AN ETHICAL STANCE: ENGINEERING CURRICULA DESIGNED FOR SOCIAL RESPONSIBILITY

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ABSTRACT
It is the role of engineering to provide the global community with socially responsible, ethical and sustainable design solutions. Engineering designers must realize their potential to contribute positively to the betterment of society through product service systems that facilitate sustainable development, enhance societal well-being and empower communities to be self determining. This will require the engineering community to take leadership roles in sustainable product design and development and to engage with emerging economies to deliver appropriate designs and technologies.
Social responsibility and sustainability will need to be at the forefront of product design and development and more importantly, integrated throughout engineering education. As global designers, engineering graduates must be ethical and responsible, fully cognizant of the consequences of their professional activities, their potential for global societal contribution and their responsibilities to all stakeholders and communities. Opportunities exist for well considered curricula to drive critical global agendas, determine attitudinal change and develop new aptitude in the next engineering designers.

Keywords: socially responsible design, ethical design, engineering curriculum, sustainability

1 INTRODUCTION
Design and engineering must progress from servicing the needs of business to servicing the needs of society, particularly those communities in developing economies – the other 90 percent. It is imperative that all global communities have access to basic essential elements of life; clean drinking water, energy, sanitation, healthcare, education and the tools for self determination. Engineering competency must be balanced with social awareness, environmental sensitivity and cultural sensitivity. “Technical virtuosity is often necessary, but never sufficient” [1] The next generation of engineers must be responsible practitioners who are critically aware of the potential impact of their professional activities, cognisant of the contribution that engineering design can make to the quality of life in global communities, and imbued with the tools and design acumen to respond effectively. [2]
New directions in engineering must be led by educators, through balanced curricula that integrate the principles of sustainable design and socially responsible design throughout the learning process and focus on ‘design for need’ rather than market agendas, to achieve the requisite attitudinal change.

2 EXAMINING THE PROBLEM
“There are professions more harmful than industrial design, but only a few of them.” [3]

2.1 Market driven design
It is almost forty years since Papanek proposed that designers’ responsibilities should shift from market driven design towards social and environmental concerns. He advocated more responsible use of environmental resources and improved societal balance through new design agendas, declaring that “designers have become a dangerous breed.” He was right to be concerned.
Product design, which emerged in the 20th century, “has historically been a contingent practice rather than one based on necessity” [4] and is seen as having a fundamental role in the emergence of post WW2 consumerism. It has impacted buyer behavior through planned, technical, functional, or stylistic obsolescence, and disruptive technology and through the use of ‘consumer engineering’ (adding value to increase desirability).
By the 1950s the USA was embracing a design-led consumer culture, leading economist Victor Lebow to state "Our enormously productive economy demands that we make consumption our way of life, that we convert the buying and use of goods into rituals, that we seek our spiritual satisfaction and our

ego satisfaction in consumption. We need things consumed, burned up, worn out, replaced and discarded at an ever-increasing rate." [5]
Design is still perceived as an industry intent on stimulating demand, regardless of the need of the consumer, [6] thus becoming an important social and economic organising force perpetuating consumerism as a way of life. “Designers operate in a world where the creation of wealth is a prime motivation…the role of design in contemporary society is essential in reproducing a socio-economic system that assumes limitless growth and a continual state of desire.” [7] Although design should become more of a negotiation between the designer and the consumer, products are often imposed on a public which has little choice but to endure their social, environmental and economic impact. Miles [6] believes “the values inherent in well designed goods are actually socially divisive and that design is actually symbolic of the socially divisive nature of consumption in general.” He continues “design is not always liberating, creative or artistic, but often oppressive, conforming and dictatorial.” Morelli agrees, “the traditional disabling (and product-centred) approach offers very few opportunities to improve the living conditions of underserved populations.”[8]
More recently the problem has gained in complexity. Global warming leading to climate change, diminishing natural resources and the impact of globalisation on emerging economies (especially global inequity, resource depletion and wealth disparity) has changed the landscape significantly, yet the agendas of the product design and development industry largely remain unchanged.
The sociology of consumption is problematic to designers working in social design. Thorpe [9] states that designers are trained to add value to a business, “design is a key cog in the wheel of consumerism so it is no wonder that most designers have trouble conceiving their work in any other form than commerce and commercialism.” Indeed it is worth noting that market-driven design practice, by catering to economically powerful groups with their consumerist design ideologies, works against the possibility of a social vision in design. [7, 10]
A review of these and other positions sees the emergence of several main issues:

