Full paper

Computing Education for Sustainability: Madrid and beyond

Alison Young and Logan Muller
Unitec New Zealand
Auckland New Zealand

+64 9 428 5050

ayoung, lmuller@unitec.ac.nz

Samuel Mann and Lesley Smith
Otago Polytechnic
Dunedin, New Zealand

+ 64 3 479 6128

smann, lsmith@ tekotago.ac.nz

ABSTRACT

This paper presents a synopsis of the report published in Inroads, December 2008, on work started by an international working group at the Innovation and Technology in Computer Science Education conference in Madrid in July 2008 and the continuation of that work in the ensuing year. The report presented a policy on Computing Education for Sustainability for adoption by SIGCSE. The original paper presented "results from a survey of Computing Educators who attended ITiCSE 2008 where such a policy statement was mooted" (Mann et al, 2008). It also sets out an action plan to integrate Education for Sustainability into computing education curriculum. This paper draws heavily on the content of the Working Group report 2008.

1. INTRODUCTION

As we move into the 21st century, technology continues to facilitate the way humans shape the world. Whether we look at our environment, our social structures, our cultural or ecological records, the picture is alarming. Worldwide, there is an increasing recognition that problems such as poverty, pollution, species annihilation, damage to ecosystems and food shortages are human created.

The working group paper of 2008 proposed a policy to be adopted by the SIGCSE as a guiding principle for computing education. It was grounded in research, in the best practice of other professions and most importantly, the need for the human race to preserve the very societal, cultural and eco systems that have enabled life on this planet.

To date the policy has not been adopted, nor brought to the attention of the SIGCSE members. At the upcoming ITiCSE conference more work on this area will be completed and enable members to see how they can incorporate sustainable concepts in their own courses and teaching areas.

This quality assured paper appeared at the *22nd Annual Conference of the National Advisory Committee on Computing Qualifications* (NACCQ 2009), Napier, New Zealand. Samuel Mann and Michael Verhaart (Eds). www.naccq.ac.nz

2. BACKGROUND

As stated in the opening paragraph of the Joint Task Force for Computing Curricula 2005:

> *Computing has dramatically influenced progress in science, engineering, business, and many other areas of human endeavor. .... and those who work in computing will have a crucial role in shaping the future.* (Joint Task Force for Computing Curricula, 2005)

Within this context, this working group paper linked computing with sustainability and offered constructive and specific recommendations to define the contribution computing education can make to sustainable life on this planet.

The way to achieve this is to think about how we think and act as sustainable practitioners. Therefore, we need to understand the concepts of social, environmental and economic sustainability in order to evaluate, question and discuss our role in the world to enable us to make changes where and when appropriate. In other words: what does it mean to be a sustainable practitioner?

The working group paper recommended that the decision be made to integrate sustainability education into every undergraduate computing course, rather than develop a stand-alone course. This demonstrates the commitment to a core value and belief, that the goal of sustainability in the world, will only be achieved through everyone learning to live and work sustainably.

A timeline for implementation was suggested and while the authors institutions are endeavouring to achieve acceptance of the 'every graduate' status for the intake of 2010, we need to have formal ACM approval of the goal and vision by September 2009 to accomplish this goal but more importantly to raise the awareness of all computing academics internationally.

3. COMPUTING AND SUSTAINABILITY

Sustainability, as a representation of the concept of survival and continued life on earth, is a word that has fallen fate to misrepresentation, fragmented meaning and even ridicule. For the purposes of this paper and ongoing work in this area, and to avert derailing of intent, the UN definition of sustainability has been adopted:

> *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* (World Commission on Environment and Development, 1987)

It is important to acknowledge that different perspectives exist and that some interpret the concepts of sustainability as a threat to 'successful' components of the modern world. Many aspects of the modern world use economics as a metric to gauge success and often the economic "cost" of sustainability becomes an accepted barrier to adoption of sustainable practice. Even the Millennium Ecosystem Assessment (Millennium Assessment, 2003), an initiative to assess the connection between life and eco systems, dedicates much of its energy to making clear the links between human life, money and the ecosystem.

While it seems odd that in the developed world there is a need to academically and pragmatically justify the connection between human life and the system that supports it, this is a product of the western economic paradigm. This concept is not new; in fact it was the father of our classical economic system, Adam Smith, who first warned that a focus on financial metrics would cause a split in social order. (Joyce, 2001).

From the outset, his economic blue print was designed to be implemented with his other works on "Moral Sentiment". Adam Smith's counter balance to wealth concentration and exploitation was a concept he referred to as "Fellow Feeling" and the "Invisible hand"; concepts that technology has further removed from the day to day reality of modern living. Hence there is social resistance to reducing the negative impacts on our life support system, especially if it means impinging on our daily comforts such as cars, hot water and consumer goods. Connection to our daily activity, business activity and the ecosystem has been well shielded by the technological revolution. Even at a professional level the role of technology and computing in sustainability still remains a somewhat distant focus of our professional ACM body.

