

## ENGAGING AND MOTIVATING STUDENTS WITH AUTHENTIC STATISTICAL PROJECTS IN A CAPSTONE UNIT

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*Students preparing for professional statistical work can benefit from experience with real statistical problems presented by real clients and requiring them to engage with the complete problem-solving process without the usual cues of 'textbook' examples. We have used such an approach in a capstone unit in statistical consulting, asking students to write about their learning experiences and to reflect on the ways in which such consultations helped them (or not) to develop their professional statistical skills. A content analysis of students' comments focusing on engagement and motivation confirmed that students had generally positive views of their experience and found the approach engaging and motivating. On this basis, we recommend utilising real problems from real clients as a means of including authentic practice in a professional statistics degree, with consequent benefits for students' engagement and motivation.*

### INTRODUCTION – A CAPSTONE STATISTICAL CONSULTING UNIT

During the Australian Association of Mathematics Teachers Conference, in Canberra in December 2014, the Chief Scientist of Australia, Prof Ian Chubb, related that when he was young, the mention of being a mathematician or loving mathematics left him alone in any in social situation! Mentioning a love of statistics would have created a similar effect, as statistics is associated with mathematics in many people's minds. One of the authors experienced a similar scenario during her introductory talk to Bachelor of Social Science students, as she was encouraging them to choose a statistics major. When she asked "who loves statistics?", only a single hand was raised from the groups of over 150 students, with most of the rest trying to look the other way. Statistics as a discipline does not usually generate high levels of engagement and motivation among students generally, nor even among students studying statistics.

When we were designing our capstone unit for the statistics major (Bilgin *et al.*, 2011), we aimed to give our students opportunity to confidently apply their statistical knowledge and skills to authentic professional problems. We created a curriculum where they could expand their communication skills, increase their confidence to continue learning, and develop their professional and personal identity as statisticians. Our previous investigations have shown that our students recognise these as key aspects of the unit (Bilgin & Petocz, 2013).

Our students come from mixed mathematical backgrounds. The actuarial students are able mathematicians wishing to add a second major in statistics, while the science/business students are not so strong mathematically, but have more experience with applied statistics. Generally, none of them has had authentic experience of the messy nature of real statistics problems presented by real clients who may not always give clear descriptions of their research aims. Like all teachers, we aimed to engage this diverse group of students and motivate them to do their best in this statistical consulting unit; in this aim we used a variety of approaches.

Firstly, we share our own experiences of statistical consulting with them, formally, as the topic of the first class, and then informally throughout the course. Secondly, we bring guests into our classes. Several times, guest researchers present real problems and ask the students for comments and advice in solving them; this allows students to practice clarifying a problem and explaining a solution. Other guests have statistical consulting experience, and they share this with the class, highlighting the 'human' aspects of consultancy. Students work in groups during the semester on larger consultancy projects, taking responsibility for the complete consultancy from start to finish (though lecturers are available for discussion if needed). The reports of these projects are used instead of examinations for final assessment. Such group project work in statistics has been shown to increase engagement (Sisto & Petocz, 2012). The curriculum is arranged to encourage students to develop their 'soft skills' and technical competence, and to use the support of their peers and lecturers to develop their expertise in the consulting process.

## PSYCHOLOGY OF ENGAGEMENT AND MOTIVATION

Deci and Ryan's (1985, 2008) *Self-Determination Theory* (SDT) provides a useful framework for understanding the psychology of engagement. This has much to do with its account of *intrinsic* motivation, defined as the doing of an activity for no reason other than the rewards in the activity itself (Deci & Ryan, 1985; Ryan & Deci, 2000). As these rewards include enjoyment, interest, challenge and the satisfaction of curiosity, it is understandable that intrinsic motivation is often taken to be the paradigm of student engagement (Russell & Slater, 2011; Valerio, 2012). Certainly, the task of promoting student engagement would be straightforward if the majority of students were intrinsically motivated. However, consistent with "the largely instrumental function universities are seen to have within contemporary societies" (Dall'Alba & Barnacle 2007, p. 680), most students seem to show an *extrinsic* motivation. Whereas the activity is an 'end in itself' for the intrinsically motivated, it is a 'means to an end' for the extrinsically motivated; as Deci (1998, p. 147) puts it, extrinsic motivation is "doing something for a separable consequence" such as a material reward or approval. Extrinsic motivation is commonly viewed as a "pale and impoverished" form of motivation (Ryan & Deci 2000, p. 55). If this view were true, the prospects for promoting student engagement would be bleak. But extrinsic motivation is not necessarily 'pale and impoverished'; as SDT shows, it ranges from relatively immature states characterised by a feeling of being controlled to more mature states characterised by autonomy and authenticity. Examination of the types of extrinsic motivation provides valuable insights into the psychology of engagement and its promotion in contemporary universities.