- Market incentives reinforce consumer-led design at the expense of social design
- When the solution is product dependant, the usefulness of the solution is dependent on the lifespan of the product
- Solutions that are not co-designed or co-owned by users and community have little value in the socially responsible design arena
- Globalisation has compounded the problem, escalating resource consumption
- Designers are inadequately trained to be effective at socially responsible design

2.2 Globalisation

Globalisation has emerged as an invasive and persistent force driving world economies. It has the potential to increase worldwide economic prosperity as well as creating opportunity, enabling empowerment and enhancing well-being especially among developing nations. It is possible that globalization will eventually lead to the enhancement of civil liberties, a higher standard of living and for free trade to result in a more efficient and equitable allocation of resources and rewards for all stakeholders.[11] However, so far globalisation hasn’t realised its potential to create a more equitable and harmonious world, instead poorer countries have suffered many disadvantages including:

- the negative impact of western government subsidies and unfair trade agreements,
- the exploitation of impoverished workers (including children)
- environmental degradation and resource depletion and
- the loss of local and regional contexts

Globalisation has even impacted upon first world economies with wide scale loss of skills and mass unemployment due to job relocation, affecting societal potential; amplified by changing cultural patterns and an aging demographic. [8] It is necessary for engineers and designers to be sensitive to the consequences of their activities, to understand the potential for a greater societal contribution and to be aware of their responsibilities to all global stakeholders, not just their clients and target market.

3 THE SOCIAL ROLE OF PRODUCT DESIGN

“We cannot, *not* change the world” [12]

3.1 Social design agendas

Since Papanek, there have been many proposals to advance a more socially responsible agenda for

product design. Whereas Papanek pitted social designers against market driven economies, Margolin [13] believes that limits the options of social designers, instead proposing that designers forge allegiances with professions related to health care, education and social work, and asks the question "what role can a designer play in a collaborative process of social intervention?" Morelli [14] takes up the issue with when he asks what the designers' role would be in a scenario where users empowered by a socially responsible action, are able to provide their own product and service solutions. He suggests that "designers will no longer be proponents of a set of product and services, but rather the facilitators of a system of value co-production." [8]

3.2 Engineering design as an agent for change

Engineering needs to develop a 'forward-looking' approach to the practice of socially responsible design. Product design has always attempted to change the world through design, but the motivation has not always been altruistic, focusing on increased sales, cheaper production and greater profit. A very real opportunity exists for engineering designers to contribute positively to the betterment of global societies, through product service systems that provide opportunities, guarantee well-being and empower communities in what we have coined the OWE-equity triad.

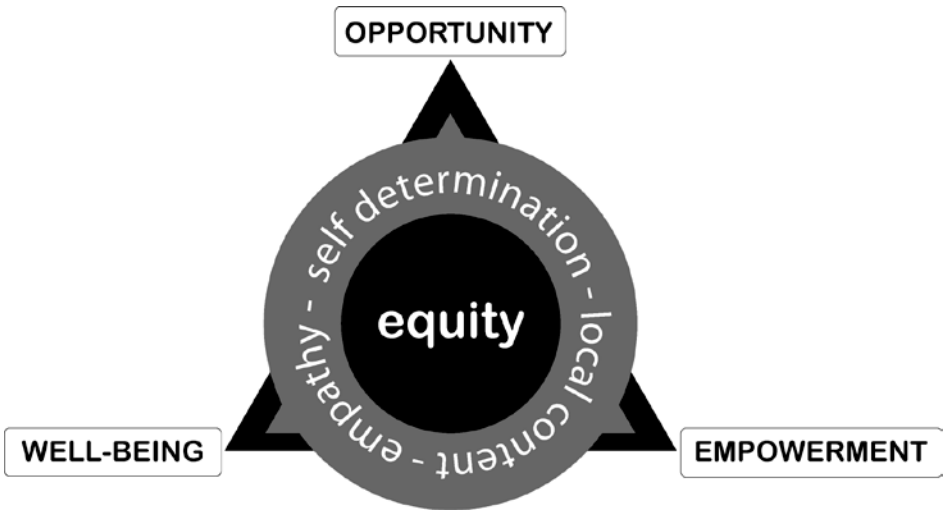

Figure 1: the OWE – equity triad (Image source: Ian de Vere)