There is much talk currently about sustainability and, more specifically, about the need to encourage a sustainable, societal conscience. There is a strong call by many for organisations and tertiary institutions to play a strong role in achieving this global sustainability vision (Blewitt & Cullingford, 2004).

It is imperative that professional computing organisations and societies play a role in the search for answers to the pressing social, civic, economic and moral problems as they are the ones with the expertise to support the future of all facets of society. It is incumbent upon them to not only lead in the technological advances of the next millennium but also lead in the sustainability challenges of our planet. The first step could be the development and adopting of a policy statement.

4. SURVEY AT ITICSE 2008

To initially gauge the awareness, understanding and beliefs of computing educators for sustainability a survey was undertaken during the ITiCSE conference in Madrid.

"We took the opportunity at ITiCSE 2008 to benchmark sustainability with the participants at ITiCSE. It may be presumed that this self-selected group of academics can be considered leaders in terms of curriculum and initiatives aimed to improve student learning." (Mann et al, 2008). To enable benchmarking, an existing survey instrument was used that was first trialled with students at Otago Polytechnic in early 2008. (Shephard, Smith & Mann 2008).

4.1 RESULTS OF THE ITICSE SURVEY

The results of the survey were divided into eight sections:

- Demographics
- New Environmental Paradigm
- Ethics
- Desire
- Activities
- Scenario
- Relevance
- Examples

As far as the demographics results were recorded it is reported in the working group final report that "71 valid responses were obtained from a total conference population of 150. The demographics of the sample show 66% male and 30% female (4% unreported). The sample has an upper career age distribution (71% being older than 40 years). Participants represent a full range of institution types, although a dominance of 65% Doctoral-awarding institutions." (Mann et al, 2008).

The New Environmental Paradigm (NEP) results showed that "the ITiCSE 2008 sample is mostly on the pro-ecological side of these categories but large standard deviations suggest a wide divergence of worldview".

In the ethics section the respondents were asked whether they agreed or disagreed with the following statement:

> *The code of ethics for computing states that employees are responsible to their employer, regardless of social or environmental consequences*

Just over half of the respondents correctly disagreed with this statement.

What was very pleasing for the authors to note was that 87% of respondents have at least a medium desire to improve the environment/community. About the same percentage of respondents think their skills and knowledge in computing can enable improvements in the environment/community.

Just over half the respondents stated that they incorporate sustainable practice activities into the courses they teach. This mainly involved "green" issues such as not having handouts and making notes available electronically. The respondents that did not incorporate sustainable activities mainly cited that the type of course

they teach was not suitable (eg data structures) or they said they did not know what to do.

A scenario was given as part of the survey:

> *In one of your graduate's first positions/jobs they are asked by their supervisor to perform a task that they consider to be unsustainable practice (i.e. has a negative impact on society or the environment). What would you recommend they do?*

Just over half the respondents chose the option to talk over the alternatives. They were also asked to give reasons for their answers and these varied from "Follow your conscience" to "Do whatever your supervisor says:

Almost 75% of the respondents declared that sustainability to computing education is medium to very highly relevant

The participants were asked for examples of sustainable practice and many and varied responses were given. These responses were ordered as to the extent to which they demonstrated a strong understanding of sustainability. The full list of responses is in Mann et al (2008), table 10.

5. POLICY STATEMENT

The Working group proposed the following statement for adoption first by SIGCSE, and eventually the ACM:

Computing and IT underpins every sector of society as a pervasive and influential discipline with global impact. As a result, computing influences the environment and society either positively or negatively. While we have seen positive benefit from incremental changes such as reductions in energy usage and recycling components, more comprehensive and transformative changes are needed to meet contemporary challenges. Therefore, our vision is that our graduates, practitioners and academics understand the concepts of social, environmental and economic sustainability in order for them to evaluate, question and discuss their role in the world and to enable them to make changes where and when appropriate. Our goal is that every graduate think and act as a "sustainable practitioner". This way computing will be a driving influence in the creation of a sustainable future in every sector it touches.

Moreover, computing educators must take a lead in sustainability so that computing practitioners can be encouraged and supported to promote sustainable practice in every sector where computing plays a role. This can primarily be achieved by the fostering of sustainability as a core value of computing education.

Creating a philosophy of Computer Education for Sustainability will be enhanced if undertaken within a context of institutional operational practice. We will then be seen to be modeling good practice.

5.1 POLICY STATEMENT UNPACKED

To be able to fully appreciate the policy statement it benefits from unpacking. As this is now the essence of the future direction that is proposed the next section is borrowed from the working group report.

