Educating for ICT4S: Unpacking sustainability and ethics of ICT student intakes

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Abstract— A key focus in transforming the profession of ICT to one of contributing to a sustainable future is the education of students who may think and act as sustainable practitioners in computing. An important understanding in this is the relationship between ethics and sustainability in the student intake. This forms a baseline upon which higher education can build. It is argued that sustainability can be considered ethics expanded in time and space but it is not previously known if an ethical understanding relates to an ecological worldview or to desires for contributing to sustainability. This paper reports on a survey of the first year intake of nine New Zealand polytechnics (n=256) and explores the link between ethics and sustainability in freshman students in their first week of higher education. A measure of ethical naivety was constructed based on standard measures of naive ethics (legalism, egoism, agency and relativism), the responses to this were compared to the standard measure of ecological worldview, the New Environmental Paradigm. While students can be considered pro-ecological, and not ethically naïve overall, the individual responses show much work is needed in education for ICT4S. A greater sophistication in ethics is associated with a more pro-ecological worldview is supported by the data, however, as the relationship is likely to account for only 20%, the implication for education for ICT4S is that both need deliberate acts of teaching.

Key words— education, New Environmental Paradigm, ethics, ecological worldview

I. INTRODUCTION

This paper explores the link between ethics and ecological worldview in a nationwide survey of first year (freshman) computing students. Understanding this relationship is instructive in the design of curriculum and pedagogy for educating for sustainable practitioners in ICT [1, 2]. It extends a study 2014 [3], which itself built upon an 2008 study [4]. Mann [3] described a study of the intake of computing students (freshmen) during the first week of semester in a New Zealand institution. Participants completed a questionnaire that rated both their ethical sophistication and ecological worldview.

Three important findings can be summarised from [3]:

1. While in general the 2014 single institution **students were not ethically naïve, there was a large range, with some exhibiting very poor ethical understanding.** The naïve legalism and idealism are the areas of greatest concern. This would be a useful area to focus teaching of ethical concepts.

2. In general, the single institution **2014 students were pro-ecological.** There was a considerable shift in mean NEP scores from 2.94 in 2008 to 3.48 in 2014 (p<.001). This is a substantial shift, one that could have implications for research and teaching.

3. A greater sophistication in ethics is associated with a more pro-ecological worldview was supported by the 2014 single institution data. However, as the relationship is likely to account for only 20% or so of the variability, Mann concluded "although teaching ethics should help develop a more pro-ecological worldview, it is not sufficient. While the two are related, sustainability is not simply ethics rebranded".

Although [3] was administered in the first week of semester, it is possible that evidence of the institutional focus on educating for sustainable practitioners [5] – such as posters of sustainability-related senior capstone projects on the walls – had already substantially influenced the students on their first day. It is also possible that the students had chosen the institution on the basis of its publicised sustainable stance. This raises the question of whether the findings were specific to a single institution or whether they applied more generally. Moreover, as Mann [3] noted, the study was undertaken with a small sample which, although it produced statistically significant results, was insufficient to examine factors such as gender or age. He suggested that it would be worth repeating this study with a wider, multi-institutional sample.

The current study replicates Mann's study with a larger, more systematic, sample and aims to investigate institutional, gender and age variation.

II. BACKGROUND: ETHICS AND SUSTAINABILITY

There is a strong call by many for organisations and tertiary institutions to play a strong role in achieving the

global sustainability vision [6] [5]. The call from the United Nations is that this is a matter for students of every discipline [7] [8]. Computing researchers have similarly promulgated a strong connection between computing and sustainability [9], [10]. The crucial sentence in education for sustainability is *"Our goal is that every graduate may think and act as a "sustainable practitioner"* This sustainable practitioner means more than technical skills but means we have to come to terms with worldviews, affective learning and action competences [11].

A. Sustainability in computing education

The understandings and beliefs of computing students are critical to the development of curricula and teaching strategies to provide a stream of graduates who may usefully contribute to a sustainable society. Rather than a focus on current technical matters as they relate to sustainability (data consolidation, virtualization etc), we are particularly interested in understanding the deeper worldviews of the students – a focus on the affective attributes of values, attitudes and beliefs [12]. This worldview is important as the desired approach to computing education for sustainability is one of integration or computing through the lens of sustainability rather than additions to the crowded curriculum [13].

The most widely used measure of ecological worldview is the New Environmental Paradigm [14, 15]. Using a 15 point scale, participants can be scored according to a continuum of anthropocentric beliefs through to an ecological perspective. The NEP has been shown to demonstrate gender (females more pro-ecological), age and regional effects [16]. It has been previously used in benchmarking the worldviews of New Zealand student intakes [12, 17-19]. In general the computing freshmen were more anthropocentric than most other disciplines (roughly equal with business and engineering). Although there was a gender effect, this was not the whole story (as business was primarily female).

B. Ethics in computing education

Gotterbarn [20] argues that computing in all of its forms is not ethically neutral. He argues that if computing is to be taken seriously as a profession then we need to look beyond the narrow task focus and take seriously the wider responsibilities – with obvious implications for education "We need to make sure that students see the impacts of their decisions".

Mason [21] argues that we should all see through the lens of ethics, but that the "optics of ethics is very large indeed". They see four principles (agent's duty, act resulting in greatest good for greatest number, pursuit of virtue, pursuit of justice) as underlying most situations, but that "frequently however, the guidance deriving from one of these theories will conflict with that of one or more of the others. This requires a moral judgement". Hence ethics cannot sensibly be taught with reference to a rule book –' in case x do y' and instead is reliant on a rigorous application of underlying principles.

Ethics has been appearing in computing curricula for more than 20 years [22], [23]. In "Implementing a tenth strand in the CS curriculum" Martin *et al.* [24] argued that the social and ethical impact of computing was so fundamental that it should occur in every undergraduate curriculum.

