Personal values and the ecological worldview of civil engineering and environmental science students

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***Abstract**: Civil and transport engineers and the discipline, with a preoccupation with design and operational standards, have historically been accused of leading infrastructure transformations that degrade the integrity of natural ecosystems and impersonalise the public arena (Bergen et al. 2001; Harris 2008; Postman 1992). The public perception is vastly improved given curricula that integrate sustainability principles (Koth et al. 2009), innovative construction materials with low embodied energy, and more public accessibility into consensual decision-making. The sustainability debate, however, has turned to questions of unlimited growth and the implied climate change crisis. There is a dearth of information on how environmental attitudes held by engineering students have transitioned to keep pace with evolving values in western industrialized societies with regard to stewardship of planetary resources. The New Ecological Paradigm (NEP) was administered to final year civil engineering (CE) students, along with Schwartz's Values Survey detailing deeply held, life guiding principles. The study found a cohort (33%) of CE students whose responses across the scale mirrors those of environmental degree students also studied, in being 'greenest' and more concerned about ecological crises. However, CE students show the greatest, significant mean differences with environmental students in dimensions associated with inter-species equity, an optimism that supports modifications to the natural world, and resiliency in the balance of nature. The bottom ranking of beauty as an important life principle also distinguishes civil engineering students. The work offers ideas for course content that addresses what may be fundamental value differences between CE graduates and the environmentalist public.*

Introduction

In terms of the how disciplines shape society's built and manufactured environment, engineers – guided by economic rationalists, planners and politicians – perhaps leave the most expansive legacy. Flaga (2000) outlines the nascent origins of civil engineering when humans observed nature and began to imitate and improve it to create safer living conditions. These initial interventions combined a sense of functionality, harmony and beauty. The principles of imitating nature could be said to ground sustainability, here defined as 'low-impact human activity that balances economic sufficiency with ecological productivity and community cohesiveness in the long-term.' Functionality is the dominant assumed directive of engineering, while harmony captures the notion of cause-and-effect and attention to systems thinking. The author suggests these concepts of respectful imitation of nature, functionality, harmony and beauty are underlain in core human values, which in turn emerge in individualistic attitudes and beliefs.

This paper reports on a study of personal value and attitudes definition in civil engineering (CE) and environmental science (ES) students. At UniSA where the study was conducted, the CE and ES programs are taught in the same School, whose vision and strategic statements, staffing and programmatic decisions emphasize integrative education in sustainability as its cornerstone. Using standard scales (Schwartz's Values Survey, New Ecological Paradigm), the study mapped personal values and environmental attitudes for two disciplinary cohorts as a means of understanding

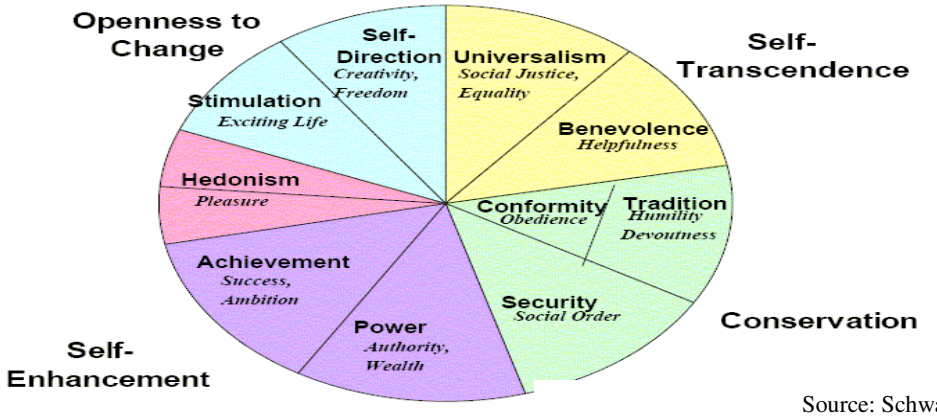
Proceedings of the 2011 AAEE Conference, Fremantle, Western Australia, Copyright © Koth, 2011

differences in soon-to-graduate students in terms of embeddedness in sustainability as a guiding professional principle. The research question is: do CE and ES students differ in personal values and attitudes associated with sustainability; if so, what is the magnitude of the difference and how can it be characterized conceptually? The ES students are assumed to represent adherents of an eco-centric world view that places sustainability criteria as foremost, whereas CE students represent an anthropocentric point of view in a society struggling to evolve on a sustainability pathway.

