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Monitoring surveying students' environmental attitudes as they experience higher education in New Zealand

Mick Strack *, Kerry Shephard, Tim Jowett, Samantha Mogford, Sheila Skeaff and Miranda Mirosa

We investigate the environmental attitudes (EA) of New Zealand's land surveying students and how they change during a four-year programme. We implemented a multi-cohort survey and developed a longitudinal statistical model of change. Findings suggest that although the EA scores of groups of students vary at different times within and between cohorts, there are no significant general trends when genders are combined. But females tend to start their studies with higher mean EA scores than males and this difference declines overtime. This occurs consistently across the four cohorts studied. This is discussed in relation to women's role within the profession.

Keywords: Surveying education, Education for sustainable development, Environmental attitudes, Student learning, Learning and teaching, Gender differences

Introduction

New Zealand land surveyors have had an ambiguous role in relation to sustainability and related environmental issues. Historically surveyors may have been regarded as guardians of the environment (Smith 1916) as exemplified by their roles in exploring and recognising that importance of setting-aside land for conservation. But surveyors also exist in a tradition of exploitation particularly in the New Zealand context of colonisation; at the forefront of Māori land takings, parcelling up land as property, bush clearing and establishing pastoral and agricultural holdings. Land surveyors no doubt have close links to the land and may have an intuitive awareness of landscape and the functioning of ecological systems but it is not clear, in a New Zealand context if they have been proactive leaders for sustainability and environmental protection.

The imperative for land professionals to have a well-developed environmental awareness and to take leadership in issues around maintaining environmental health or restoring environmental degradation is clearly stated in many environmental codes of ethics and conduct. Many of these were elaborated in a previous article reporting on this research project (Strack *et al.* 2013). The New Zealand Institute of Surveyors (NZIS) released its environment policy in 1993 (NZIS 2005) which seeks to ensure that 'an environmentally sound approach is used in all aspects of professional practice as far as it is practicable.' The policy had specific links to surveying education in New Zealand and specifically required that 'survey education programs include measures to enhance the environmental awareness and understanding of all participants' (NZIS 2005). The ethos of this early aspirational guidance has had an impact on the New Zealand School of Surveying and there is a strand of environmental thinking incorporated throughout all papers of the BSurv degree at the University of Otago. Similarly, the International Federation of Surveyors (FIG) provides strong guidance on these issues. For example in 1991 it issued 'Sustainable Development – A challenge and responsibility for surveyors' to guide the environmental stance of surveyors, including to '[p]rovide opportunities for expanding the education of the professional surveyor to include understanding of and solution to environmental problems' (FIG 1991). Furthermore, at an institutional level, the University of Otago has adopted 'environmental literacy' as an attribute to be fostered in all degree programmes and recently has committed to an institution-wide sustainability framework (University of Otago 2017) which includes key strategies such as to 'develop ways to integrate sustainability into teaching and learning practices' and 'increase sustainability literacy among all students' (2017, p. 11).

Translating these aspirations into student learning is, however, proving challenging internationally, not only within surveying departments, but within higher education more generally. The broad field of academic enquiry known as education for sustainable development identifies a range of substantial barriers to achieving its objectives. Higher education institutions, for example, although often and collectively agreeing to 'Educate for Environmentally Responsible Citizenship' (Association of University Leaders for a Sustainable Future 1994) struggle to demonstrate their success in doing so (Barth 2015, Shephard 2015). University teachers in our universities have variable dispositions to contribute to sustainability education (Shephard and Furnari 2013) and the

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field is struggling to identify precisely what objectives can be reasonably translated into learning outcomes (Wiek *et al.* 2011). For surveying, in particular, research by Dent and Dalton (2010) identified limited engagement with sustainability issues in UK surveying departments, perhaps indicative of a fundamental disconnect between what students come to surveying for, and what employers want from graduates, and the needs of the sustainability movement. A large part of the work of a professional surveyor is land development, infrastructure engineering, monitoring construction and mining, and site works and position fixing for extractive industries; all with a strong economic-development focus, and not naturally recognising the rights of nature and the aspirations of environmental activists. On the other hand, Otago's surveying programme is explicit about cultural awareness (for example, in recognising the history of New Zealand land transactions and the indigenous Māori relationship with land and resources), about environmental and planning legislation and practice (for example understanding the environmental impact of land development, and application of the Resource Management Act whose purpose is the 'sustainable management of natural and physical resources'), and about ethical practices. Surveying educators are clearly interested in these broad, and often conflicting, objectives and in their outcomes as represented by student learning.