The OWE - equity triad represents the role of socially responsible design:

- to provide opportunities for fair, sustainable and appropriate development
- to enhance the social and collective capability of a community to develop its own solution
- to enhance societal well-being through an agenda of equity, equality, and empathy
- to empower communities to be self determining,
- to empower individuals to contribute positively
- to engage with understanding in a local context, to provide local solutions

This model represents a useful platform for the teaching of social responsibility to the next engineers.

3.3 Social engineering

The engineering profession needs to maintain a firm commitment to improve the lives of those in developing nations, through the practice of 'design for need'. Engineers and designers must ensure that in their professional practice they:

- address the impact of their design and manufacturing on other communities,
- respond to critical societal and environmental issues (climate change, water, sanitation),
- develop renewable energy production systems,
- engage with communities to develop self sufficient and sustainable systems,
- involve the local community in the problem framing and design processes,
- respect cultural diversity and traditional values and ways of life,
- seek to achieve solutions that promote equity, equality and well-being,
- extend their professional responsibilities (from that of service provider).

To prepare engineers for these new societal roles and responsibilities, a fundamental change must occur, not only within the engineering profession, but within the engineering education sector. Whilst it is critical that engineering curricula includes thorough training in engineering and scientific theory, it must evolve from technical training towards a more human-centred design agenda. To achieve this, a strategic approach to social engineering must be implicit throughout educational pedagogy.

4 EDUCATING SOCIAL DESIGN ENGINEERS

"Engineering appears to be at a turning point. It is evolving from an occupation that provides clients with competent technical advice to a profession that serves the community in a socially responsible manner." [15]

4.1 The 'next' engineer

For many years engineering regulatory bodies worldwide have identified the need for a new underlining principle for engineering practice. In 'Educating Engineers for a Changing Australia' [16] Engineers Australia recognizes the need for "a high level of understanding of the broad human, economic and environmental consequences of the professional tasks engineers have to face today." These sentiments are widely held. "It is clear that engineering must go beyond pure technology...and address matters that are imbedded in the social and economic fabric of society." [17] and "in this evolving world, a new kind of engineer is needed, one who can think broadly across disciplines and consider the human dimensions that are at the heart of every design challenge." [18]

Clearly the engineering profession is at a turning point; one that could redefine the profession. Engineering designers must move from their role in market–driven product development away from products and towards more systematic solutions; it will need human-centred design, universal design, participatory design and co-design/ co-production to achieve an appropriate design agenda.

It is imperative that engineering curricula addresses a broad social context of understanding, such as the mandatory generic graduate attributes set by Engineers Australia that include:

- understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development;
- understanding of the principles of sustainable design and development
- understanding of and commitment to professional and ethical responsibilities

However there is scope (and a genuine need for) significant revision in engineering curricula (and in course accreditation) if the 'next engineers' are to be thoroughly prepared for the challenges that lie ahead. Many engineering graduates lack training and practical experience in socially responsible and sustainable design, are not fully cognisant of the potential environmental, social and economic impacts of their practice, and are insensitive to cultural idiosyncrasies. The next generation of engineering graduates will require more than the 'awareness' mandated by regulatory bodies; they will need an embedded ethical philosophy, design acumen and engagement experience to lead effective and appropriate local solutions that empower the user and their community.

