Computing and sustainability

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Abstract

Sustainability is a global issue and one that should concern every professional. This paper examines the relationship between sustainability and computing. Sustainability is briefly introduced and defined before a literature review of the relationship between sustainability and computing. The paper concludes that there are strong links between computing and sustainability and that these should be reflected in computing education.

Keywords: Sustainability, ICT, development, corporate responses

1 Sustainability context

United Nations Secretary-General Ban Ki-Moon (2007) argues that "information and communications technologies (ICT) are crucial in spurring development, dignity and peace". He argues that we should "turn the digital divide into digital opportunity" and that ICT should be promoted "in fighting poverty, illiteracy and disease, in protecting the environment and empowering women and girls". These statements suggest that he clearly understands the role of computing in a sustainable future.

This paper provides an overview of the place of sustainability in computing. It begins with a brief introduction to the context of sustainability and then examines the connections between computing and sustainability. Structured roughly according to stages of business development, we then examine compliance, corporate responses, and the use of ICT in sustainability, and advances in computing research.

In this section we give a brief overview to sustainability, definitions and relationship with business.

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The concept of sustainability has deep roots, born from the twentieth century realisation that human activities were endangering future life on the earth. Definitions of sustainability vary widely, from a strong environmental focus:

"Sustainable development - improving the quality of human life while living within the carrying capacity of supporting ecosystems." (IUCN 1991)

through economic approaches:

"Sustainable development: The amount of consumption that can be sustained indefinitely without degrading capital stocks, including natural capital stocks." (Costanza and Wainger 1991)

to a broad global view:

*"Sustainability- The ability to meet present needs without compromising those of future generations" (*Wikipedia, 2007)

Murcott, (1997) lists 57 definitions; a current survey would produce dozens more from a variety of contexts. Current definitions generally include three components; environment, society and economy, along with the recognition that "the well being of these three areas is intertwined, not separate" (McKeown, 2002).

Corporate awareness of sustainability concerns has been evident for more than two decades. Rondinelli and Berry (1999) report that "by 1999 more than 130 major corporations were members and financial supporters of the World Business Council for Sustainable Development, a leading international advocate of corporate environmental responsibility", with significant environmental protection initiatives in place. Many corporations have adopted "Triple Bottom Line" accounting practices, where they are required to report on environmental and social impact as well as financial outcomes.

The ISO14000 series of international standards emerged from the Rio Summit of 1992 (United Nations, 1992), with ISO14001 as the certification standard for environmental management of businesses.

Current business thinking can be exemplified by the framework outlined by Natural Step, an international non-profit organisation aiming to accelerate global sustainability (Natural Step, n.d.). According to the

Natural Step framework, an organisation should develop sustainability objectives which aim to:

1. "...eliminate our contribution to systematic increases in concentrations of substances extracted from the Earth's crust.
2. ...eliminate our contribution to systematic increases in concentrations of substances produced by society.
3. ...eliminate our contribution to systematic physical degradation of nature through over harvesting, introductions and other forms of modification.
4. ...contribute as much as we can to the meeting of human needs in our society and worldwide, over and above all the substitution and dematerialisation measures taken in meeting the first three objectives." (Natural Step, n.d.)

2 Sustainability and IT

In this section we examine the interaction of sustainability and information technology . We use a framework of increasing maturity to explore the implications of a sustainable approach on computing.

2.1 Corporate Response

In 2004, it was estimated that by 2006 the US would be producing almost 3,513 tons of obsolete computers, televisions and cell phones per day (Silicon Valley Toxics Coalition, 2004). Destined primarily for waste dumps in the developing world, this e-waste represents a growing global environmental crisis. In addition to the volume of waste, these electronic goods contain significant amounts of heavy metals and other toxic substances, which are gradually released into the groundwater.

This problem is acknowledged by manufacturers in the computing industry. Dell Inc, for example, promotes a strong message of sustainability through recycling programs, reduction of hazardous materials and energy management (Dell, 2007). Business Ethics Magazine annually publishes a list of best companies, assessed across a range of metrics including financial performance, human relations and environmental responsibility (Raths, 2006). Dell, Apple, IBM and HP consistently feature in the top ten companies, primarily on the basis of their environmental efforts. Microsoft are notable for their absence. Raths (2006) comments that "Technology seems to be a genuinely socially responsible sector."

2.2 Stage of business

Willard (2005) identifies five stages of a organisations adoption of sustainability.

Stage 1: The company feels no obligation beyond profits.

These companies are considered to be "pre-compliant". They actively rebel against sustainability regulations, while aiming to avoid financial penalties.

Stage 2: The business reactively does what it legally has to do and does it well.