Literature Review

A plethora of literature on sustainability education for engineers shows significant insight into content, pacing of the introduction, providing an ethical framework, and integration issues (Hopkinson & James 2010, Desha et al. 2008; El-Zein et al. 2006; Boyle 2004; Abdul-Wahab 2003, Dominick et al. 2003), with additional inspiration from business schools (Stubbs & Cocklin 2007). However, there have been limited pedagogic contributions from environmental psychology, applied in analyzing the various elements of perception - values, attitudes and beliefs, and norms. Social norms, the rules for how people should act in a given group or society, and personal norms, a feeling of moral obligation (Steg et al. 2005) are important to disciplinary standards and environmental lifestyle considerations, but outside the scope of this paper. Deeply held values are posited to explain attitudes, which weakly correlate with actual behaviour. The imperfect relationships can be over simplistically diagrammed as: values > (lead to) attitudes > behaviour. Underlying human values transcend specific situations and reflect ideas or principles that people hold as important to them, ordered by relative importance (Brown 1984). Held values are concepts or beliefs about desirable end states or behaviours, and can be used to guide the selection or evaluation of behaviours.

Schwartz's Values Survey (Figure 1) is a commonly used psychometric scale (up to 56 items) to measure basic human values, with application in over 60 countries. Participants are asked to rate the importance of each value as a guiding principle in their life on a 9-point 'not important' to 'of supreme importance' scale. At least three items relate directly to sustainability: protecting the environment/preserving nature, unity with nature (fitting into nature), as well as social justice (correcting inequities and caring for the 'weak'). These are altruistic, self-transcendent value orientations, along with equality, a world at peace, and helpfulness (working for the welfare of others). This dimension contrasts with egoistic value orientations focused on self-enhancement: social power (control over other, dominance), authority (the right to lead or command), wealth, influence, and ambition/aspirations. Lundmark (2007) suggests that the biospheric value orientation, that is concern for all life forms, is missing from this paradigm (2007).



Source: Schwartz 1992

Figure 1. Schwartz's Value Scale

As Shakespeare told us beauty is a complex multifaceted agent that centres and reconnects humans to the biophysical world in reflective emotional acknowledgement of satisfaction (Meyer 2008); it is interpreted at both the individual and collective level. This author calls attention to the universal value of beauty here categorized under self-transcendence, contending that beauty is a critical, oft-

ignored aspect of sustainability as it relates to community liveability and quality of life, attractiveness as a function of a region's capacity to attract and maintain growth, and on a more intangible level, the capacity of nature to be a source of personal renewal and restoration. The interface between beauty and technology --- one of the main ways humans express their values, ideas and global view onto the rest of the social and natural world --- had its zenith in the 19th century (Pretzer, 2009). Meyer (2008) in fact compares landscape architecture, in effect environmental modification, to art, in the belief that natural processes, when amplified, amplify the human experience. A recent CABE report (2011) found 8 out of10 people believe we should be able to experience beauty on a regular basis.

In contrast to more stable values, attitudes are generally positive or negative views of a person, place, thing, or event, and can change across contexts. The classical tool in use to measure cognitive environmental attitudes is the New Ecological Paradigm (NEP) originally developed in 1978 by Dunlap and Van Liere, and revised in 2000 (Dunlap et al.). The scale outlines an ecological worldview, with applicability at many levels of measurement (Dunlap 2008; Steg et al. 2005) (e.g. countries, disciplinary/ professional, lifestyle, age cohorts). It contains 15 statements that measure broad beliefs about the human-environment relationship, perceived consequences of environmental action, and the individual's responsibility for these problems and taking corrective actions. A plethora of previous studies indicate Schwartz's power and tradition values, as well as universalism and benevolence, distinguish underlying NEP dimensions of nature-centred versus human-centred attitudes (Schwartz & Zelezny 1999). Ecocentrists score highly on universalism and report less importance on power and tradition variables, whereas anthropocentrism is defined by greater importance of power, tradition and security values, with negative correlation to benevolence.