Many students come to computer science with a hacker mentality; that is, they view the computer as a personal intellectual challenge, a test of their ability to solve logical problems and to control the computer. Such a narrow approach to computing emphasizes the relation between a solitary programmer and the computer. It implicitly denies any ethical responsibility or social obligation in the practice of computing skills.

Rather than just taking an instrumental approach to ethics – laws covering intellectual property, risk management and so on, Martin *et al.* recommended a focus on ethical principles such as honesty, fairness, autonomy, justice, and beneficence define personal responsibility.

These principles may not lend themselves to teaching. It is perhaps difficult to convey messages such as 'honesty is good' without appearing trite. Fortunately, Martin *et al.* proposed teaching through helping students to understand that "some easy ethical approaches are questionable". Students need to become aware of the differing grounds for ethical claims that have become common, and of the significant weaknesses of arguments often put forward in defense of an ethical choice. They pointed to four naïve approaches to ethical reasoning likely to lead the beginning ethical thinker astray:

Naïve Legalism. Equating ethicality with legality is a tempting way to dispense with serious ethical reflection. Students should certainly be aware of the legal issues that will confront them. However, assuming that "if it is legal, it is ethical" is asking more of the law than it can provide, and denies the legitimacy of principled disagreement with the law.

Naïve Agency. Surrendering all moral authority by claiming to be a simple agent of some other entity (e.g., an employer) has its own problems. In the end, even the legal system requires individual responsibility, and military codes of conduct require soldiers to disobey some orders. Personal responsibility cannot be this easily dismissed.

Naïve Egoism. The simple belief that selfishness is the best guiding principle can make it convenient to ignore duty to others while concentrating only on personal profit. This approach conceals a fundamental inconsistency, since its naïve form suggests everyone else should still follow ethical forms.

Naïve Relativism. The belief that all moral choices are relative to the situation and the culture makes it easy to have polite conversations with others, since it requires no confrontations. However, when difficult choices have to be made, students need to realize a truth can emerge that is not culturally specific.

Martin proposes engaging students in "recognising the weaknesses in using these simplistic approaches have

significant flaws when used as reasons in ethical decision making". Only then can skills be taught (such as arguing from example; identifying ethical issues in concrete situations; applying ethical codes to concrete situations).

But by 2008, Spradling *et al*. [25] concluded that there is still "work to be done".

1) Measurement

There are two primary ways to study ethical understanding: scenarios and ethical ideology. The scenario approach (eg [26]) tests participants' recognition and tolerance of violations. Unfortunately, the reliability of scenarios to uncovering unethical behaviour is questioned [27]: "we may well recognise good ethical behaviour and respond accordingly in a questionnaire but we may not have the moral stamina to stick to our good intentions when faced with a real life situation". The alternative approach is to try to elicit underlying principles or ideology eg [28].

C. Research question

It is clear that sustainability cannot be defined without reflecting on values and principles. As a result, as Bosselmann [29] argues, any discourse about sustainability is essentially an ethical discourse. Sustainability can be described as "ethics extended in time and space" [30] [31]. For Fagan [32] too, the ethical imperative is the basis of sustainability:

To live a particular lifestyle that, knowingly, impacts detrimentally on a neighbour—be that an individual living in the next house—or a country in the next region, cannot, arguably, be tolerated. To know of poverty in the economically developing world and not use that knowledge to act to relieve it, could be considered unethical. This position holds profound implications for politicians, schools and universities.

Most, if not all sustainability curriculum documents strongly feature ethics (see for example [5], [33]). Second Nature [34], state:

The context of learning would change to make the human/environment interdependence and values and ethics a central part of teaching in all the disciplines, rather than isolated as a special course or module in programs for specialists. All students would understand that we are an integral part of nature. They would understand the ecological services that are critical for human existence and how to assess and minimize the ecological footprint of human activity

So is sustainability just ethics rebranded? Could we dispense with teaching sustainability and focus on ethics? (Or vice versa?). If a student has a strong set of moral standards, does this make it easier to engage them in sustainability? An important understanding in this is the relationship between ethics and sustainability in the student intake. This paper explores the relationship between ethical sophistication and ecological worldview.

What is the relationship between ethical understandings and sustainability in freshman computing students? We are interested in understanding the sustainability worldviews and ethical underpinnings of students who have made their career path decision, but not yet been formally influenced by teaching in the discipline. Little is known about the affective learning status of students at this stage but this survey begins to give a baseline of whom we, as educators, are working with. To give an idea of the generalizability of findings, it is useful to explore whether there are geographical regional differences in any relationships.

TABLE I. THE 15 ITEM NEP. WORDS IN BOLD PROVIDE THE ABBREVIATED TERM USED IN SUBSEQUENT ANALYSIS

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

TABLE II. THE ITEMS USED IN ETHICAL SOPHISTICATION

Naïve Legalism	If it's legal it's ethical
	If I'm operating within the law I don't need to worry about ethics
Naïve Egoism	Selfishness is the best guiding principle
	As long as everyone is following "they are in it for themselves" society as a whole will prosper
Naïve Agency	My employer will protect me if anything goes wrong, so long as I've followed their rules.
	My job as a computer professional is to provide the technical solutions (code or infrastructure), my managers will have considered the ethical implications

Naïve Relativism	Questions of what is ethical for everyone can never be resolved since what is moral or immoral is up to the individual.
	What is ethical varies from one situation and society to another
Relativism in Computing	Business is a special case, the ethics are different to personal life
	There is no room in business for soft things like ethics, if your competitor does it then you can
	Computing is largely theoretical or technical - with little consequence
Idealism	The dignity and welfare of people should be the most important concern in society
	It is never necessary to sacrifice others
	The existence of potential harm to others is always wrong, irrespective of the benefits to be gained

III. PROCEDURE

As part of a wider NZ IT Learning and Career Expectations project an online survey was taken by freshman ICT students at nine New Zealand polytechnics in the first week of semester in February 2014.

