opportunity to dive into those topics and have a*

*look at the mathematics and the data...they'd enjoy it. Similar to what we're doing here, I think it's something the teachers would enjoy too. It works really well with the syllabus."*

A female participating secondary school teacher, who has taught extensively in remote and rural regions and more recently in regional and city schools stated: *"I like that the activity gives children purpose for their learning...that it lets them work collaboratively on something that they get to choose. I like that it has a real audience, in that there's a competition at the end, there could be prizes, they'll at least get a certificate....Highly recommend it as it gives purpose, passion, productivity to the work. I think it (statistics) is a real key 21<sup>st</sup> century skill that all students need and the poster competition project is a great vehicle for getting that in there."*

A female primary school teacher commented: *"The Australian Poster Competition was great as it enabled the students to investigate an area of interest, and use the statistics skills that we learnt in class in a practical way. ...it enables students to become more involved and motivated in the area of mathematics, and it enables them to use skills which is a requirement of STEM...students can actually see the applications of it (statistics). ... we had a fantastic mentor...helped us creating ideas on how to present and gather data."*

A male primary school teacher commented: *"The poster competition addressed a huge number of things that we were focussing on in the school. One of them was about student voice, we wanted to give students agency...and we did that through the poster competition. (It brought a) focus on active and informed citizens, ... addressing real-world problems in our community, they flourished in being able to do that, but also addressing the 21<sup>st</sup> century skills, ....the project-based learning activity allowed them to cover large areas of curriculum through the one project.... I'm a huge advocate for (this)...it really does break down the siloed learning...."*

### ***Student reflections on the competition***

The students' reflections on the competition were somewhat similar to the teachers' reflections and covered the following aspects: challenging but at the same time engaging and interesting, they were happy to be able to choose a topic that they were interested in which allowed them to be creative and at the same time there were no set answers to problems that they were trying to solve. Interestingly they were happy to be challenged to think about the problems that they posed. The student reflections on the activity included the following students' own words.

Male 1 (Year 10): *"The National Poster Competition challenged us to think of a unique idea....I happened to be having a conversation with my friend about watering plants with milk, and it kind of went into the poster (concept)"*.

Male 2 (Year 10): *"Statistics is very helpful to know what the population needs ...it's helpful for what humanity needs for the future."*

Female 1 (Year 7): *"It gives you a chance to do what you're interested in instead of doing set work that you may find boring and may not want to complete...It gives you a chance to do something you're interested in while still learning at the same time."*

Male 3 (Year 7): *"It's really interesting as it's not something we usually get to do. ... It was more interesting and engaging...doing what our ideas are rather than having a set basis of what we have to do...it's a really good opportunity."*

Female 2 (Year 7): *"You can be as creative as you want, and pretty much can choose your own topic, for example I like music and how sometimes it affects how you feel. ...I find it amazing that you can just be who you are...I find I'm enjoying it, I've never actually had an opportunity to do something like this before. Doing something that's national is just amazing."*

## **RESULTS**

A pilot was run for secondary schools in 2014 in the Hunter region resulting in 85 students submitting 32 posters (teams). In 2015, the competition was national with 235 students in 76 teams across six of the eight Australian states and territories. In 2016, the competition expanded further, upon request, to include primary schools. With the increasing secondary schools' participation, 828 students submitted 293 entries. Based on the annual increase in participation, both the number of schools and the number of students, and the feedback offered to us, the competition appears to be valued by teachers and students.

Whilst it would be natural to assume a statistics competition would flourish within the mathematics discipline, and it has, the success of the competition is such that the majority of teams are from classes other than mathematics. The winner of the senior division in the pilot year (2014) was a team of three female students from a school’s debating team. Their project focussed on testing how well represented ethnic groups were in television advertisements compared with the population proportions of such groups in Australia (Figure 1). Considering Australian multicultural society, this is an important question to tackle. Further, the winner of the junior division in the pilot year (2014) went on to win the ISLP in 2015; they were from a science class and assessed the effects of various liquids on the deterioration of teeth (Figure 2).