Methodology

A four-page questionnaire including Schwartz's abbreviated value scale (Schwartz & Bilsky 1987; Schultz & Zelezny 1999) and the NEP, with expansions, was distributed in person to final year CE (year 4) and ES (year 3) students during one core subject, respectively. Given Lundmark's critique (2007), the author added 9 additional scale items to NEP that further expand conceptualizations of the appropriate range of human response to environmental degradation (1-3), limiting economic growth and the new green economy utilizing Jackson's (2009) conceptual framework (4-6), biocentrism versus anthropocentrism (7-8), and drivers of poverty (9):

1. Humans need to take responsibility for negative action affecting future generations.
2. Humans need not adapt to the environment because we can remake it to suit our needs.
3. Flourishing of life requires human population decrease.
4. To maintain a healthy environment we have to develop a 'steady state' economy where industrial growth is controlled.
5. There are limits to growth beyond which industrial society can not expand.
6. The economy can be restructured so there is significant revenue from selling green products and services.
7. Nature is valuable for its own sake.
8. Plants and animals exist primarily to be used by humans.
9. Income gap between rich and poor is in part an environmental problem.

Final year students are hypothesized, after 3-4 years of study, to have been inculcated with a disciplinary language and values they hold upon matriculation into the workplace, where they are further shaped by peers and organizational norms. After a follow-up email was sent to each class encouraging study participation, with a random drawing for a monetary prize, the response rate was 97% for engineers (n = 46) and 88% for the environmental cohort (n=47). The two sample profiles vary significantly on gender and birth nationality variables: engineers were 93% male (n = 3 females), and the majority (55%) were born overseas, primarily in Malaysia (n = 11). Further analysis showed 6 foreign-born Australian citizens had been living in the country at least 5 years, suggesting the effective proportion of students raised in an overseas culture, while still a potentially significant confounding factor, more closely approximated 41 percent. In contrast, the environment sample

showed even gender distribution, and 13% of students were foreign born. However, there were more mature age students in the environmental cohort, with 18% older than 30 years (5% of engineers). Income level was operationalized by asking for class positioning relative to other Australian families; the sample is solidly middle class with both groups averaging 6 on a 10-point scale (10 = wealthy). In assessing potential sources of bias, it is important to note that the author is a lecturer in the environmental science program, and scores high on altruistic values and biocentric attitudes. The co-location of the two degree programs in the same school is likely to modulate differences between disciplines, thus it is intended this exploratory work is expanded to a tertiary institution where CE and ES are housed in different administrative units, as well as repeat the study at UniSA next year.

Findings - Student Values

Students self-reported the degree to which 39 values were driving forces in their life on an 8-point scale from zero (not important) to 7 (very important guiding principle in my life). They were also given the opportunity to indicate opposition to the value. Table 1 displays the top ten variables for each discipline. The priority values share extensive commonality in measurement of importance and

Table 1: Top ten personal values for each disciplinary subgroup

Rank	Value	CE ($\bar{x}$)	CE (%A & SA)	Value	ES ($\bar{x}$)	ES (% A & SA)
1	Enjoying life	6.2	72.1	Protecting env ($^{**}p<0.001$)	6.2	84.4
2	Honest	6.1	81.4	Freedom	6.2	75.5
3	Honours parents/elders	6.0	72.1	Enjoying life	6.2	77.7
4	Freedom	5.9	72.1	Honest	5.9	71.1
5	Successful ($^{**}p<0.001$)	5.8	62.8	Choosing own goals	5.9	64.5
6	Politeness	5.8	69.8	Loyal	5.9	68.9
7	Choose own goals	5.8	60.5	Unity with nature ($^{*}p< .01$)	6.0	62.2
8	Broad minded	5.7	65.2	An exciting life	5.7	64.5
9	Self-discipline	5.7	61.9	Politeness	5.6	62.2
10	An exciting life	5.6	55.8	Helpful	5.6	60.0
10	Family security	5.6	55.8			

rank: pleasure (enjoying life), openness (freedom, choosing own goals, excitement), and morality (honest, polite). Uniquely, CE rate success as a core value, suggesting a degree of desired integration with the current socio-political paradigm. However, the two biophysical-related sustainability values – protecting the environment and unity with nature – overtly guide and direct the lives of many ES students. In difference of means testing for these variables associated with self-transcendence, the difference in average score for the student subgroups is statistically significant, and CE rank the respective items quite low, with protecting the environment 25th and unity with nature 30th. The social justice component of sustainability, another self-transcendence variable, scores similarly ($\bar{x}$= 5.1 CE; $\bar{x}$ = 5.5), although ES rank the item 15th (versus 24th). The social order and social power values are conceptualized as belonging to broader orientations toward tradition and self-enhancement respectively, and the CE and ES students score and rank the items similarly ($\bar{x}$ ranges from 4.4 - 4.8).