Although the sustainability-related outcomes most sought by educators, and perhaps by employers, are behaviours and the choices that graduates will make when they enter the profession, these are difficult for educators to assess, evaluate or otherwise assure. Considerable research has therefore converged around the use of attitude surveys that, when applied in anonymous situations, may provide at least some measure of our students' environmental and sustainability concerns and some estimation of the kinds of choices that they may make as professionals. The Revised New Ecological Paradigm scale (NEP) is widely used internationally for this purpose and our research has identified a valid longitudinal approach to its use to monitor changes (Shephard *et al.* 2015b). Since 2007 our research group has been exploring how our students' environmental attitudes (EA) (or ecological worldviews) vary depending on their chosen degree programme, gender and age; and since 2010, how their environmental worldview changes as they experience higher education with us (Harraway *et al.* 2012, Strack *et al.* 2013, Jowett *et al.* 2014, Shephard *et al.* 2015a, 2015b).

The NEP questionnaire was administered in classes where the researcher had a teaching role, but where the curriculum was not necessarily (and not specifically) related to environmental issues. However the sensibilities of the lecturer were sometimes placed at the core of class discussions and their behaviour was on view. In terms of Education for Sustainability pedagogy, Christie *et al.* (2013, p. 390) describe the teacher modelling good practice as a valid alternative approach to reinforcing EA. There was an effort to describe the research as an independent concern of the lecturer, and in no way connected to any knowledge expectations or assessments of the students. The results of the questionnaire are, therefore, not intended to assess the quality or relevance of the teaching or the course content to environmentalism, but rather a snapshot (or rather a panorama over several years) of student attitudes. Other studies (e.g. Kuo and Jackson 2014) have used the NEP to assess the effectiveness of environmental studies courses.

Overall we have identified substantial and relatively stable differences in the worldview of groups of students who have chosen different degree programmes within our institution (surveying students frequently demonstrating lower environmental worldview ranges than all other groups researched in our institution, Strack *et al.* 2013), no apparent trend or averaged change in environmental worldview over the years in which students stay with us (Shephard *et al.* 2015b) and the general tendency for females to be more pro-environmental than males, as widely reported elsewhere within the literature (Zelezny *et al.* 2000, Kuo and Jackson 2014). Kuo and Jackson identified two factors about comparisons of student environmental awareness. First, 'females are likely to possess a more pro-EA compared to males' and second 'students majoring in natural science disciplines such as biology and forestry tend to possess more positive environmental attitudes compared to students majoring in engineering, mathematics, or business' (Kuo and Jackson 2014, p. 92). To some extent both these factors come together in surveying courses – a strong focus on mathematics and technology and a relatively small cohort of female students.

The research described here builds on previously published research to incorporate a multi-cohort analysis of the EA of four cohorts of surveying students in our institution and from this data develops a longitudinal statistical model of the change that students achieve within their four-year programme of study. The research identifies, in particular, differences in how female and male students change and we discuss the relevance of these findings to the aspirations of surveying departments internationally to increase the proportion of females in the profession.

Methods

Students enrolled in papers (courses) at 100, 200, 300 and 400 level for the four cohorts starting 2009, 2010, 2011 and 2013 voluntarily participated in the research described in this paper and completed the 15-item NEP [Revised NEP (Dunlap *et al.* 2000) summarised in Table 1] at three points of time in their four-year programme. Students were asked to rate the level of agreement for each NEP statement on a 5-point Likert-like scale and to provide, on the survey form, some additional socio-demographic information to aid the analysis (year of study, gender and self-reported programme affiliations). The project was entirely voluntary and anonymous in accordance with a University of Otago ethical research approval. Students adopted a code (variously based on their date and place of birth) that allowed them to remain anonymous within the research but enabled the researchers to match the time-sequenced data.