To measure ecological worldview we included the revised New Environmental Paradigm Scale (NEP [14]). The items are shown in TABLE I. Respondents were asked to indicate their agreement with each item on a five-point Likert-like scale (Strongly agree, mildly agree, unsure, mildly disagree, strongly disagree). The revised-NEP contains seven items worded so that disagreement indicates a pro-ecological worldview and eight items worded so that agreement indicates a pro-ecological worldview. Items in each set were alternated and for our subsequent analysis the scores for seven disagreement = pro-ecological items were reversed, so that 1 (*strongly agree*) becomes 5 (*strongly disagree*), 2 becomes 4 and vice versa [15].

To measure ethical ideology we developed an instrument based on the four naïve ethics [24] (TABLE II.). To these we added three idealism elements from Forsyth's Ethical Position Questionnaire [35]. Respondents were asked the extent to which they agreed or disagreed with each statement. These were all measured on five-point agreement scales (1 = strongly disagree, 2 = disagree, 3 = neither agree nor disagree, 4 = agree, 5 = strongly agree).

IV. RESULTS

A total of 256 respondents completed both the Ethics and the NEP sections of the survey. 84.7% identified as male, 13.2% as female (with 1.9% not disclosing), approximating the population of freshman students. 63.6% of respondents were in the school-leaver age range (Table 1). 94% of the respondents came from five institutions (Table 2 Institutions

– institution 4 and 19 are excluded from further institution based analysis). The "single institution" from the previous study [3] is identified here as Institution_15.

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Table 1 Demographics

Age	Number of Respondents
Under 17	2
17-18	90
19-20	71
21-24	33
25-30	34
Over 30	26

Table 2 Institutions

Institution	
Institution_1	45
Institution_2	25
Institution_4	1
Institution_6	22
Institution_10	5
Institution_12	74
Institution_15*	75
Institution_18	8
Institution_19	1

1) Ethics (main dataset)

Overall, the sample was not ethically naïve. On a scale of 1 to 5, with 5 being most naive, the mean score was 2.66, SD was 0.57 and the 95% confidence interval was 2.59 to 2.72. A one sample t-test suggests ($t_{(255)}$=-9.6959; $p<.0001$) that participants are significantly non-naïve ethically. A similar pattern is found in most of the ethics subscales (Table 4: Table 3); with the exception of naïve relativism, participants were not naïve.

Table 3: Total dataset ethics subscales

Scale	Mean	SD	CI low	CI high	$t_{(255)}$	sig	Naïve?
Naïve Agency	2.88	0.79	2.78	2.98	2.41	0.016	No
Naïve Egoism	2.16	0.80	2.06	2.26	16.69	< .001	No
Naïve Legalism	2.25	0.83	2.14	2.35	14.46	<.001	No
Naïve Relativism	3.41	0.77	3.32	3.51	8.53	<.001	Yes
Naïve Computing Relativism	2.60	0.75	2.51	2.69	8.56	<.001	No
Idealism	3.49	0.65	3.41	3.57	11.99	<.001	No

However, that is not to say that all participants were ethically sophisticated. If we take a deficit model of ethics and include the neutral with the naïve, the picture is not so rosy (Table 4). This table shows the proportion of participants that would need to modify their worldview to be considered ethically sophisticated.

Table 4: Deficit model for ethics

	A	B
Naïve Legalism	35%	**48%**
Naïve Egoism	33%	**49%**
Naïve Agency	65%	**83%**
Naïve Relativism	72%	**93%**
Relativism in Computing	50%	**79%**
Idealism	47%	**81%**

Column A shows the proportion of unsophisticated answers. Column B shows the proportion of participants who gave at least one unsophisticated answer to a question in that section. Almost all (255 of 256) participants gave at least one unsophisticated answer. Details of responses to the individual questions are given in Appendix B.

2) NEP (main dataset)

Overall, the sample was pro-ecological. On a scale of 1 to 5, with 5 being pro-ecological, the mean score was 3.44, SD was 0.55 and the 95% confidence interval was 3.37 to 3.50. A one sample t-test suggests ($t_{(255)}$=12.62; p<.0001) that overall participants are significantly pro-ecological.

However, as with the ethics questions, that is not to say that all participants are pro-ecological. Using a deficit model of sustainability that includes the neutral with the anti-ecological (Table 5) it is clear that a substantial shift of worldviews is needed.

Overall, almost all participants (253 / 256) gave at least one response that was not pro-ecological and 84% (216) gave at least one anti-ecological answer.

Table 5 Eco scale deficit model

Question	Deficit
limit	54%
modify	52%
interfere	35%
ingenuity	71%
abusing	27%
resources	85%
plants	23%
balance	46%
abilities	29%
crisis	67%
spaceship	52%
rule	48%
delicate	42%
control	70%
catastrophe	41%

3) Relationship (main dataset)

There is a significant correlation between Ethics and Ecological scores ($r_{(254)}$=-0.3029; p<.0001), with higher values of ecological scores associated with lower values of ethics naivety. The relationship accounts for 9% of the variability; adjusted R^2 was 9%. The 95% confidence interval of the adjusted correlation coefficient is 0.187 to 0.419 corresponding to an adjusted R^2 of 3% to 18%. Because both ecological scores and ethics scores are measured with error, the relationship is attenuated. Applying a Spearman correction for attenuation gives an estimate of the level of correlation in the population of about 15% (9% / (.754*.810)).

A Jarque-Bera test of normality indicates (p<.001) that the distribution of the residual from the regression is significantly different from a normal distribution. Non-parametric tests of association were carried out to elaborate the degree of association.

A Spearman's rank correlation test (r_s= 0.3266; p<.0001) shows a positive relationship that is significant at the 0.05 level. A test of strict monotonic association (Gamma=0.2239; p=0.0006) shows a positive ordinal relationship, significant at the 0.05 level. A test of weak monotonic association (Gamma=0.2426; p=0.0002) shows a positive ordinal relationship, significant at the 0.05 level.