According to SDT, four types of extrinsic motivation can be identified. Two of these – *external regulation* and *introjected regulation* – are classed as 'controlled', for in both cases the person feels that his/her behaviour is controlled by social forces (or 'regulations'). In external regulation, behaviour is performed to obtain a reward or to avoid punishment. In introjected regulation, the social authority who rewards and punishes has been internalised such that it assumes an independent existence in the psyche. As a result, behaviour is performed out of a sense of obligation, i.e., to avoid guilt and anxiety, or to live-up to some ideal standard. The other types of extrinsic motivation – *identified regulation* and *integrated regulation* – are classed as 'autonomous', since the behaviour is performed with a full sense of personal agency and is thereby authentic (Ryan & Deci, 2006). In identified regulation, the relevant social requirement has been fully internalised because the person has identified with the personal importance of the behaviour. In integrated regulation, identifications are brought into congruence with other aspects of the self, such as other values, goals, and needs.

Clearly, different forms of extrinsic motivation involve different levels of engagement. While students possessing 'controlled' forms of extrinsic motivation could display the behavioural markers of engagement (e.g., attend classes, submit work), they would be deficient with respect to emotional and cognitive indicators of engagement (Newbery, 2012). A high level of engagement – characterised by emotional and cognitive as well as behavioural indicators – will be exhibited by extrinsically motivated students only if they have a sense of autonomy. The crucial applied question, then, is how to cultivate this sense of autonomy.

Ryan and Deci (2000, p. 64) state that for a person to fully internalise a regulation and become autonomous with respect to it, he/she "must inwardly grasp its meaning and worth". This is consistent with the widely accepted notion that student motivation and engagement can be promoted by providing tasks that are personally meaningful to students (Pintrich, 2003; Saeed & Zyngier, 2012). As most students view study as a 'means to an end', an academic task will be personally meaningful to them if they can see that it is relevant to their particular 'end', typically, their future employment. The applied implication is clear: student motivation and engagement can be promoted by designing the academic task such that students can see its relevance to their vocational aspirations. However, getting students to see the real-world significance of an academic task is no easy matter. As Deci and Ryan (1985) point out, people whose extrinsic motivation is 'controlled' have a strong tendency to perceive events as controlling, even if they are not. Hence, presenting exercises based on real life cases and/or explaining their vocational relevance to students may not be enough. To ensure that students transcend the tendency to feel 'caged' by an external authority, it is necessary to throw them into a state of autonomy by providing learning experiences so authentic that the 'means/end gap' is effectively closed.

## RESEARCH METHOD

As an important part of the assessment for this unit, students were asked at several points to write reflections about their experiences during the process of carrying out statistical consulting projects. They wrote about various aspects: how their team carried out their joint work and what specific role they played in their team, how they interacted with their clients, the best and worst features of their consulting projects, what they had learned from their experiences and how they might do things differently in future projects. Such self-assessment has been shown to be an important component of successful learning at all levels, but particularly in tertiary courses and in further lifelong learning (Boud, 1995); specific examples in the area of statistics assessment are given in Petocz and Reid (2007).

For our analysis, we only used the reflections of those students who gave us written permission to do so (19 of 28 students). Using this corpus of written material, we carried out a content analysis focusing specifically on engagement and motivation. Such analysis of themes is a basic form of qualitative analysis (Boyatzis, 1998), aiming to identify common ideas from the shared emphases and concerns put forward by the students, and to use these common ideas for continued investigation of the materials. Two of the authors (AB and PP) read through the complete body of text independently and identified and clarified themes relating to engagement and motivation. The third author (GN) read through the themes and their supporting comments and added commentary from the psychological viewpoint. These themes are the subject of the following section. Supporting quotes are labelled with pseudonyms, and the writing is as the students presented it, with ellipses (...) to indicate left out sections of a quotation.