There is a moderately sized cohort of CE students that mirror the core sustainability values of ES students. One-third (32.5%) of CE rate the importance of environmental protection at least 6, and unity with nature and social justice at least a '5' or greater, compared with 62 percent of ES. In fact, 44 percent of CE score environmental protection in the two most positive response categories (i.e. '6' or '7'). Thus it appears that a moderate number of CE are driven by strong environmental values, but many other values are dominant (including humility, loyalty, creativity, curiosity, being capable, security, and tradition). Figure 2 displays the nine values with statistically significant differences in the subgroup means by discipline. Adding to the initial finding on comparatively how important life success is to CE, being creative and capable is also more important to this cohort, suggesting a greater embedding in career and professional outcomes than ES. This theme culminates in the evidence that EM place far less importance on wealth, and some in fact oppose this value. To provide perspective,

however, the researcher notes that students in both disciplines rank wealth accumulation low (32nd CE; 38th ES). Finally, CE rank 'a world of beauty' last of all values (compared with 24th for CE), and exhibit a moderate level of opposition to this value. Given the author's earlier contention that beauty is a critical aspect of sustainability, this finding suggests a potentially critical gap in engineering and environmental education. A cluster analysis was performed using the 39 values, and only one conceptually coherent cluster (describing ES students) emerged, explaining 21% of the variance.

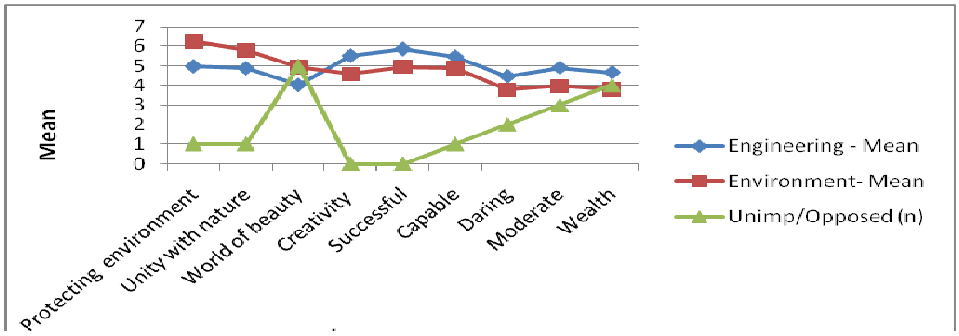


Figure 2: Statistically significant values distinguishing student subgroups

New Ecological Paradigm and Attitudinal Statements

Fourteen of 15 NEP attitudinal statements show statistically significant differences between CE and ES students. Only the dimension that human ingenuity would ensure that the earth did not become unliveable, an item measuring the anthropocentric domination dimension, was similar. Tellingly, while both subgroups express moderate optimism about the creativity and problem solving ability in modern society, CE are significantly more optimistic than ES about 'environmental conditions on earth now.' A summative statement using an 11-point scale (0=very pessimistic; 10=very optimistic) showed a 1.1 point difference (6.0 CE; 4.9 ES), suggesting inculcation of a disciplinary mindset regarding the inability to solve complex environmental threats is strongly embedded within ES. Fig. 3 continues the NEP analysis in displaying the scale items showing the greatest subgroup differences. Three additional items showed low levels of agreement for all students - humans will eventually learn enough from nature to control it, human have the right to modify the natural environment to suit their needs, and the balance of nature is strong enough to cope with environment impacts – but there was still statistically significant variation in the predicted direction. That is, ES are more cautionary about