The population correlation estimate of about 15% is likely to underestimate the true population effect because a simple summated scale cannot capture the varying contributions each question makes. To explore this further, we carried out a path analysis at the sub-scale level. The path diagram is shown in Figure 1.
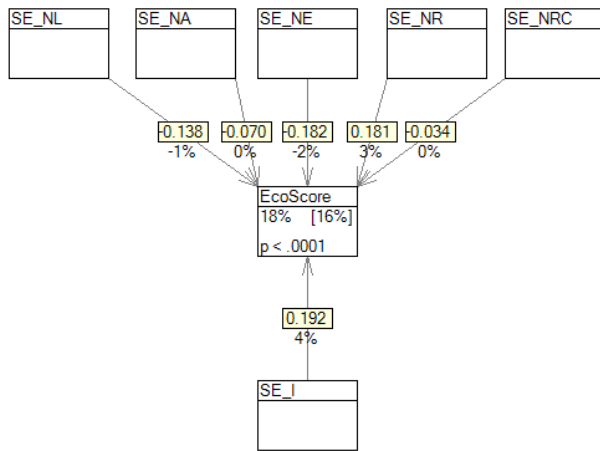
Figure 1 Contributions of ethics subscales

In this path diagram, the variability explained by the subscales is 16% (adjusted R^2) before correction for attenuation. This corresponds to a population estimate of around 26% (16% / (.754*.810)). Such a path analysis approach is prone to over-fitting, so this estimate should be taken as a likely upper bound. Moreover, since there is substantial correlation between the individual subscales, the model has considerable multicollinearity and thus we have little confidence in the weights of the individual predictors. Removing the least significant predictors in a step-wise procedure leads to a model with just two predictors (Figure 2).

Within the sample, the best two predictors of variability in ecological scores are naïve egoism and idealism. An absence of naïve egoism and presence of idealism is associated with higher ecological scores. In this more robust model, the variability explained by the subscales is 11% (adjusted R^2) before correction for attenuation, corresponding to a population estimate of around 18% (11% / (.754*.810)).

Taking the estimate of 18% as a lower bound and 26% as an upper bound, our best guess as to the effect size in the population is around 20 to 25%. From this, we conclude that there is considerable overlap between ethics and sustainability, but they are not the same.
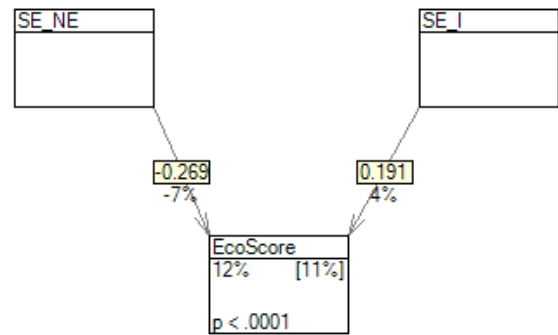

Figure 2 Best predictors of eco score.

4) Variation by institution

There is a small (1%) but significant difference across institutions in terms of ethical sophistication. A non-parametric Kruskal-Wallis test comparing ranks of Ethics scores across institutions was significant ($H_{(8)}$=16.16; φ_C=0.0888; φ_C^2=0.8%; p=0.0401). However, two institutions have counts of 1; counts less than five may be a threat to the validity of this test. An independent samples van der Waerden test, treating each category as a separate sample, reported a significance of p=0.0163; this suggests that the samples were not drawn from a single population.

Summary statics are shown in Table 6.

Table 6: Ethics scores by institution

Institution	Mean	SD	N	CI Low	CI High
1	2.79	0.49	45	2.64	2.93
2	2.62	0.52	25	2.42	2.82
4	2.21	0.00	1	2.21	2.21
6	2.67	0.39	22	2.51	2.83
10	2.69	0.21	5	2.51	2.87
12	2.54	0.46	74	2.43	2.64
15	2.60	0.43	75	2.51	2.70
16	2.33	0.28	8	2.13	2.53
19	4.57	0.00	1	4.57	4.57

These are shown graphically in Figure 3.
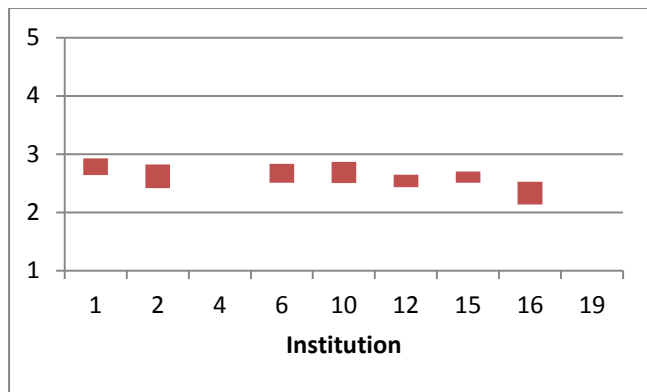
Figure 3 Ethics scores by institution

Figure 4 Ecological scores by institution

Ignoring institutions 4 and 19 which have just one participant each, there are some significant differences among institutions. Participants from institution 1 are significantly more naïve than those from institutions 12, 15 and 16. Participants from institution 12 are significantly more naïve that those of institution 16.

There is also a small (1%) but significant difference across institutions in ecological scores. A non-parametric Kruskal-Wallis test comparing ranks of eco scores across institutions was significant ($H_{(8)}$=18.67; φ_C=0.0955; φ_C^2=0.9 %; p=0.0167). An independent samples van der Waerden test, treating each category as a separate sample, reported a significance of p=0.0066; this suggests that the samples were not drawn from a single population.

Summary statistics are shown in Table 7.