For most students involved in this study, the data from the first year of study was obtained from a single semester introductory statistics paper in 2009, 2010 and 2011. Subsequent data was collected from students studying surveying papers at 200–400 levels during 2010–2016, omitting the year 2013. All NEP surveys were conducted using paper forms handed out towards the end of lectures. In all cases, the response rate (the proportion of students

Table 1 The 15 item revised NEP scale

1. We are approaching the limit of the number of people the earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will ensure that we do not make the earth unliveable.
5. Humans are severely abusing the environment.
6. The earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite their special abilities humans are still subject to the laws of nature.
10. The so-called ecological crisis' facing humankind has been greatly exaggerated.
11. The earth is like a spaceship with very limited room and resources.
12. Humans are meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course we will soon experience a major ecological catastrophe.

who attended the lecture where the NEP was made available, who completed the NEP survey) was very high, in the order of 95–100%. The outcome variable for both analyses was the mean NEP score for each student across the 15 NEP statements given in Table 1.

Description of the data used for longitudinal modelling

NEP data were analysed as mean NEP score for individuals and for groups as described previously (Harraway *et al.* 2012). The data from the surveying students' papers were matched into cohorts to allow for the longitudinal analysis of each student's mean NEP score. Table 2 shows the sampling schedule for the longitudinal analysis on the four cohorts of students who started studying for their surveying degree in 2009 (Cohort 'S2'), 2010 (Cohort 'S3'), 2011 (Cohort 'S4') and 2013 (Cohort 'S5'). Because the NEP survey was administered at three occasions for each cohort of students, some students took the survey on three occasions but some on fewer occasions as their absences from some lectures caused them to miss some opportunities. Statistics relating to the rate of repeated sampling is also shown in Table 2. As the NEP was not used in all papers in all years, we have used cohorts where three samples are available for analysis. Table 3 describes the data by cohort and gender.

Results

Individual and cohort mean scores

Figure 1 plots the students' mean NEP scores over weeks since the start of the semester when they entered the study. Matching of NEP scores from repeated surveys on individual students is represented by connecting lines. Although there are some substantial individual changes over time, the mean NEP scores for Cohorts S2, S3 and S4 appear to remain somewhat constant over time. In contrast, the initial time interval for Cohort S5 exhibits a relatively steep positive trend in mean NEP score over time.

Two analyses of this data were undertaken: an independent sample comparison of means using an analysis of variance (ANOVA) (assuming independent observations) and a longitudinal analysis using a linear mixed-effects model.

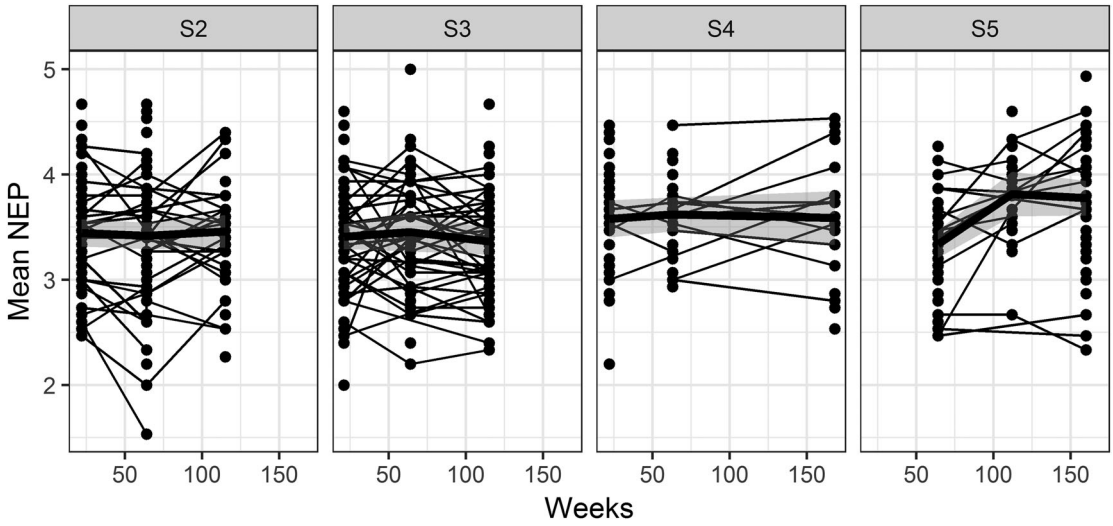
Table 3 Survey data by cohort and gender

	Cohort S2	Cohort S3	Cohort S4	Cohort S5
Females (%)	8.3	17.9	25.3	17.5
Males (%)	91.7	82.1	74.7	82.5

Table 2 Longitudinal sampling details

Cohort	% of students with repeated NEP surveys	Paper	Year	Semester	Weeks since start of study	N
S2	1: 71	STAT115	2009	2	22	70
	2: 23	SURV206	2010	1	64	83
	3: 6	SURV306	2011	1	115	40
						Total: 193
S3	1: 60	STAT115	2010	2	21	77
	2: 22	SURV206	2011	1	64	42
	3: 18	SURV305	2012	1	115	60
						Total: 179
S4	1: 79	STAT115	2011	2	22	39
	2: 17	SURV206	2012	1	63	27
	3: 4	SURV455	2014	1	168	23
						Total: 89
S5	1: 81	SURV206	2014	1	64	48
	2: 14	SURV305	2015	1	112	20
	3: 5	SURV454	2016	1	160	49
						Total: 117

The "N" column gives the number of completed survey forms at each occasion.