4.2 Sustainability and Social Responsibility

"Sustainability cannot be conducted on the sidelines. It can only be achieved by a paradigm shift which results in sustainability becoming part of everyday life, directing the way in which communities and individuals make decisions that contribute to the realisation of broad social goals…we are uniquely placed to contribute to the development of this paradigm shift." [19]

The 'next engineers' must assume a leadership role in addressing the challenges faced by the manufacturing sector; including energy conservation, clean carbon emissions, consumption of resources, and emerging technologies. However their biggest challenge will be addressing the needs and aspirations of those who are not part of the first world consumer society; those who currently lack the basic elements that contribute to a healthy, safe and equitable lifestyle. The issues confronting these global communities are well known, but are no less devastating when reiterated. At present:

- 1.1 billion people (out of 6.9 billion) don't have access to clean, safe drinking water, [20]
- 2.6 billion lack basic sanitation, resulting in 1.8 million annual child deaths from diarrhoea.
- 1.6 billion people, a quarter of humanity live without electricity and
- up to 11 million children die each year due to conditions of poverty and debt
- at least 80% of humanity lives on less than $10 a day.
- more than one million people die each year from malaria, mostly young children

- HIV/AIDS accounted for 1 million deaths in 2009
- 963 million people suffer from chronic malnutrition
- the wealthiest 20% account for 76.6% of consumption, the poorest 20% just 1.5%

Many global societies lack the necessary resources for wellbeing, healthcare and education and are denied the tools for self-determination. Communities are in desperate need of solutions to sustainable energy production, sanitation, water supply, disease prevention, shelter, clean and efficient cooking, communication, and need permanent alternatives to ongoing humanitarian aid. Whilst we are not the instruments of these problems, it will be the responsibility of the designer/engineer to lead change that addresses these issues – we are professions with the technical ability to affect better solutions.

These substantial and complex problems will need holistic solutions, solutions that are not product focussed, but people focussed, local/regionally focussed and co-designed. We will need to ensure more efficient, responsible and equitable resource utilisation, greater opportunities for developing nations and socially responsible design solutions that "not only fulfil specific individual needs, but also enhance the social and collective capacity of a community to develop its own solution." [14]

It is estimated that 80 percent of all product-related environmental impacts are determined during the design stage, whether that be through material specification, manufacturing processes, transport or packaging requirements, resource consumption etc. Consequently, product design teams must not only be conversant with the potential negative impact of their design decisions from environmental, social, cultural and economic aspects, but are sufficiently skilled and knowledgeable to navigate these difficult decision making processes to achieve appropriate, sustainable product solutions.

But simply developing 'lower impact' products is not sufficient (even if they are more sustainable, reduce waste and reduce CO_2 emissions) if they are still feeding the material and consumption needs of market driven economies. A very opportunity exists for designers and engineers to make a positive contribution to increasing the well-being of many global communities, particularly in the areas of water supply, energy production, sanitation, heating and cooking and healthcare. One example of a successful product design contribution is the 'LifeStraw' a portable water purification device that for a relatively small cost addresses the need for safe drinking water; a positive design contribution to the UN's Millennium Development Goal[21] of improved water sources and reduction in infant mortality.

The next generation of engineers must use their skills and knowledge to address critical societal issues through collaborative alliances with humanitarian agencies and direct engagement with global societies: they will be agents of change - we must prepare them well.

4.3 Human-centred and culturally sensitive

"To better serve humanity, engineers must at least attempt to understand the human condition in all its complexity."[16] It is vital that the 'next' engineers are truly human-centred in their design practice, understanding the requirements, roles and community status of they interact with, and respecting differing nuances of behaviour and expectation.

Social research combined with community engagement facilitates significant cultural understanding and sensitivity to the value systems of differing communities. [2] Engineering students must learn the value and the tools to conduct thorough human-centered design research into the user, the culture and the environment. The traditional 'what, who, why, how, when and where' line of inquiry, should now be supplemented with new lines of inquiry based on appropriate technology guidelines:

- do they need this product/solution?
- is it culturally appropriate?
- is it locally and regionally affordable?
- does it create local jobs and develop new skills?
- can it be understood/ controlled / maintained locally?
- does it utilise decentralised energy sources?
- is it flexible and adaptive to changing circumstances?
- does it add to third world dependency?
- does it empower the community to develop / own their own solution