Table 7 Ecological scores by institution

Institution	Mean	SD	N	CI Low	CI High
1	3.64	0.58	45	3.47	3.81
2	3.65	0.41	25	3.49	3.81
4	4.93	0.00	1	4.93	4.93
6	4.05	0.57	22	3.82	4.29
10	3.80	0.53	5	3.33	4.27
12	3.91	0.59	45	3.73	4.08
15	3.88	0.47	75	3.78	3.99
16	3.88	0.58	8	3.47	4.28
19	2.60	0.00	1	2.60	2.60

Participants from institution 1 and 2 have significantly lower scores than those from institutions 6, 12 and 15. Confidence intervals are shown graphically in Figure 4.
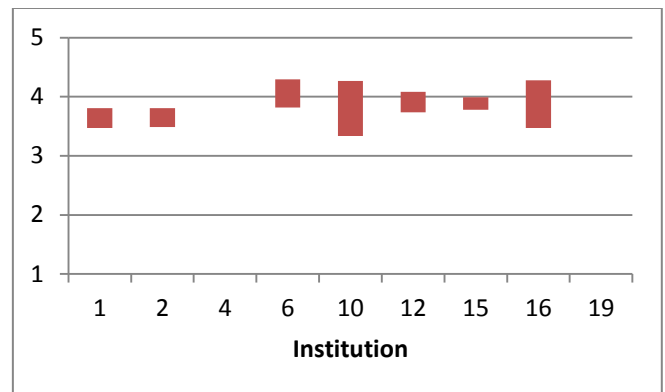
5) Variation by gender

Overall, there were no significant differences between genders for ethical naivety or ecological scores. However, a significant difference was found for one of the ethics subscales: naïve agency. A comparison of means of naïve agency.across categories of *gender* detected a significant ($F_{(2, 253)}$=3.53; η^2=2.72 %; ω^2=1.94 %; p=0.0300) difference in means. The analysis met the assumptions of ANOVA. Although group sizes were not equal, variance was acceptably homogeneous across groups (the ratio of the smallest to the largest is 3.22) and all samples were acceptably close to a normal distribution. The results were also confirmed by non-parametric tests. A non-parametric Kruskal-Wallis test comparing ranks of naïve agency across categories of *gender* was significant (H(2)=8.54; φC=0.1291; $\varphi C2$=1.7 %; p=0.0140) and an independent samples *van der Waerden* test, treating each gender category as a separate sample, reported a significance of p=0.0281, suggesting that the samples were not drawn from a single population

Summary statistics are shown in Table 8.

Table 8: Mean naïve agency scores by gender

Category	Mean	SD	N	CI Low	CI High
Male	2.94	0.80	217	2.83	3.04
Female	2.56	0.68	34	2.33	2.79
Unspecified	2.70	0.45	5	2.31	3.09

Males were more naïve on the naïve agency scale than females.

6) Variation by age

Summary statistics of ethics scores by age are shown in Table 9.

Table 9: Ethics naivety by age

Age	Mean	SD	N	CI Low	CI High
Under 17	4.21	0.51	2	3.51	4.91
17-18	2.67	0.40	90	2.58	2.75
19-20	2.65	0.46	71	2.54	2.76
21-24	2.64	0.51	33	2.47	2.81
25-30	2.57	0.43	34	2.43	2.72
30+	2.33	0.45	26	2.16	2.50

Confidence intervals for the scores are plotted in Figure 5. Although pairwise comparisons of age categories do not show significant differences, there is a small but visible trend of naivety reducing with age.
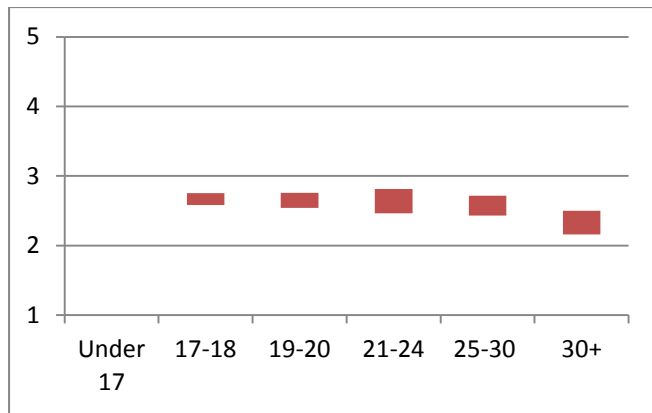

Figure 5 Ethics scores by age

Summary statistics of ecological scores by age are shown in Table 9

Age	Mean	SD	N	CI Low	CI High
Under 17	3.10	0.71	2	2.12	4.08
17-18	3.73	0.53	90	3.62	3.84
19-20	3.85	0.56	71	3.72	3.98
21-24	3.81	0.48	33	3.64	3.98
25-30	4.02	0.57	34	3.83	4.21
30+	4.03	0.55	26	3.82	4.24

Confidence intervals for the scores are plotted in Figure 6.
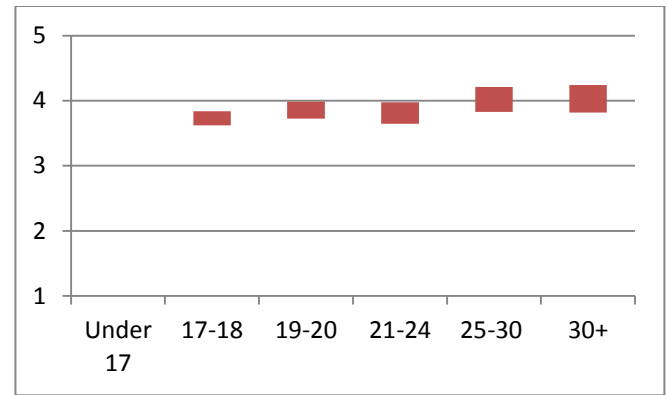

Figure 6 Ecological scores by age

Although pairwise comparisons of age categories do not show significant differences, there is a small but visible trend of pro-ecological worldviews increasing with age.