1 Individual mean NEP scores over weeks since start of study

Independent sample comparison of means

We conducted a one-way ANOVA using the Mean NEP as the outcome variable and 'Paper' as the classifying factor, to determine whether the NEP mean scores are statistically equal across all papers at the same level (Year 2, 3, 4) across years. Differences between years are of interest, as they would influence our analyses of change between years. The ANOVA identified significant differences within the SURV305 papers ($F = 12.283$, df2, $p < 0.001$) between 2012 and 2015 but not within other papers or groups of papers recorded in Table 2. For the SURV305 papers included in the cohorts recorded in Table 2, Tukey-Kramer post-hoc comparisons of means tests determined one significantly different mean between years. Pairwise comparisons determined SURV305 students during 2015 were significantly more pro-environmental (higher mean NEP scores) than the SURV305 students in 2012 (difference of means = 0.45, $p = 0.001$, CI: 0.16, 0.74). Given that the majority of NEP scores for surveying students in our research exist within the range 3–4, a significant difference in mean approaching 0.5 NEP points is of interest. In Table 2, SURV305 shows as the third time point in S3 and SURV305 is the second time point of S5; the former noticeably smaller than others and the latter noticeably larger.

For this analysis, when comparing the mean NEP scores from the same paper across cohorts, it is very unlikely that the same student will have been sampled twice. Consequently, the issue of non-independence due to repeated observations on the same student is not relevant (this issue is discussed in the longitudinal analysis section below). Other differences in means were seen in other combinations of papers within this time period, but are not reported here as they did not occur within the four cohorts reported.

Longitudinal analysis

The primary focus of the longitudinal analysis was to assess the extent to which, on average, students' NEP response change over time after commencement of their study. Because repeated responses are obtained from the same individual students over time, the repeated observations from the same student are correlated (i.e. not independent). This lack of independence violates one of the key assumptions of conventional regression analysis and as a consequence requires the use of a model that can allow for the lack of independence. Linear mixed-effects models allow for this correlation by the introduction of person-specific 'random effects' in addition to 'fixed effects'. The fixed effects are modelled by parameters that are common to all participants. It is the fixed effects that are of primary interest as these represent the effect averaged over all the participants. The fixed effects in this study were *Cohort*, *NEP Survey Occasion* and *Gender* and *the interactions between these effects.* These variables are explained in more detail in Table 4. A useful feature of studies with repeated responses over time is that each individual acts as their own 'control' which allows for a more precise estimation of 'within subject' effects like *Survey Occasion* and consequently, we are likely to identify changes in the mean NEP score over time, if they exist (Fitzmaurice *et al.* 2012). Table 3 shows that the large majority of students surveyed were male and as

Table 4 Fixed effects included in the longitudinal mixed-effects model

Fixed effect	Description
Cohort	A four level factor variable with a level allocated to each of four cohorts. Determined by the year in which a student started study for their surveying degree. Cohort S2 started study in 2009, S3 in 2010, S4 in 2011 and S5 in 2013.
Survey occasion	Given as 1, 2 or 3 representing the first, second and third time that the NEP survey was administered to each cohort. Used to measure the change in mean NEP over time. Identified in Fig. 1.
Gender	Male or female.

Table 5 ANOVA (Type III) table from the longitudinal mixed-effects model

	SumSq	MeanSq	Num. DF	Den. DF	*F*-value	Pr (>F)
Survey occasion	0.0419	0.02099	2	294.14	0.1861	0.8303
Cohort	1.07374	0.35791	3	456.14	3.1734	0.0240
Gender	0.65792	0.65792	1	377.67	5.8334	0.0161
Surv. Occasion:Cohort	2.06063	0.34344	6	323.93	3.0451	0.0065
Surv. Occasion:Gender	0.77325	0.38662	2	262.47	3.428	0.0339

such, the data could be described as being 'unbalanced'. An important advantage of linear mixed-effect models is that they can yield valid and unbiased estimates of effects even with unbalanced data.