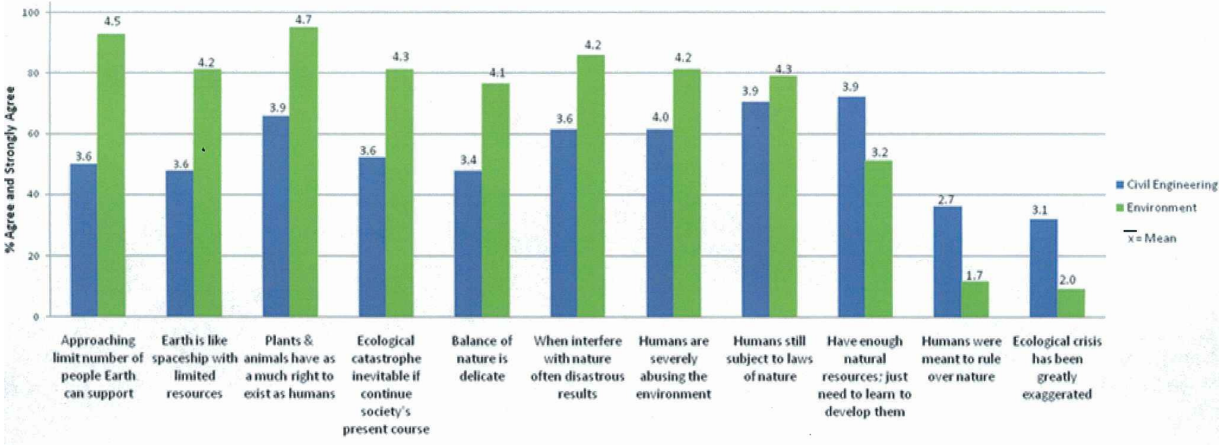


Figure 3: Attitudinal differences between disciplines for the New Ecological Paradigm

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of the additional scale items showed statistically significant differences in subgroups response. The item on each generation taking responsibility for environmental degradation into the future was included in original NEP, and still shows the highest rates of support among both disciplines, ranked either 1st or 2nd of all scale items; it shows at least 84% agreement (98% among ES). The intrinsic value of nature for its own sake, as above with NEP (right of existence, rule over nature), received

significant lower levels of agreement from engineers, suggesting biocentrism is not a common attitude among this cohort. Finally, far more ES define the rich-poor income gap, in part, as an, environmental problem (43% CE, 86% ES). Perception of limits, viability of a green economy population reduction, and the need for human adaptability show no cross-disciplinary differences.

Discussion and Conclusion

If ES students represent professionals driven by sustainability that will lead society in its evolution toward balancing economic, social and environmental considerations, CE report placing importance on many of the creative and risk taking values that western culture will need as it solves the ecological crises borne out after two hundred years of the industrial revolution, capitalist system and growth paradigm. CE appear to be more embedded in the success-oriented culture and self-improvement, as opposed to the more altruistic concerns of EM in terms of orientation to nature. Not surprisingly, environmental values guide the lives of EM, but whether the cohort of CE that 'feel' similarly (one-third) is sufficiently large and influential enough to keep the profession grounded in engineered outcomes that satisfy society's demands for environmentally responsible actions is an open question. The differing disciplinary importance placed on 'beauty' suggests study of the human cognitive and physiological response to aesthetic stimuli (Seymour 2011), and explicit use of the term 'beauty,' may strengthen the sustainability curricula in engineering. Civil engineering advances such as water-sensitive urban design, the U.S. context-sensitive highway design movement and Singapore's leadership in green infrastructure are examples of functional built environment that enhances the public aesthetic. The degree of concern for social justice is similar across both disciplines, indicating the imperative to also integrate this more weakly defined social component of sustainability in curriculum design (Kagawa 2007).

CE express opinions linked with a weak sustainability perspective that calls for change within the dominant socioeconomic status quo, while ES are more closely aligned with the strong sustainability paradigm that challenges the dominant socio-political discourse (Williams & Millington 2004). Both subgroups strongly believe in the human problem solving potential in terms of maintaining liveability on earth, but CE and ES differ markedly in their response to science, information and popular media reporting environmental degradation. The greater optimism about the status of planetary resources appears to be a function of the perceived right of humans to shape their built environment that CE express, and stronger beliefs in the resiliency of nature. This optimism serves the engineering profession as it motivates CE to respond creatively to challenge, but also may be a professional blind spot in acting with urgency as environmental crises emerge. The author would advocate for curricula that incorporates some principles of environmental psychology, with particular emphasis on inter-generational stewardship responsibility, as well as biocentrism. The emerging concern of ES for all life including animals, expressed as inter-species equity, also indicates a potential point of conflict as societal attitudes are being reshaped in this sustainability era. Although this exploratory study of final year students needs expansion with a larger sample cohort, the preliminary data calls attention to strengths in fundamental values that CE brings to current environmental problems, as well as highlights ways to strengthen educational content to enable the profession to potentially contribute even more to societal advancement under the sustainability agenda. Aighewi and Osaigbovo's (2010) research indicates non-environmental students support tertiary degree shifts incorporating more environmental literacy; further study is imperative to assess whether the reaction of the CE community is similarly open to such trans-disciplinary dialogue.

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