## RESULTS ON ENGAGEMENT AND MOTIVATION

We identified three distinct themes concerning engagement and motivation from our investigation of students' reflections. These themes can be described as: working on 1) authentic tasks increases employability, 2) real problems for real people is personally meaningful, and 3) diverse problems with varied clients develops resilience. We will take each of these themes in turn, expand on its description and adduce several quotes from our students.

### *Theme 1: Working on authentic tasks increases employability*

The first theme is the motivation to do well in this unit in order to gain career or professional experience to 'stand out from the crowd' of other graduates when applying for a job. This is an ever-present concern for students as they are moving towards the conclusion of their degrees. The quotes below expand on the idea; Jo describes her aim in this respect at the beginning of the course, while Lee and Karen reflect on their experience.

*Jo: I expect to put the skills that I have learned in the classroom to the test in the workplace environment of statistical consulting. This is an area where other units fail to help graduates develop the necessary soft skills to jump right into the workforce upon graduation. I expect to be at an advantage in the workforce over other students who have not participated in a similar unit.*

*Lee: After this project, I realised that I am far, far away from being a statistical consulting [consultant]. It requires a lot of skills when working with different cases (from what I have seen in the others' projects, each of us used a completely different method to analysis the data and some of the methods I have never seen before), as well as excellent communication skills when interacting with our clients. This 'gap' that I have will not stop me from learning statistical consulting, but in fact it is a motivation for me.*

*Karen: There is nothing like real world experience, and to get that before you actually move from university into the real world real is invaluable. The insight that you get and the skills that this insight subsequently allows you to build and develop are the ones that will be most sought after not only by employers but also when clients are sounding out potential consultants. Thus by doing this course you will be one step ahead of the rest, which can only be a good thing.*

### *Theme 2: Working on real problems for real people is personally meaningful*

This theme is central to students' personal development as professionals in the field of statistics. Working with real clients on real projects increases students' motivation since, maybe

for the first time in their university studies, their efforts have real meaning and importance for other people. It is not only that the consulting projects are authentic tasks, but their solution may be important for clients' work or business. Students made many comments along these lines:

Alex: *I believe working with real clients definitely increased the seriousness of the work. Rather than just being a made up question for grading purposes, knowing that my work is actually going to be used by someone is a joyful feeling.*

Jackson: *The aspect I enjoyed most about working with real clients was that it gives the analysis more importance and adds greater meaning. Working with real clients made me feel that I was helping people to create better business processes.*

Jo: *One of the best aspects of my project would be the sense of worth knowing that the client appreciates my work and that it will in fact impact the lives of many. I feel that this was a driver and motivator throughout the duration of the project.*

Such work with real clients also increases students' confidence in their abilities as statistical problem solvers and provides a definite motivation for continued engagement.

Hannah: *Having put your own mark on something is something of an achievement and encouragement. The pressure of needing to 'do good' ... It is the only stats subject that gives you real experience of being a statistician.*

James: *I am convinced that I gained a great education so far but I always missed the 'big picture' of statistics. ... Working in this project, thinking of possible solutions and combining contents of several statistical areas by myself helped me a lot with that and made me feel a little bit more confident.*

Sylvia: *It was difficult and daunting at first, however after receiving positive feedback and appreciation from the client for our hard work, it was definitely satisfying and a confidence booster.*

### *Theme 3: Working on diverse problems with varied clients develops resilience*

The third theme is interesting because it can initially be considered as a negative aspect, but at the same time it keeps students motivated to do their best. There were various problems that students had to face during their consultations. Some students were worried because the problem presented to them by their clients was either too easy – and so they could not apply the sophisticated analysis that they had learnt – or too complex – so they did not know the required techniques. Others were disappointed when the data they received were in a poor condition and required extensive preparation for analysis. Yet despite this, students remained focused and engaged with the projects. The difficulties helped them develop professional resilience as they acquired new techniques, or sought new ideas from their peers and lecturers.

The following quotes give some idea of this process. Steve identifies a difficulty with real problems, Nicola highlights the learning from facing up to data problems, and Edward extends his experience to the qualitative aspects of data analysis.

Steve: *I really like how we get to apply what we have learned from books to real world problems. However the real world problems are complex which I did not like. They are different from what I have seen in the textbooks or exams; there seems no one correct answer.*

Nicola: *A theoretical study of statistics did not prepare me to fully grasp the importance of 'clean' data. While I knew that having 'good' data was important to any statistical analysis, I did not fully appreciate the effects of 'bad' data on statistical analysis until I actually got the opportunity to run these analyses myself.*

Edward: *Dealing with the several open-response questions – which was something I've never had experience in dealing with. We obviously didn't want to ignore these as they may provide meaningful information. After consulting our lecturer about this, we managed to form themes in order to categorise these into groups.*

A final problem, but also an opportunity for professional learning, was some clients' lack of statistical or research knowledge, requiring students to write their explanations in simple, jargon-free language, or even in some cases to formulate the client's problem.