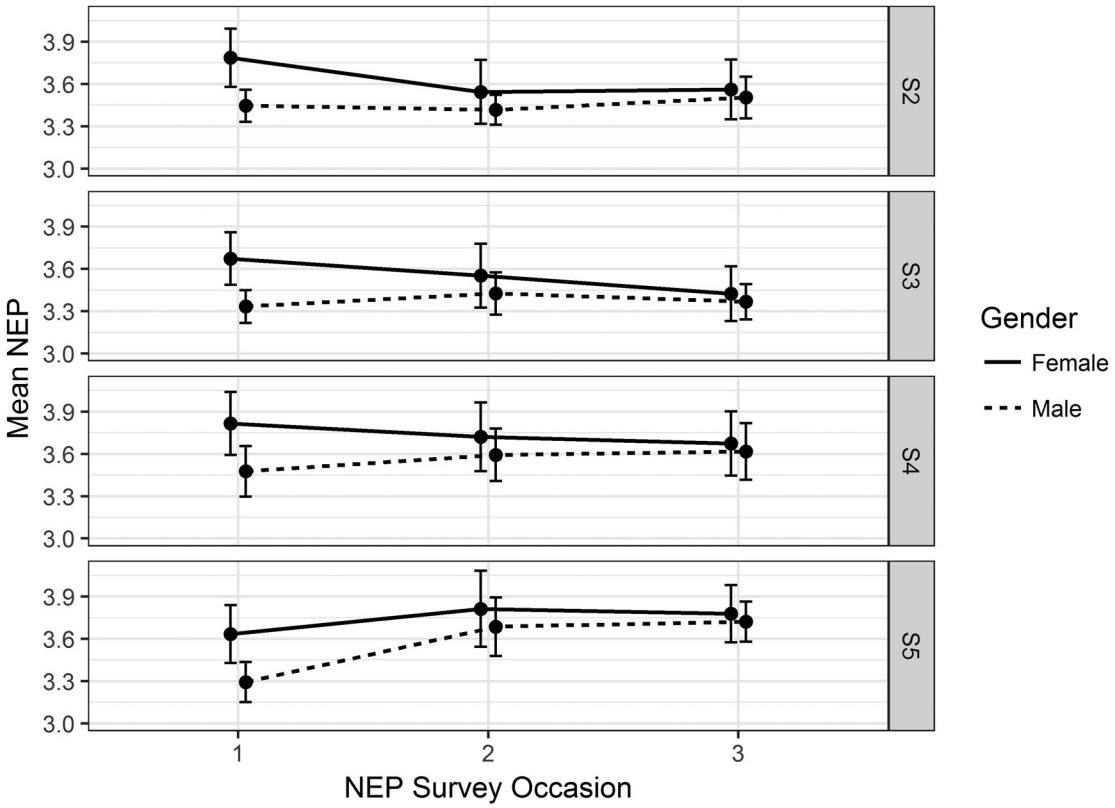
The process of model selection has been described elsewhere (Fitzmaurice *et al.* 2012, Shephard *et al.* 2015a). Using a combination of Akaike's Information Criterion and likelihood ratio testing, the random intercept model (with the main effects of *Survey Occasion*, *Cohort* and *Gender* and the interactions: *Survey Occasion: Cohort* and *Survey Occasion: Gender*) was selected as the preferred model in this study.