V. DISCUSSION

This paper has described a study of the intake of computing students (freshmen) during the first week of semester in nine New Zealand tertiary institutions. Participants completed a questionnaire that rated both their ethical sophistication and ecological worldview. Developing ethical sophistication is a key component of developing sustainable practitioners so it is important that this relationship be understood, both generally [5], and in the specific field of ICT [1, 2].

This larger dataset largely confirms previous findings [3], and confirms that we can generalise beyond the single institution (Institution_15) in that study. There was some effect of institution, but Institution_15 was roughly in the middle of both ethics and ecological worldview. There was no strong effect of gender except on one of the ethics subscales (males more naïve for Agency) and overall no significant effect of age, but a slight trend in the more eco/less naïve direction with increasing age.

While in general the freshman students were not ethically naïve, there was a large range, with some exhibiting very poor ethical understanding. Of concern is the high number of students who responded with ethically unsophisticated answers for Agency and Relativism.

It is worrying that freshman students appear to believe in agency as a basis for their profession. This nationwide IT finding can be seen to align with that of a 2008 cross disciplinary study [4] where freshmen students from all disciplines wrongly agreed with the statement that "the code of ethics for my discipline states that my primary loyalty is to my employer, regardless of social and environmental consequences". Students need to be taught that surrendering all moral authority by claiming to be a simple agent of some other entity (e.g., an employer) is not a viable basis for being a professional.

It is perhaps not surprising that students agreed with the theoretical general case for naïve relativism: "questions of what is ethical for everyone can never be resolved since

what is moral or immoral is up to the individual". It is easy to propose an example for such thinking ("it is bad to kill someone, but not if they are about to murder ten other people" for example), but the naivety comes about when this is applied to all ethical situations, and used to justify poor behaviour. 79% of students were considered naïve in these terms to at least one of these statements putting relative ethics in the context of business computing:

Business is a special case; the ethics are different to personal life

There is no room in business for soft things like ethics, if your competitor does it then you can

Computing is largely theoretical or technical - with little consequence

It would be useful to compare these freshman responses with that of those expected by employers. On the basis that they differ, and that changes in responses to specific ethical situations may not be expected to occur through a simple maturity, these areas should be a focus of teaching of ethical concepts to computing students.

While the full dataset shows that students are broadly pro-ecological, there is still a lot of work to be done in this area. While this study does not have previous nationwide data to compare change over time, the nationwide data does agree with the single institution data in showing a broadly pro-ecological worldview. This can be seen in agreement to questions on the rights of the biota, that humans are subject to laws of nature and that humans are abusing the environment. This core of an ecological worldview, however, is largely undone by responses to the questions regarding resources ("resources", "spaceship", "limit"). As the notion of limits is fundamental to sustainability, this would perhaps be a useful area to address in ICT education. Further, perhaps not surprisingly as computing students, there is also a high reliance on our ability to solve the problem. Perhaps this optimism could be usefully used to engage students on the role of ICT in the recognition of the cause (human activity), and a greater understanding of the issue (resources). The role of technology to fix, or perhaps paper-over problems (or as a magic bullet) without addressing root causes, would be a useful discussion to have with ICT students.

It would be useful to a repeat an exploration of patterns within the NEP data, including classification of individuals [12, 19] – within the sample were many individuals with components of strong anthropocentric views.

We do not think it means that educators should ease off on a sustainable practitioner imperative.

The nationwide data confirms the earlier finding [3], that there is some commonality (20% to 25%) between ethics and sustainability, but they are not the same. We can reassert the conclusion [3] "although teaching ethics should help develop a more pro-ecological worldview, it is not sufficient. While the two are related, sustainability is not simply ethics rebranded".

Thus, other means should also be used to develop awareness and a pro-ecological worldview. Further, while the pro-ecological worldview can be considered a useful precursor to developing graduates that may think and act as sustainable practitioners, it cannot be assumed that a pro-ecological worldview determines a sustainable practitioner. Hence, although they are related – and perhaps usefully so for developing teaching engagement strategies – ethical sophistication, an ecological worldview and the practice of being a sustainable practitioner each need to be the focus of deliberate acts of teaching. One strategy worth investigating would be to engage students via the different elements of ethical sophistication as scaffolding concepts for notions that sustainability is "ethics extended in time and space" [30] [31].

This survey was undertaken in the first week of the first semester – before students had learnt much at a tertiary level. They had, however, chosen their field of learning –at least computing in general if not also their specific pathway. This study has examined the differences in the sustainability worldviews of students who have made that career path decision, but not yet been formally influenced by teaching in that discipline. The lack of a strong gender effect (as would be expected eg [16]) may indicate a self-selection and norm-fitting of students into computing, along the lines of the "I was to enter IT by leaving my cultural identity at the door when entering" reported by Hamilton-Pearce [36]. This would be a rich field of further research.

It would be worth exploring if similar relationships to that this paper has found for sustainability, apply in other motivated computing endeavours such as Computing for Social Good, [37, 38] and Computing for Peace [39].

Unlike many studies involving students it is worth remembering that the student intakes (freshmen) are the target population so usual caveats about students representing the population do not apply. A longitudinal approach would also be worthwhile to investigate how the ethical sophistication and ecological worldview change during students' education. It would also be worthwhile to compare the student responses with that of computing professionals, especially those engaged in employment of ICT graduates.

VI. CONCLUSION

This paper presents the results of a national survey of the ethical sophistication and ecological worldviews of first year students entering computer science degree programmes. A greater sophistication in ethics is associated with a more pro-ecological worldview. While this relationship is sufficient to suggest integrated approaches to engagement, it is insufficient to suggest teaching only ethics or sustainability alone and hoping for automatic transference.

REFERENCES

1. Mann, S. and L. Smith. *Computing Education for Sustainability*. in *20th Annual Conference of the National Advisory Committee on Computing Qualifications*. 2007. Nelson, New Zealand: NACCQ in cooperation with ACM SIGCSE.

2. Mann, S., L. Smith, and L. Muller, *Computing education for sustainability.* SIGCSE Bull., 2008. **40**(4): p. 183-193.