Jun: *It really makes me to think about how I can do better and how will the client be impressed. It is like a motivation to my learning.*

Hugo: *It was a thoughtful realisation to me that devoting countless hours learning complex statistical theory and techniques, amount to devastatingly little if one has not developed and practised the talent of explaining findings to the statistically uninitiated, who will not know or care about the technicalities of a result.*

## DISCUSSION AND PEDAGOGICAL IMPLICATIONS

The students' reflections on their experiences of statistical consulting projects corroborate the theory of motivation and engagement outlined earlier. Working on "real problems for real people" was personally meaningful for students and transformed their motivation from more controlled to more autonomous states. Their quotes indicate that they experienced an increased sense of autonomy from working on authentic professional problems. This increase in autonomy appears, in turn, to have promoted a higher level of engagement – one characterised not just by behavioural indicators, but also by emotional indicators (such as Alex's "joyful feeling" to know that his work will actually be used) and cognitive indicators (such as Jun's statement that a real project "really makes me to think about how I can do better").

In addition to supporting the theory of motivation and engagement, these students' reflections shed further light on why they found the authentic professional problems to be "personally meaningful". Many quotes point to how working with "real clients ... increased the seriousness of the work" (Alex) and "adds greater meaning" (Jackson) to the task. One factor that contributes to the motivational salience of working with real clients is referred to explicitly. Clients provide students with informational feedback that increases their sense of competence: Sylvia states that "receiving positive feedback and appreciation from the client ... was definitely satisfying and a confidence booster", and Jo believes that "one of the best aspects of my project would be the sense of worth knowing that the client appreciates my work".

Another factor implicit in the quotes is that helping real clients to solve real statistical problems is especially motivating for the students because it puts them in the kind of mature role to which they aspire; that is, students assume the role of a 'parent figure' whose job is to 'look after' a dependent other – a role reversal from their usual formal learning context. In view of this change in the underlying psychological dynamic, it is only natural that students should find working with a real client to be "difficult and daunting at first" (as Sylvia says). Authentic learning experiences do more than just open the cage for students; they throw them out of the nest! Closing the perceived 'means/end gap' in this way may shock some students into the realisation that they are not quite ready to assume the professional roles to which they aspire; but it appears that such a shock can be so motivational that students come to see even the means to their end as personally meaningful. As Lee says: "After this project, I realised that I am far, far away from being a statistical consultant ... This 'gap' that I have will not stop me from learning statistical consulting, but in fact it is a motivation for me."

On the basis of these results, we suggest that the approach of working with real data, real problems and real clients forms an essential part of a professional statistics degree, with consequent benefits for students' engagement and motivation. Such 'authentic education' can augment, or even replace, the traditional approach of presenting theory supported by tailored examples and exercises. It is true that the level of authenticity that can be included will depend on students' preparedness and maturity to deal with real problems and contexts. It seems important to scaffold students' learning and to build their confidence throughout their studies by presenting examples from lecturers' current research and providing opportunities to discuss real statistical problems verbally or as assessment tasks. This would be valuable preparation for a capstone unit where students could experience the process of becoming and being a statistician while they are still at university (Petocz & Reid, 2010).

We leave the last word to one of our students, Karen, who speaks eloquently of the benefits of authentic statistical work and the development of an autonomous professional stance. Her statement is strong evidence in favour of this pedagogical approach.

Karen: *I think the best part was being able to work with a real client as it finally enabled me to be able to work with real data, rather than having to play with fake datasets that had been created purely to produce results that worked well with the theory it was explaining. These datasets also never had problems commonly associated with real-life datasets such as missing or*

*inadequate data so this dataset was a real eye-opener and was probably one of the best things about the project. I also enjoyed the practicality of working with a real client and the responsibilities that it burdens you with. Most of your university life you are put in a cage as such and have no real freedom or are told what to do, but when you get to work with a real world client it opens up so many possibilities and there are so many directions you can head with them and their data. As such I would say that this was another aspect that helped to further my learning and something I couldn't have gained from sitting in a classroom.*

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