Longitudinal model results

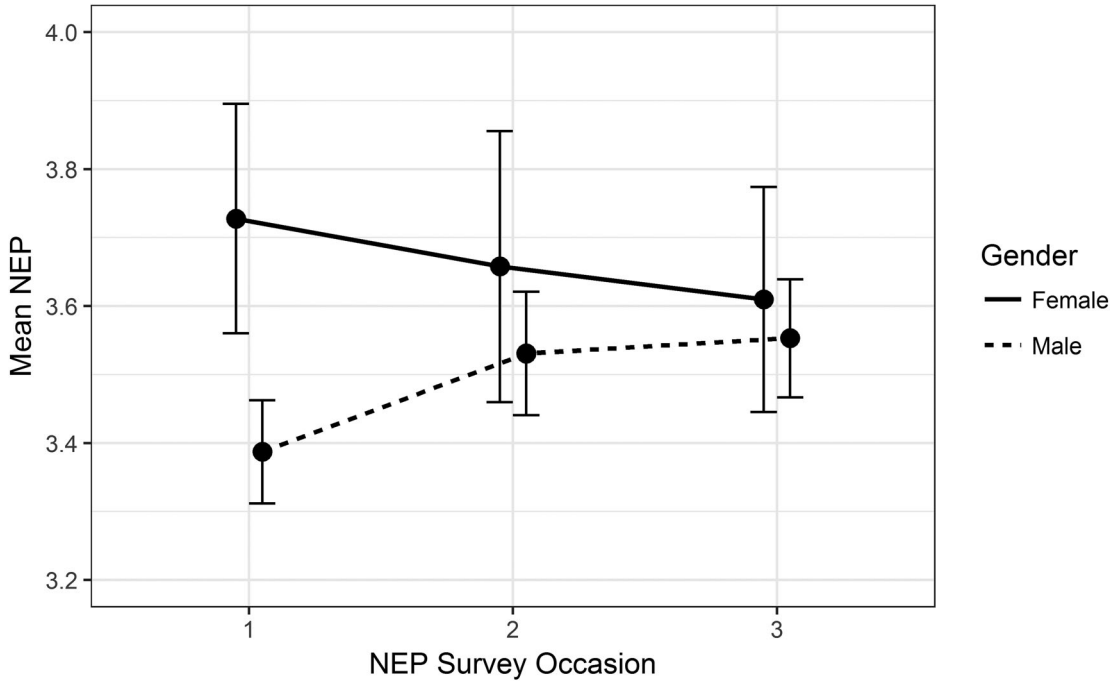
Table 5 shows the ANOVA results from the final model and (Fig. 2) plots the predicted means from the model along with 95% confidence intervals for both sexes. The most obvious feature of Fig. 2 is that averaged across the Cohorts, the mean NEP was relatively constant over time. However, there does appear to be some regular differences between Genders across Cohorts. Differences appear to be larger at the first survey occasion than they are at subsequent survey occasions. This is reflected in Table 5, where apart from *Survey Occasion*, all of the effects were significant ($p < 0.05$). These results are analysed in more detail in the following sections.

The effect of gender

As shown in Table 5, there is evidence of a statistically significant difference in mean NEP between Genders ($p = 0.016$). There was also a significant interaction effect between *Gender* and *Survey Occasion* which shows that the difference in mean NEP between Genders varies over time. Figure 3 illustrates the interaction effect. In the first survey, the mean NEP of Males was significantly lower than that of Females with a difference in mean NEP of about 0.3 averaged across the cohorts. However, the gap is reduced in subsequent surveys to the extent that by the second and third survey, when averaged across the cohorts, the difference in mean NEP was not statistically significant. Another key feature of the data that can be observed in Fig. 3 is that the trend for females was essentially negative whereas in contrast the profile for males was essentially



2 Predicted NEP means and standard errors for both sexes from the model averaged across cohort



3 Linear and non-linear trends for gender with respect to survey occasion.
***Note*: The connecting lines between results at each survey occasion are intended to be used as a visual guide to better illustrate the interactions identified by the statistical models. The lines are not intended to be used for interpolation or to infer a linear trend during the time periods between the survey occasions**

positive, albeit with a minor apparent slope between the latter two survey occasions.

The effect of cohort and of survey occasion

As shown in Table 5, there was evidence of a statistically significant difference in mean NEP between Cohorts ($p = 0.024$). The largest difference was between Cohort 5 and Cohort 3 ($p = 0.042$) and a difference also occurred between Cohort 4 and Cohort 3 ($p = 0.073$). There was a significant ($p = 0.0065$) interaction between Cohort and Survey Occasion. There was also evidence of a statistically significant difference in mean NEP between Survey Occasions ($p = 0.8303$), but when averaged over Gender and Cohort, there was no significant difference in mean NEP between Survey Occasions.

Discussion

There should be no doubt that the surveying profession and university departments of surveying that prepare future surveying professionals are interested in the sustainability-related attributes of these future professionals. And internationally, this sentiment appears to be repeated not only within the surveying profession, but also in a wide range of related professions (Dixon *et al.* 2008, Strack *et al.* 2013, Kuo and Jackson 2014). In the USA, for example, the Accreditation Board for Engineering and Technology (ABET) requires demonstration of *the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental and societal context* (ABET 2017). But being interested and making significant progress towards acting on this interest are different things.