Computing and IT underpins every sector of society as a pervasive and influential discipline with global impact. As a result, computing influences the environment and society either positively or negatively.

Ed Lazowska is chair of the Computing Community Consortium and in his keynote address to the Portland SIGCSE conference (Lazowska, 2008) he stated that he sees that the "future ahead is full of opportunity". Computing is enabling a transformation of all areas of science and nowhere, states Lazowska, is this more critical than in the area of sustainability: "There is no more important problem than our environment - this is the space race for today's generation". He also refers to our growing social divides and says on empowering the developing world: "Three billion people in the rural developing world need the same information we do".

The developing world's need is not for the current economies and practices like the 'developed' world. Some have stated that by doing this we would need ten earths to sustain our consumption. Rather, we need to provide the information and means of feeding and sustaining ourselves in a manner that maintains or (even better) enhances the eco system that supports us.

In his speech Lazowska also referred to some of the greatest engineering achievements of the 20th century (National Academy of Engineering, 2003). Two points in this list are interesting:

- Whilst computing is placed as a standalone "achievement" it is also a critical factor in every other achievement on that list.
- On that list of "greatest achievements" are some of the primary causes of our rapid environmental and social decline.

The working group report went on to say "Computing has come to a place where even the most disinterested acknowledge the powerful role computing plays in the ever accelerating race toward human extinction. The human race is taking on a new meaning. Our sector is well placed to increase awareness and ignite proactive approaches amongst our students and practitioners. By doing so we entrench, by default, an awareness of environmental and social issues into nearly every component of new technology and development. Our willingness to be at the forefront of technology and development comes not only with the kudos of being a "enabling science" but also carrying a responsibility of its social and environmental impacts." (Mann et al, 2008)

While we have seen positive benefit from incremental changes such as reductions in energy usage and recycling components, more comprehensive and transformative changes are needed to meet contemporary challenges.

It is part of our academic responsibility that we would like our students and our colleagues to be able to think creatively and critically and be able to make transformative changes. Jensen and Schnack argue "our point of departure is that relevant answers to environmental problems are not only a matter of quantitative changes (less consumption of resources, less transport by car, less electricity consumption, etc.), but also (and maybe more so) of qualitative changes.

Therefore, the aim of environmental education is to make students capable of envisioning alternative ways of development and to be able to participate in acting according to these objectives". (Jensen & Schnack, 1997).

Sustainability has roots in ethics and is implied in several clauses of the ACM Code of Ethics:

1.1 Contribute to society and human well-being.

1.2 Avoid harm to others.

3.1 Articulate social responsibilities of members of an organizational unit and encourage full acceptance of those responsibilities.

However our definition of development needs now to move past technological and economic acceleration to alternative metrics of success and actions that actually help sustain life on earth and not jeopardise it. The enormity of such challenges to the status quo is overwhelming and the results of inaction are the continued acceleration of environmental and social decline. However, coming back to our responsibilities and commitment to the ACM code of ethics, the enormity, difficulty and discomfort in challenging a problem does not give us immunity to our responsibilities. If we shy away as an international body representing an earth changing science, then who is left to make change?

Therefore, our vision is that our graduates, practitioners and academics understand the concepts of social, environmental and economic sustainability in order for them to evaluate, question and discuss their role in the world and to enable them to make changes where and when appropriate.

The focus of technological advancement or community development should not be on the technology, but on how we define development. The term development has become so focused on process it has lost its sense of direction and more importantly, needs to refocus its purpose and priorities.

We must accept that our science, computing science, has been a significant accelerant behind the earth and humanity's development and it is time to address, where we can, the reasons why we have not taken an active role in ensuring our science is grounded in the philosophy of sustainability.

Our sector is well placed to enhance awareness of sustainability and ignite proactive approaches in our students and practitioners. By doing so, we by default, entrench an awareness of environmental and social issues into nearly every component of new technology and development.

Our goal is that every graduate may think and act as a "sustainable practitioner".

This is the critical sentence in the policy. It sets the goal and vision for the ACM. It states our "every graduate" approach. This means that everyone who is associated with the ACM SIGCSE should have the characteristics and support for building the "sustainable practitioner" vision. A starting point of this is a focus on students in every computer related discipline and every level of education. "May think and act" was very carefully worded. Much as we might have liked to use the word "will", an institution such as the ACM is not in a position to prescribe behaviours following graduation or those of practitioners. This is akin to the "can address" described by Tilbury *et al.* 2006, but goes further than Machen's "sensitivity" (Carlson, 2006) "Think and act" highlights the balance between cognitive and action capability (Jensen & Neilson, 2003).

This way computing will be a driving influence in the creation of a sustainable future in every sector it touches.

Moreover, computing educators and iconic organisations such as ACM must take a lead in sustainability so that computing practitioners can be encouraged and supported to promote sustainable practice in every sector where computing plays a role. This can primarily be achieved by the fostering of sustainability as a core value of computing education.