A good example of this approach is the Rural Integrated Development Service in Nepal (RIDS-Nepal).[22] Amongst their many initiatives is the development of a smokeless metal stove for remote communities who use open fires for cooking, lighting and heating, which results in eye and respiratory problems, lung cancer, tuberculosis, pneumonia, low life expectancy and wide spread deforestation. The design of the stove, besides addressing the key criteria of indoor air pollution and resultant health,

also achieves cleaner and safer interior environments, improved cooking, reduces the consumption of limited firewood resources by 50 percent and heats water for cooking, cleaning and hygiene.
But besides achieving all of its performance related targets, the product service systems agenda is also well considered. The stoves are made in the business centre of Nepalgunj (directly below the mountain villages) by local people trained with new skills of sheet metal fabrication and welding. In this model, the urban workers with training become skilled and free of external dependence, whilst the end user receives an affordable and effective solution that can be assembled, installed and maintained using local expertise. The "Family of 4" holistic community development project (installations of clean water, pit latrines, smokeless stove, and indoor lighting) offers a 50 percent subsidy to families.
These projects along with many others (including the “Light up the World” initiative) are led by engineer Alex Zahnd, who works directly and collaboratively with communities to realise viable resolution to local problems. These examples of successful engineering-led socially responsible design are truly inspirational for the engineering community and its educators.
In these solutions the cultural context of the solution is that of the user and their community, not the designer's projected personal values. Designers and engineers should not view their role as the provision of a product outcome (as the benefit is limited to the product lifespan) but rather view the customer as a resource rather than the problem. In this sense, design becomes a facilitating tool with power of suggestion, resulting in community enablement and lifelong solutions. [8]
Engineers need to be taught how to engage with communities to understand the problem and co-develop a solution. We advocate the following approach, derived from human centred design and appropriate technology practice.

Figure 2: a process of engagement for socially responsible design (Image source: Ian de Vere)

This ‘engagement’ approach is dependent on the design engineers actively engaging with the local community, listening to their problems, using observation and reflection to learn before engaging with the community to co-create a solution that empowers the community to determine their own destiny.

5 NEW DIRECTIONS IN ENGINEERING PEDAGOGY

“A better response lies in changing the scope and significance of what engineering is, and more important, who engineers are – namely, adept people who serve humanity through the application not simply of math and science, but of a wide array of disciplines. This new breed of engineer will be not only be a truly comprehensive problem solver, but a problem definer, leading multidisciplinary teams.” [18] This admirable aspiration for the engineering profession from Grasso and Martinelli sets a critical agenda for engineering as a profession; however engineering curricula must ensure that it prepares engineering graduates for their new roles and responsibilities.

5.1 Curriculum aims

“Engineering education has to prepare young engineers to accept sustainability as a basic design requirement for the development of products and processes …it has to provide the older generation of engineers with a reformation process in order to adjust to a technology that is in harmony with the environment” [23] Engineers need to play central (leadership) roles in developing appropriate technical solutions, however the major challenge is to educate a new generation of engineers who are capable of problem framing and working in multi-disciplinary environments. Whilst engineers occupy key roles in innovation, their practice is often limited by the current discourse of the profession; which

emphasises problem solving, but fails to involve the community in framing the problems. [23]
It is not sufficient to merely provide tacit knowledge or awareness. Deep-centred understanding and empathy is required; this can be achieved with curricula that fully integrates sustainable and socially responsible design at all stages throughout the learning journey.
The Australian Universities Community Engagement Alliance states that "exposure to curricula that are informed by real world problems and solutions promises many benefits for students and their communities." [24] Reflecting this position is the Product Design Engineering program at Swinburne University of Technology where the teaching and learning imbues students with an understanding of their societal role as engineering designers through humanitarian projects and community engagement.