Compliant Stage 2 companies pay lip service to sustainability initiatives, viewing them as costs with no overall benefit to the organisation.

An exploration of the Microsoft web site suggests that the company is in Stage 2, with few meaningful sustainability initiatives in place. The company adopted a set of environmental principles in February 2006 and supports waste recycling and carpooling. Their e-waste initiative was launched on 7 March, 2007. (Microsoft, 2007).

Stage 3 is about incremental, continuous improvements in eco-efficiency.

The company recognises the cost benefits of operational sustainability schemes, and the marketing value of community investment. Generally, these post-compliant companies are making incremental changes to their existing processes, with initiatives still "tacked on as green housekeeping". Core business functions as always.

Stage 4: The firm transforms itself. It re-brands itself as a company committed to sustainability and integrates sustainability with key business strategies.

Through the use of fully integrated strategies, Stage 4 companies create competitive advantages from sustainability initiatives.

Dell's Sustainable Business Manager (Arbogast, 2006) sees his position as one of protecting the company's future and sees a wider commitment to sustainability as crucial: stakeholders, socially responsible investor groups. The Electronics Industry Code of Conduct (EICC) is also a key document. The code "outlines standards to ensure working conditions in the supply chain are safe, workers are treated with respect and manufacturing processes are environmentally responsible". (Arbogast, 2006)

Rosenberg (2004) describes a similar position at HP: Corporate, Social and Environmental Responsibility. He describes a long legacy of "core objectives, which included good citizenship and responsible business practices".

Cortese (1999) argued that such organisations benefit from considering product chains in innovative ways. He points to the notion of "products of service": "a key to resource efficiency is to understand products as a means to deliver a service to a customer. For example, people do not want energy, they want the service it provides such as heat or light".

Stage 5: Driven by a passionate, values-based commitment to improving the well-being of the company, society, and the environment, the company helps build a better world because it is the right thing to do.

Stage 4 and Stage 5 companies behave in similar ways. They both deploy sound sustainable practices, but their motivations differ. “Stage 4 companies “do the right things” so that they are successful businesses. Stage 5 companies are successful businesses so that they can continue to “do the right things.””(Willard, 2005)

The drivers for such initiatives are unknown, but have been legitimised through financial sector activities such as the Dow Jones Sustainability Index and the FTSE4Good Index – which differs in its exclusion of “sin stocks”: weapons, tobacco etc. Such indices are used to measure the performance of companies which demonstrate socially responsible investment standards and provide ethical investment options.

2.3 Regulatory Imperative

Sustainable management is defined as an imperative to use, develop and protect natural resources in a manner which:

- Meets the needs of the present generation without compromising the ability of future generations to meet their own needs.
- Safeguards the life-supporting capacity of ecosystems.
- Avoids, remedies or mitigates adverse effects of activities on the environment.

Governmental agencies can drive sustainability initiatives by imposing regulatory systems. The 1991 Resource Management Act attempts to provides a new context for the use and preservation of resources within New Zealand/Aotearoa. Relevant provisions within the Act could be explored and incorporated into policy where appropriate to support environmental justice and the commitment to sustainability.

In the United States, the US Environmental Protection Agency has initiated several projects to reduce the environmental impact of the consumer driven information technology industry, including a compulsory federal Environmentally Preferable Purchasing program. Criteria for the program are defined in the IEEE 1680 standard and stretch from the product design stage - “Design for end of life” through extending the product lifecycle, to packaging and disposal. Measures such as the Energy Star program use informative labelling to educate consumers on ‘green’ purchasing options (EPEAT, 2006).

Case and Panciera (2005) give several examples of American government contracts requiring environmental considerations in purchasing. A RFR for Denver, for example requires information on corporate environmental responsibility practices and policies, compliance with Energy Star, third party certifications, take-back and end of life management services and use reduced, recycled, and recyclable packaging.

Yegyazarian (2006) reviews (lists really) “Eco-Friendly Tech Gear” in the popular PC World. She states “given the rising cost of energy, going green for your wallet's sake makes sense, and it could help the environment. Check out the ecologically friendly offerings below”. Apple's Take-Back Service, Voltaic's Solar Bags, and Toshiba's Satellite A105 laptop are listed (with thumbnail images).