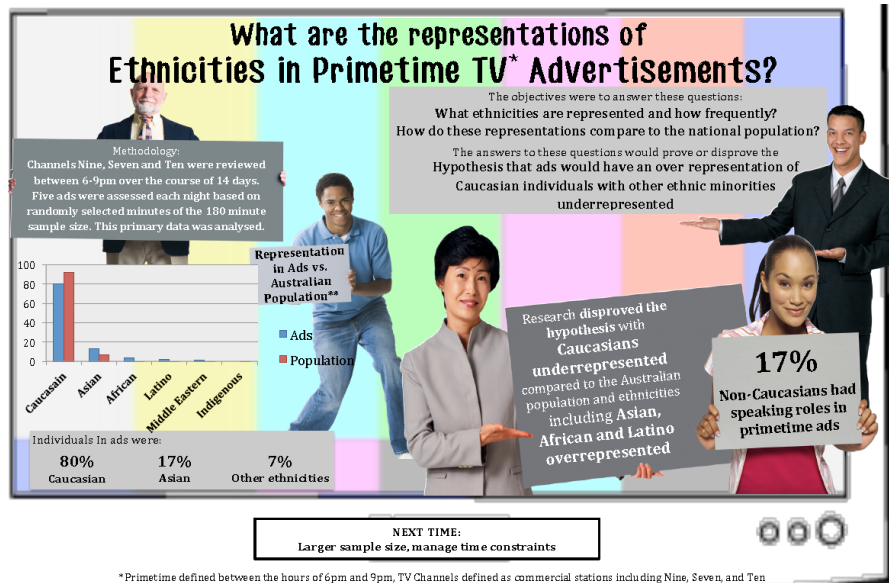


Figure 1: Poster of team of females who won the senior division of the pilot competition (see full poster at <https://www.ssaipostercomp.info/winners2014.html>)

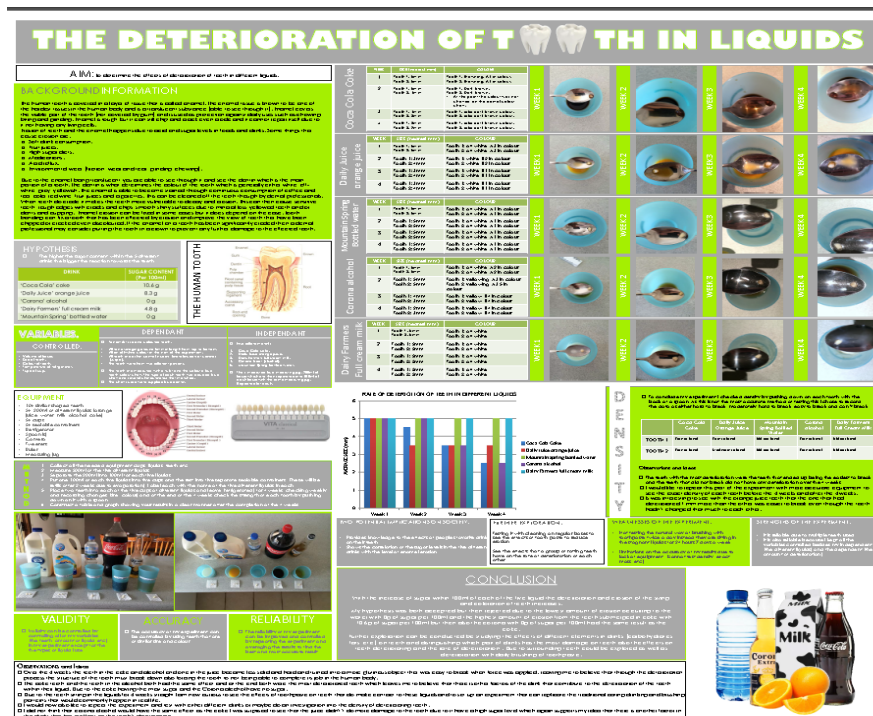


Figure 2: Poster of team of 2 females and 1 male who won the junior division of the pilot competition and the junior division of the international leg of the competition (see full poster at [http://iase-web.org/islp/documents/posterwinners2015/1\\_Australia\\_Poster.pdf](http://iase-web.org/islp/documents/posterwinners2015/1_Australia_Poster.pdf))