5.2 Product Design Engineering

Product design engineering at Swinburne is a unique engineering design course that integrates sustainability and socially responsible design throughout the four-year undergraduate program. The curriculum is structured to ensure student awareness and understanding of socially responsible and sustainable design, and to develop responsible and appropriate practice. Sustainable design is introduced in the second year and expected to be incorporated in all future project outcomes, whilst socially responsible design is the nucleus of third and final year studies.
Students are required to embrace a 'cradle-to-cradle' philosophy [25] and to demonstrate aptitude and understanding of sustainability with appropriate low-impact material and manufacturing process selection, with consideration of energy usage, embedded energy, resource renewability and 'end of life' scenario. Critical analyses of design solutions include design for disassembly (DfD) life-cycle analysis (LCA), Design for Sustainability (D4S) and Triple Bottom Line (TBL) outcome analysis. [26]
Students are regularly presented with real world scenarios, often through direct engagement with community groups and humanitarian aid agencies (such as World Vision Australia). These scenarios are often active projects concerning disaster relief, health care provision, communication and development of remote community infrastructure. These projects "encourage human-centred research examining the contribution of the design engineer, facilitate collaborative working with communities to realize appropriate sustainable solutions, develop sensitivity to cultural issues and barriers, and demonstrate the importance of appropriate technologies." [2]
Adopting a human-centred and socially responsible design philosophy that incorporates appropriate technology principles, the product design engineering course aims to generate design solutions that help the socially and economically disadvantaged and deliver 'social' engineers into the workplace. Projects focus on the utilisation of local materials, technologies and expertise to achieve viable and appropriate solutions; this can be difficult for students expecting to deliver high quality commercially oriented product designs. Real world 'design for need' projects encourage students to shift their focus away from the allure of consumer products and unsustainable practice towards design solutions that respond to a community's immediate existence, subsistence and cultural needs; such a solution may be system or services bases rather than product focused.
"In the design perspective, a socially-responsible design solution is a solution that not only fulfils a specific individual need but also enhances social and collective capability of a community to develop its own solution. Socially-responsible design should therefore aim at generating solutions based on a mix of products and services with high cultural and social significance." [14]
It is not always possible in an educational context for students to fully engage with their targeted communities, nor to fully understand the context and cultural environment in which they are operating; however the involvement of experienced humanitarian aid workers in the projects facilitates information transfer and feedback significantly broadening student understanding and engagement.
Working collaboratively with these community groups has helped developed cultural sensitivity, a human-centred focus and a socially responsible approach to design, amongst these 'next' engineers.

5.3 Project examples

The product design engineering curriculum integrates sustainability and social responsible design to foster culturally sensitive and appropriate design, and develop a socially responsible design ethic.

5.3.1 Introducing the sustainability agenda (2nd year)

This introductory subject introduces the principles of sustainability through an environmental design project. Students undertake electronic product design, exploring the impact of 'e-waste', using ethical and eco-design means to develop 'low impact' communication devices. Design outcomes are informed

by the early inclusion of sustainable design agendas. 'Band Aid' solutions are not acceptable, neither are designs without a 'genuine need'. Designs are validated against a range of critical eco-design criteria, such as life cycle analysis and adherence to Luttrop's Ten Golden Rules of EcoDesign. [27]

Figure 3: hand powered communicator (left) and life band' emergency communication device (Image source: student generated designs- 2nd year product design engineering group projects)

5.3.2 Social responsibility and community engagement (3rd year)

Working collaboratively with a humanitarian aid agency over several years has resulted on more than 70 product design solutions addressing real world scenarios, often from active humanitarian projects. Engagment with NGO aid organisations provides students with opportunity to work closely with aid workers gaining valuable insights into the social, cultural, environmental, fiscal and technical issues that impact on successful design development and implementation of appropriate solutions. The NGO partner has supplied several scenarios from their global humanitarian relief activities including:

- low birth outcomes in Makwanpur, Nepal,
- child survival in Uttar Pradesh. India
- reducing child and maternal mortality rates in Uganda
- health service reconstruction in Banda Ache, Indonesia (post tsunami)
- Kala Azar (Leishmaniasis) disease prevention in Somalia.