3. Mann, S., et al. *An ethical basis for sustainability in the worldviews of first year students?* in *The 2nd international conference ICT for Sustainability, ICT4S 2014*. 2014. Stockholm.

4. Shephard, K., et al., *Comparing different measures of affective attributes relating to sustainability.* Environmental Education Research, 2011. **17**(3): p. 329-340.

5. Mann, S., *The Green Graduate: Educating Every Student as a Sustainable Practitioner*. 2011, Wellington: NZCER Press. 175.

6. Blewitt, J. and C. Cullingford, eds. *The Sustainability Curriculum: The Challenge for Higher Education*. 2004, Earthscan: London. 258.

7. Tilbury, D., et al., *A National Review of Environmental Education and its Contribution to Sustainability in Australia: Further and Higher Education,* . 2005, Australian Government Department of the Environment and Heritage and Australian Research Institute in Education for Sustainability - ARIES, Canberra.

8. United Nations. *United Nations Decade of Education for Sustainable Development: Information Brief*. 2004 [cited 2007 15/3/07]; Available from: http://www.unesco.org/education/tlsf/TLSF/decade/img/DESDbrief.pdf.

9. Blevis, E. *Sustainable Interaction Design: Invention and disposal, renewal and reuse*. in *Conference on Human Factors in Computing Systems*. 2007. San Jose, California: ACM.

10. Tomlinson, B., *Greening through IT*. 2010, Cambridge. MA: MIT Press. 210.

11. Jensen, B.B. and K. Schnack, *The Action Competence Approach in Environmental Education.* Environmental Education Research, 1997. **3**(2): p. 163-179.

12. Mann, S., et al., *Seeking richer descriptions of learners' sustainability attributes and learning needs.* International Journal of Sustainability in Higher Education, 2013. **14**(1): p. 90-100.

13. McGettrick, A., et al., *Grand Challenges in Computing: Education*. 2004, British Computer Society: Newcastle, UK. p. 26.

14. Dunlap, R., et al., *New Trends in Measuring Environmental Attitudes: Measuring Endorsement of the New Ecological Paradigm: A Revised NEP Scale.* Journal of Social Issues, 2000. **56**(3): p. 425-442.

15. Manoli, C.C., B. Johnson, and R.E. Dunlap, *Assessing Children's Environmental Worldviews: Modifying and Validating the New Ecological Paradigm Scale for Use With Children.* The Journal of Environmental Education, 2007. **38**(4): p. 3.

16. Zelezny, L.C., P.-P. Chua, and C. Aldrich, *Elaborating on gender differences in environmentalism.* Journal of social issues, 2000. **56**(3): p. 443-458.

17. Mann, S., et al., *Benchmarking sustainability values of incoming computing students*, in *NACCQ - The 22nd Annual Conference*. 2009: Napier. p. 43-51.

18. Shephard, K., *Higher education for sustainability: seeking affective learning outcomes.* International Journal of Sustainability in Higher Education, 2008. **9**(1): p. 87-.

19. Shephard, K., et al., *Benchmarking the environmental values and attitudes of students in New Zealand's post-compulsory education.* Environmental Education Research, 2009. **15**: p. 571-587.

20. Gotterbarn, D., *Why Bother with Ethics in Computing: Addressing Harmful Paradigms.* ACM Inroads, 2010. **1**(1): p. 9-10.

21. Mason, R.O., *Applying ethics to information technology issues.* Commun. ACM, 1995. **38**(12): p. 55-57.

22. Granger, M.J., et al., *Using information technology to integrate social and ethical issues into the computer science and information systems curriculum (report of the ITiCSE '97 working group on social and ethical issue in computing curricula)*, in *The supplemental proceedings of the conference on Integrating technology into computer science education: working group reports and supplemental proceedings*. 1997, ACM: Uppsala, Sweden. p. 38-50.

23. Martin, C.D., *The case for integrating ethical and social impact into the computer science curriculum*, in *The supplemental proceedings of the conference on Integrating technology into computer science education: working group reports and supplemental proceedings*. 1997, ACM: Uppsala, Sweden. p. 114-120.

24. Martin, C.D., et al., *Implementing a tenth strand in the CS curriculum.* Commun. ACM, 1996. **39**(12): p. 75-84.

25. Spradling, C., L.-K. Soh, and C. Ansorge, *Ethics training and decision-making: do computer science programs need help?* SIGCSE Bull., 2008. **40**(1): p. 153-157.

26. Hartikanen, O. and S. Torstila, *Job-Related Ethical Judgment in the Finance Profession.* Journal of Applied Finance, 2004. **14**(1): p. 62-76.

27. Adam, A. and J. Ofori-Amanfo, *Does gender matter in computer ethics?* Ethics and Information Technology, 2000. **2**(1): p. 37-47.

28. Vanmeter, R.A., et al., *Gen Y's Ethical Ideology and its potential workplace implications.* Journal of Business Ethics, 2013. **117**(1): p. 93-109.

29. Bosselmann, K., *The principle of sustainability: transforming law and governance*. Transforming Law and Governance Series. 2008, Farnham, Surrey: Ashgate Publ.

30. Koehler, A. and C. Som, *Effects of pervasive computing on sustainable development.* Technology and Society Magazine, 2005. **24**(1): p. 15-23.

31. Mann, S., *Sustainable Lens: a visual guide*. 2011, Dunedin: NewSplash Studio. 206.

32. Fagan, G., *The Emerging Paradigm*, in *The Handbook of Sustainability Literacy: Skills for a Changing World*, A. Stibbe, Editor. 2009, Green Books: Foxhole, Dartington, Totnes. p. online.

33. Earth Charter Intiative. *What is Education for Sustainable Development*. 2009 21/9/9]; 2]. Available from: http://www.earthcharterinaction.org/download/education/what-is-ESD.pdf.