This important statement sets our position that sustainability will be a part of careers and that the organisation or associated teaching institution does have a role in promoting such values. We recognise that some theorists have a different view on this (eg Fish, 2006 suggests academics should "save the world in your own time"). This can primarily be achieved by fostering education for sustainability in all our qualifications and by re-visioning and changing our approach to teaching and learning to model a transformative context for all learners.

Following Jensen & Snhack, 1997 "Education for democracy, or political liberal education, is, in itself, a fundamental educational task. We do not believe in educational efforts in relation to the environment, health and peace which are divorced from this fundamental perspective … democracy is participation. In a democracy, the members are not spectators, but participants; not equally active participants in everything all the time, naturally, but always potential participants who decide for themselves in what and when they will be involved". In other words, it is not possible to provide opportunities for transformation without a fundamental examination of both what we teach and how we teach.

As a consequence sustainable practice becomes a context and a process for learning and is recognised as a core capability within each discipline. The core capability places sustainability at the same level as other generic competencies: literacy, numeracy etc. (or, as we are fond of describing: "reading, writing and sustainability").

Creating a philosophy of Computer Education for Sustainability will be enhanced if undertaken within a context of institutional operational practice. We will then be seen to be modeling good practice.

For reasons of hidden curriculum and because it is the right thing to do, the institution needs to be an exemplar of sustainable practice (i.e. both our respective educational institutions and ACM/SIGCSE as an institution). (World Commission on Environment and Development, 1987)

6. CONCLUSION

The 2008 Working Group report recommended that "the decision be made to integrate sustainability education into every programme, rather than develop a stand-alone course. This demonstrates the commitment to a core value and belief, that the goal of sustainability in the world, will only be achieved through everyone learning to live and work sustainably."

This is still true one year on, and a major undertaking and step forward for all the stakeholders in computing education.

The Working Group is meeting again at the ITiCSE conference 2009 in Paris and will endeavour to produce resources to support computing academics to incorporate the core values of sustainability into their course, whatever they maybe and even hopefully Data Structures.

To enable the original target of achieving acceptance or "every graduate" status for the intake of 2010 we still need to have formal ACM approval by September 2009.

7. REFERENCES

Blewitt, J and Cullingford, C (2004) (Eds.), *The Sustainability Curriculum: The Challenge for Higher Education*. Earthscan, London.

Carlson, S. (2006) The Sustainable University: In Search of the Sustainable Campus. The Chronicle of Higher Education 20/10/2006. Retrieved from http://chronicle.com/free/v53/i09/09a01001.htm

Fish, S., (2006) "*Tip to Professors: Just Do Your Job*" Retrieved 12/08/2008 from http://fish.blogs.nytimes.com.

Jensen, B.B. & Nielsen, K. (2003) "Action-oriented environmental education: Clarifying the concept of action" Journal of Environmental Education Research 1:173-193

Jensen, B. B. and Schnack, K. (1997). "The action competence approach in environmental education." Environmental Education Research 3(2): 163-179.

Joyce, H. (2001) "Adam Smith and the Invisible Hand" retrieved 25th June 2009 from http://plus.maths.org/issue14/features/smith/

Joint Task Force for Computing Curricula 2005 http://www.acm.org/education/curric_vols/CC2005-March06Final.pdf

Lazowska, E., (2008) *Computer Science: Past, Present and Future.* Keynote address to SIGCSE Technical Symposium on CSE, March, 2008. Portland, Oregon. Retrieved 12/08/2008 from http://lazowska.cs.washington.edu/SIGCSE/Lazowska_SIGCSE_files/frame.htm

Millennium Assessment (2003), "*Ecosystems and Human Well-being: A Framework for Assessment*" Accessed online at http://www.millenniumassessment.org/en/Framework.aspx

National Academy of Engineering, (2008). *"Greatest Engineering Achievements of the 20th century".* Retrieved 12/08/2008 from http://www.greatachievements.org/

Shephard K, Smith N and Mann S (2008) Answering the Call: Otago Polytechnic's role in creating sustainable practitioners *31st Annual HERDSA Conference* Rotorua, New Zealand.

Tilbury, D., Janousek, S., Elias, D., & Bacha, J. (2006). *Asia Pacific Guidelines for the Development of Education for Sustainable Development Indicators*. Bangkok: UNESCO. Asia and Pacific Regional Bureau for Education.

World Commission on Environment and Development (1987) *Our Common Future: Report of the World Commission on Environment and Development*. Retrieved 12/06/08 from http://www.un-documents.net/ocf-02.htm

Mann, S., Muller, L. & Smith, L. (2008). Computing Education for Sustainability, *Inroads,* 40(4), 183-193