The data reported in the present study is strongly aligned with much of our previous work. Mean NEP levels averaged over different cohorts in different papers are broadly stable over the years of student study and at a level that we have come to identify as characteristic of surveying students within our institution (typically approximately 0.5 NEP units lower than, for example, zoology students). Gender remains a significant predictor of individual NEP score. As with previous studies, there is variability in the data. Mean NEP scores for some cohorts are higher than for others (possibly reflecting temporal changes in national perceptions about sustainability brought about, as examples, by local events such as the Christchurch earthquake or global events such as sea level rise). Mean scores for some student groups in individual papers also vary from year to year, possibly associated with different university teachers teaching in different years (as also described by Teisl *et al.* 2010) and by the NEP questionnaires being delivered within different courses and contexts for each cohort. But the data of most interest to us in this study, and potentially to surveying schools internationally, is that over four recent cohorts there appears to be a trend in which mean NEP scores of females decline, so that differences between female mean NEP scores and male NEP scores decreases with time. There are several interacting issues that interest us here.

Within our surveying school and indeed internationally, males have traditionally outnumbered females. Indeed surveying is one of several professions in which males traditionally outnumber females. The NZIS statistics report (NZIS 2017) shows that females make up just under 12% of the membership. In the UK, the Women's Engineering Society identifies that only 9% of the engineering workforce is female (http://www.wes.org.uk/statistics). At least some of these professions have

identified this as a problem to be overcome. For example, in the UK, in 2000 the Royal Institution of Chartered Surveyors set up the Raising the Ratio taskforce to help break down barriers to the recruitment and retention of women in the property profession (http://www.rics.org/nz/about-rics/responsible-business/rics-futures/discussions/women-and-the-next-generation-in-surveying/). These interests are not simply a quest for equality. There is a strong sense that the professions will be stronger, and better, with more women involved, as women may bring qualities that may enhance the profession's ability to engage in and support sustainability activities and decisions, and that relatively speaking, men lack. Research on engineering education in the Netherlands, for example, suggested that female students spent more time on independent study, reported more social integration, completed more credits and were more likely to stay in engineering than were male students (Kamphorst *et al.* 2015). Particularly relevant to our analysis, from a broadly based exploration of the literature, Zelezney *et al.* (2000) suggested that women reported stronger EA and pro-environmental behaviours. Their analysis suggested that females had higher levels of socialisation, were more able to take on the role of 'conceptualised other' in discussions and reported stronger levels of social responsibility than did males. Chigbu and Agbonika (2013) suggest that 'women have a greater moral commitment to the environment than men' because of 'their concern for the well-being of future generations' (2013, p. 5). Other researchers have used a national probability adult sample of more than 4000 to note that women tend to display higher levels of empathy and lower levels of social dominance orientation than males (Milfont and Sibley 2016) and suggest that this goes some way to explain their stronger environmental concerns.

Extrapolating from population norms to the needs of individual professions and the obligations of the systems, and people, responsible for educating future professionals, we might wonder if the expression of these values would be particularly cherished. It would no doubt be concerning to all involved if the educational system experienced by these future professionals in some way failed to identify and cherish such assets.

So, as educators we are concerned that our data suggest that a four-year programme at our institution might be diminishing some of these particular qualities rather than enhancing them. This would not necessarily be a unique observation. Recent research on engineering students' motivations and aspirations (Alpay *et al.* 2008) indicated that although many students start an engineering degree with an aspiration to make a difference to the world, these aspirations diminish with time to be dominated by issues such as financial security. But it might be particularly worrying if these diminishing aspirations were more profound in female students than in males.

As researchers we are mindful, however, that our limited data set and analysis does not pretend to be more than it is. This is one set of data from one surveying school in one country. The data are complex and the issues involved not readily discernible using conventional educational assessment approaches. Ours is a particular research approach designed to help us to understand and to evaluate the impact of our educational system on outcomes that are not readily assessable, for example by examinations. But at this stage the data are both interesting and worrying and we hope that researchers at other institutions will work with us to further identify what may be happening within our surveying schools that may enable women to enter with different environmental concerns from males, but potentially to leave no different from males in this respect. We hope to undertake further research in our own institution with a focus on our curriculum, our teaching approaches and on the extra-curricula activities available to our students. We do not underestimate the challenges involved in this exploration.

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