2.4 Use of ICT in sustainability

From the earliest days of the Club of Rome, computing has had an important role in sustainability. Computing provides the tools which allow the measurement, monitoring and modelling of environmental and social systems. For example:

- GIS (Pearson and Ross 1994) (Mann and Benwell 1996)
- System models – nutrients (Smaling and Fresco 1993)
- Climate change modelling (Shackley and Wynne 1995)
- Remote sensing (Duvernoy, Albaladejo *et al.* 1994)
- Modelling complex systems eg rangelands (Redetzke and Van Dyne 1990)
- Decision support systems (Buick and Lilburne 1995)
- Human system modelling (Luckman 1994)
- Conflict resolution (Brown et al. 1994)
- Regional decision making (Despotakis, Giaoutzi et al. 1993)
- Participatory modelling (Marr, Pascoe et al. 1998)

Pahl-Wostl (2007) notes that “the increasing awareness for the complexity of environmental problems and of human-technology-environment systems has triggered the development of new management approaches.” This complexity requires the involvement of ICT systems in developing a sustainable future.

2.4.1 ICT as sustainable development enabler

Batchelor and Sugden (2003) reviewed 17 projects where computing formed the basis of large scale projects aimed at sustainable development. These include training and telecentres, networks and partnerships, eCommerce, eServices, Radio and Education. The projects were assessed against the Millennium Development Goals (MDG) for reducing poverty and creating sustainable development. The projects achieved significant progress towards the MDGs by increasing the participants’ incomes through ICT training and access to work, in addition to

"broaden(ing) the reach and/or utility of existing ICT infrastructure" (Batchelor, 2003).

The Sustainable Human Development Networking Programme (Zambrano, 1995) was a "computer mediated communication project…addressing issues of information flow by fostering information sharing within developing countries, empowering users and helping decision makers on issues related to sustainable human development." As a United Nations initiative which ran from 1992 until 2000, the project recognised that "the Internet and the widespread use of IT tools provide developing countries with a golden opportunity not only to promote sustainable development in a systematic manner but also to "leap-frog' themselves well into the 21st century."

Pade *et al*. (2006) describe success factors in ICT projects in developing countries. The problems are rarely technical; rather projects "not accompanied by, or fail to generate the broader economic and social changes". They argue that "there is a need to integrate social, cultural, institutional, economic, political and technological sustainability as vital elements in the planning and operation of ICT projects."

In New Zealand, ICT is an enabler in many development projects involving the indigenous Maori population. The government's digital strategy and agreements between local institutions and iwi provide a basis for a sustainable future based around traditional values.

2.5 Computing Research

The ACM Digital library and the associated "Guide to Computing literature" contain 750,000+ citations in computing and related fields (ACM 2007) but searching on sustainability is almost a fruitless task. Of the first 150 articles (and after that the pickings get really thin) nearly 40% are about sustainability in other contexts (usually meaning continuation). Use of IT in sustainable development are 20%, 10% are case studies about sustainable businesses or products, 13% are development of software to support sustainability analysis, and another 13% about sustainable management information systems. As a percentage of the complete body of literature, this area is extremely small.

In 2004 and again in 2006, computing research focused on identifying "long-term grand challenges for Computer Science, which could contribute to the long-term advancement of the subject, and which could be selectively adopted as a basis for policy by the funding bodies" (UKCRC, 2004). The selected Grand Challenges include education (McGettrick *et al.* 2004) but there is no mention of sustainability (nor anything like it). Reviews in 2006 led to the addition of six more Grand Challenges but again, sustainability is not seen. A major international review of ICT research in 2006 also fails to mention sustainability (Lorenson 2006).

The 2006 International Conference on Computers & Industrial Engineering was published as "Special topic: Sustainability and globalization" (Heavey, 2006). Unfortunately, not a single paper could be described as sustainability as defined here, the closest an "Ant colony algorithm for the shortest loop design problem" isn't about sustainability at all (but at least it has reference to an insect!).

2.6 Systems thinking

Software engineering has perhaps already adopted a sustainable approach without explicitly realising it - Agile proponents at least. The language of software engineering is already close to sustainability – stakeholders, interaction, and system requirements – perhaps giving evidence to an extant systems approach.

Tate (2006) uses a coral reef metaphor for the software development industry since, like a coral reef, successful software "inhabits a complex and continually evolving ecosystem..." and "the development team needs to interact with and foster its ecosystem."

While many Agile references to sustainability derive from a goal of maintaining work pace (through small teams and 40 hour weeks) and long term survival, nevertheless the notion of being aware of the environment in which the industry exists, and the need to nurture that environment, are apparent. By definition, lean methodologies are easier on people, use fewer resources and consider the needs of the stakeholders at every stage of the development and beyond (Boehm, 2004).

2.7 Conclusion

Cortese (1999, 2001) stressed the importance of articulating the future (he uses 2050). As computing professionals we need examine what role we see computing professionals playing in that future. As computing educators charged with creating those computing professionals we are doubly responsible, as we also have put in place the system to get us there.

At present there has been no review of the state of Computing Education for Sustainability. This requires urgent attention.

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