These scenarios are by definition 'wicked problems' that required firstly problem framing then a human-centred design processes that included the use of Empathy Maps (to identify needs and insights) and Composite Character descriptions (to personalise the students' perception of the user). Project outcomes analyse the social, environmental and economic implications and must provide not only functional design solutions, but utilise local skills and materials, provide economic benefits to the region and empower the community to own the solution and determine their own destiny.
Many innovative appropriate design solutions have been realised, including:

- honey extractor to provide nutrition for Ugandan children
- bamboo pulp fibre portable water filter (water quality in Papua New Guinea)
- locally produced ceramic autoclave (incorporating traditional materials and craftsmanship)
- portable transpiration greenhouse to generate clean water
- solar powered food drying/preserving system
- portable vaccine and syringe transportation unit

Figure 4: ceramic autoclave utilising local materials (left) and bamboo pulp fibre portable water filter (Image source: student generated designs - 3rd year product design engineering group projects)

5.3.3 Addressing local issues

Whilst engagement with international communities is enlightening (but difficult) there is also value from engaging students in local issues where the students can more easily connect with end users and understand the local vernacular. In this local context, students have addressed urban behaviour through public transport (tram and train) design, shared ownership vehicles and shared bicycles schemes.

5.3.4 2030 carbon neutral vehicle project (4th year)

Students were challenged by an industry partner to develop a future commuter vehicle intended for shared ownership, which utilised a low carbon power source and considered recharging and collection infrastructure. Central to the project intent was the alleviation of urban problems caused by car dependency; traffic congestion, diminishing air quality, green house emissions and urban sprawl. Research examined the demands of vehicles on urban infrastructure, commuter behaviour and alternative power source technologies and these were incorporated with 'a cradle to grave' philosophy in the final designs. Project outcomes were well received by local government and facilitated sponsorship and future project involvement from Sustainability Victoria.

5.3.5 Bicycle share scheme (4th year)

The "Ozcykler' project involved students studying the Melbourne vernacular, identifying commuter behaviour patterns, transport hubs and then developing a shared public bicycle scheme. The outcomes included the bicycle design plus system design and infrastructure (hiring and payment strategies and systems and collection hubs) that were fully integrated into the local urban environment. The project addressed the congestion of Melbourne urban areas through the development of an appropriate bicycle sharing system that facilitated short urban commutes, met compulsory helmet-wearing requirements, encouraged healthy lifestyles and provided a distinctive bicycle design for promotional purposes. The project relied on human-centered research, in particular behavioral observation and needs anticipation. The result was a product service system with the potential to act as an agent of change.

5.3.5 Addressing social needs

The culmination of the course is a final year self initiated and directed 'capstone' project.
Projects must address environmental, humanitarian, medical or sustainability agendas and represent innovative human-centred design and creative engineering. Extensive research is necessary to identify critical social needs that will inform the design process. Design outcomes must be socially responsible, sustainable and appropriate for the target user, community, culture and their environs, providing graduating students with the opportunity to express their fluency and competency in social design.
Recent projects include wind and hydro-energy generators, an agricultural fertilisation/pesticide applicator that eliminates chemical spraying, a bio-ethanol generator, water purification, sanitation for disaster relief, mobility aids for the physically impaired, energy independent lighting, pest management, and an air purification system that utilise micro algae to transform CO^2 into oxygen.

5.4 Learning outcomes

Whilst collaborative projects aim to achieve successful outcomes, of far greater impact has been the learning journey and the resultant attitudinal change. Graduates have a philosophy of sustainable and socially responsible design, not just the professional skills and knowledge expected by industry.

6 CONCLUSION

"The engineering profession must be accountable not to the needs of business but to the communities and environments that are affected by its professional activities."[2] Design engineers will continue to be challenged to prevent further environmental degradation, to alleviate the impact (and causes) of climate change and ensure that future design solutions are sustainable, appropriate, and empowering. This will require a paradigm shift in the design, engineering and manufacturing sectors, driving cultural change in consumer behaviour and promoting a new awareness and consciousness in product design and development. This must be led by educators, through curricula that integrates and values the principles of sustainable and socially responsible design at all levels of the learning journey. Whilst most engineering courses cover sustainability and ethical design in some form, most theory based subjects do not provide the learning experience afforded by real world projects, consequently graduate engineers may not have the skills, knowledge and motivation to participate in social design.

We need to instil awareness, understanding and the tools to facilitate change, into the 'next' engineers; this will require a new ethical philosophy in both student and lecturer. The social and environmental impact of products must be addressed not just at the design stage, but at an educational level. Swinburne's product design engineering contributes to new engineering knowledge; ensuring students understand the impact of professional behaviour and their potential to contribute to societal welfare.

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