34. Second Nature. *Education for Sustainability*. 2005; Available from: http://www.secondnature.org/efs/efs.htm.

35. Forsyth, D.R., *A taxonomy of ethical ideologies.* Journal of Personality and Social psychology, 1980. **39**(1): p. 175.

36. Hamilton-Pearce, J., *Mana Wāhine in Information Technology: Ngā Kaiwhatu Kākahu Me Te Kākahu*. 2009, Auckland University of Technology.

37. Goldweber, M., et al., *A framework for enhancing the social good in computing education: a values approach.* ACM Inroads, 2013. **4**(1): p. 58-79.

38. Goldweber, M., et al., *Enhancing the social issues components in our computing curriculum: computing for the social good.* ACM Inroads, 2011. **2**(1): p. 64-82.

39. Hourcade, J.P., *Give peace a chance: a call to design technologies for peace*, in *Proceedings of the 27th international conference extended abstracts on Human factors in computing systems*. 2009, ACM: Boston, MA, USA.

Appendix A: Eco scales

		1 SD	2 D	3 N	4 A	5 SA	1 SD	2 D	3 N	4 A	5 SA	Deficit Model
				Counts					Percentages			
Q36_1	We are approaching the **limit** of the number of people the earth can support.	18	33	87	78	40	7%	13%	34%	30%	16%	**54%**
Q36_2	Humans have the right to **modify** the natural environment to suit their needs. [EV13]	31	92	66	54	13	12%	36%	26%	21%	5%	**52%**
Q36_3	When humans **interfere** with nature it often produces disastrous consequences.	5	25	58	103	65	2%	10%	23%	40%	25%	**35%**
Q36_4	Human **ingenuity** will ensure that we do not make the earth unlivable.	35	39	105	51	26	14%	15%	41%	20%	10%	**71%**
Q37_1	Humans are severely **abusing** the environment	5	27	36	112	76	2%	11%	14%	44%	30%	**27%**
Q37_2	The earth has plenty of natural **resources** if we just learn how to develop them.	8	31	53	100	64	3%	12%	21%	39%	25%	**85%**
Q37_3	**Plants** and animals have as much right as humans to exist.	8	15	37	81	115	3%	6%	14%	32%	45%	**23%**
Q37_4	The **balance** of nature is strong enough to cope with the impacts of modern industrial nations.	54	84	91	21	6	21%	33%	36%	8%	2%	**46%**
Q38_1	Despite their special **abilities** humans are still subject to the laws of nature.	7	8	59	99	83	3%	3%	23%	39%	32%	**29%**
Q38_2	The so-called "ecological **crisis**" facing humankind has been greatly exaggerated.[EV8]	29	56	109	48	14	11%	22%	43%	19%	5%	**67%**
Q38_3	The earth is like a **spaceship** with very limited room and resources.[NEP4] [EV4]	13	46	75	87	35	5%	18%	29%	34%	14%	**52%**
Q38_4	Humans are meant to **rule** over the rest of nature.[NEP6] [EV6]	71	61	65	41	18	28%	24%	25%	16%	7%	**48%**
Q39_1	The balance of nature is very **delicate** and easily upset. [NEP1]	3	35	68	102	48	1%	14%	27%	40%	19%	**42%**
Q39_2	Humans will eventually learn enough about how nature works to be able to **control** it.	20	56	90	70	20	8%	22%	35%	27%	8%	**70%**
Q39_3	If things continue on their present course we will soon experience a major ecological **catastrophe**.	7	18	80	85	66	3%	7%	31%	33%	26%	**41%**

Appendix B: Ethics scales

	Question	SD 1	MD 2	N 3	MA 4	SA 5	SD 1	MD 2	N 3	MA 4	SA 5	Deficit Model
		Counts					Percentages					
Naïve Legalism Q32_1	If it's legal it's ethical	50	97	78	23	8	20%	38%	30%	9%	3%	**42%**
Q33_2	If I'm operating within the law I don't need to worry about ethics	63	124	50	16	3	25%	48%	20%	6%	1%	**27%**
Naïve Egoism Q32_3	Selfishness is the best guiding principle	66	109	60	16	5	26%	43%	23%	6%	2%	**31%**
Q33_1	As long as everyone is following "they are in it for themselves" society as a whole will prosper	77	91	63	19	6	30%	36%	25%	7%	2%	**34%**
Naïve Agency Q33_5	My employer will protect me if anything goes wrong, so long as I've followed their rules.	28	81	82	56	9	11%	32%	32%	22%	4%	**58%**
Q34_2	My job as a computer professional is to provide the technical solutions (code or infrastructure), my managers will have considered the ethical implications	18	51	106	73	8	7%	20%	41%	29%	3%	**73%**
Naïve Relativism Q32_4	Questions of what is ethical for everyone can never be resolved since what is moral or immoral is up to the individual.	8	41	82	87	38	3%	16%	32%	34%	15%	**81%**
Q33_4	What is ethical varies from one situation and society to another	6	21	109	102	18	2%	8%	43%	40%	7%	**90%**
Relativism in computing Q32_5	Business is a special case, the ethics are different to personal life	23	59	91	74	9	9%	23%	36%	29%	4%	**69%**
Q34_3	There is no room in business for soft things like ethics, if your competitor does it then you can	52	103	73	25	3	20%	40%	29%	10%	1%	**40%**
Q34-4	Computing is largely theoretical or technical - with little consequence	29	97	96	30	4	11%	38%	38%	12%	2%	**52%**
Idealism Q32_2	The dignity and welfare of people should be the most important concern in society	5	12	70	122	47	2%	5%	27%	48%	18%	**34%**
Q33_3	It is never necessary to sacrifice others	12	40	80	86	38	5%	16%	31%	34%	15%	**52%**
Q34_1	The existence of potential harm to others is always wrong, irrespective of the benefits to be gained	4	51	89	81	31	2%	20%	35%	32%	12%	**57%**

Note: idealism questions are reverse-coded for ethics scores