The Index of Community Socio-Educational Advantage (ICSEA) is a national measure for schools which provides an indication of the socio-educational backgrounds of students. It combines student factors such as parents' occupation and education, and school factors such as the geographical location and the proportion of Indigenous students. Twenty-four percent of schools registered in the competition had an ICSEA below the average score. About half of these were between one-half and one standard deviation below the average. The ICSEA of the 2014 winning school was average.

## **DISCUSSIONS AND CONCLUSION**

The reflections from mentors, teachers and students clearly identify the void in education that was once there, and how the national competition is filling this omission and taken all in its wake. The value in this endeavor and the enrichment it brings in a discipline that traditionally is not well-received are evident from: the increasing number of annual participants; the request from primary schools to be involved upon hearing of the competition for secondary schools; and the increasing support of mentors as well as sponsors.

In simple terms, such national initiatives and their potential for longevity are like small businesses. Initiatives like these require devotion, of either a team or an individual, and there needs to be development and enthusiasm to sustain the momentum. Some key elements in the success of this project included identification and/or specification of a) the audience (or customers), and a void to be filled; b) clear value-add for customers engaging with the activity; c) methods to build momentum and growth – know your goal, have a plan to achieve and continue to show evidence of successes. Such methods included the focus on group gain (for students, teachers, mentors, coordinators, society, etc), and a strategy of collaboration and cross-promotion. This involved tapping into existing national and state networks and cross-promoting, and establishing additional key advocates to help spread the word (teachers, those in leadership roles for teaching community). Building a team of like-minded people (whether as sounding boards, to assist with promotion, or for IT support) was also important. Similar success factors are identified by Macfeely et al (2017) for the ISLP competition. Having a systems approach, and supporting mechanisms is also important since a chain is only as strong as its weakest link. An holistic approach was invoked based around systems thinking and total quality management (TQM). For example, relying on teachers alone is fraught, so a system to support them is required - this included both mentors and resources.

Sponsorship or funding that may support the key elements is invaluable. Like any small business, an initial investment of time and financial support, and ongoing support and energies focussed on the desired outcome is required. For the Australian schools' poster competition, the initial financial support was provided by the Statistical Society of Australia, after a 'business plan' was submitted. Since then, multiple sponsors have helped to sustain and grow the activity. It should be noted that funds without engagement of the teachers and students would not have been enough to produce the outcomes the competition has achieved.

Underpinning the framework for success was the Plan-Do-Check-Act cycle of improvement, and this included the key element of pilot testing, as well as growing commitment of the mentors and of course assessors of the submitted posters. In short, as a statistician and educator of TQM, it was a matter of practice what we preach.

So, where to from here? It's pleasing to report that the national poster competition is teaming up with another successful school initiative, the electric vehicle challenge, to bring statistics and sustainability to students in remote and rural regions thanks to funding from the national Department of Education and Training. Utilising mini-electric vehicle (EV) kits, which have multiple factors that influence their speed, students will be encouraged to build their own mini-EV and test it against the designs of their fellow students, simultaneously testing the factors that influence its speed, and ultimately developing a study to report upon as their submission to the national statistics poster competition. Such activities will be complemented by additional topics surrounding sustainability, as well as the many more that students devise themselves! As part of this initiative, one of the authors will be visiting schools across three remotely located towns in his home state, locations with high proportions of schools in low SES areas, and with disproportionately high numbers of indigenous students.

We look forward to further data building upon this short reflective paper. Formal evaluations are in construction, to assess the impact of the competition on students' statistical anxiety and future

study choices (whether they choose to study further mathematics and/or STEM subjects), as well as teachers' knowledge about, and confidence in teaching statistics. In light of the positive feedback received, these are important areas to pursue. The studies together will inform aspects of the total impact of the competition and its contribution to statistical education and the growth of future generations.

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