A Definition for a Sustainable Computing Educator

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ABSTRACT

The concept of sustainability has been penetrating the education sector for some time. In addition to degrees in sustainability, numerous majors, and indeed whole institutions have been imbuing their curricula with a sustainability perspective. Computing Education for Sustainability (CE4S) is one such framework designed for computing curricula. There are a number of interesting questions from the viewpoint of computing education: What does it mean to be a sustainable computing practitioner? What does it mean to be a sustainable (tertiary) faculty member? This paper offers a perspective on the overlap of these two questions: what does it mean to be a sustainable (tertiary) computing faculty member/educator?

Keywords: Computing Education for Sustainability (CE4S), sustainable (tertiary) computing educator

1. INTRODUCTION

Sustainability becomes a major issue across many aspects of modern society, as we contemplate the cumulative effects of resource depletion, climate change, and increasing urbanization (Brundtland, 1987). Corporations are being increasingly encouraged or required to address sustainability by their boards and stockholders so as to explore and implement sustainable practices to improve both the environment and their own competitiveness (Rusinko, 2007). At the same time, institutions of higher education are exploring methods to synthesize sustainability into their curricula (Cusick, 2009). Over the past several years, there have been a number of studies on how to integrate sustainability in higher education. These studies tended to be case-oriented and/or focused on an individual course, program, or institution (Wals & Jickling, 2002, Tilbury, 2004, Thomas and Nicita, 2002).

Focusing on computing programs, the Computing and Information Technology Research and Education New Zealand (CITRENZ, formerly NACCQ) has adopted a policy that states:

Computing and IT underpins every sector of society as a pervasive and influential discipline with global impact. The NACCQ vision is that our graduates, our practitioners and our 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.

Internationally, a working group at the 2008 Innovation and Technology in Computer Science Education (ITiCSE) conference formulated and proposed a similar policy (Mann et al., 2008). Their hope was that their policy would be adopted by the ACM Special Interest Group on Computer Science Education (SIGCSE) in particular, and eventually the Association for Computing Machinery (ACM) as a whole.

This quality assured paper appeared at the 6th annual conference of Computing and Information Technology Research and Education New Zealand (CITRENZ2015) and the 28h Annual Conference of the National Advisory Committee on Computing Qualifications, Queenstown, New Zealand, October 6-9, 2015. Michael Verhaart, Amit Sarkar, Rosemarie Tomlinson and Emre Erturk (Eds).

Computing Education for Sustainability (CE4S) (Mann et al., 2010) was developed as a framework to be referenced by computing educators to access resources for the integration of sustainability in computing curricula. It established a structure that educators can use to evaluate learning resources that meet both the need of computing curricula and also sustainable practices.

These frameworks, while useful, beg a number of operational questions from the viewpoint of computing education: What does it mean to be a sustainable computing practitioner? What does it mean to be a sustainable (tertiary) faculty member? This paper offers a perspective on the overlap of these two questions: What does it mean to be a sustainable (tertiary) computing faculty member/educator? Our goal is to provoke some cognitive dissonance and suggest some direction on how to operationalize the goal of educating for sustainability. In that respect this is not an empirical piece but, in the terms of Valentines (2004) taxonomy, a philosophical contribution to debate. Hopefully, computing educators will pay deeper attention to their paradigms, policies, purposes and practices from a sustainability perspective.

2. RELATED WORK

Sterling defined sustainable education as (Sterling, 2001):

"a change of educational culture, one which develops and embodies the theory and practice of sustainability in a way which is critically aware. It is therefore a transformative paradigm which values, sustains and realises human potential in relation to the need to attain and sustain social, economic and ecological wellbeing, recognising that they must be part of the same dynamic"

There exist a couple of pilot sustainable education programmes such as the Green Teaching Certification initiative by American University (AU).[1]

[1] We observe that the University of California, San Diego's Creating A Village for Educators (CS: CaVE) program has a focus on "sustainability." Sustainability, in this context refers

AU has developed a certification checklist and accompanying set of support materials to encourage and acknowledge "green teaching." Green teaching is defined as using less resources (e.g., paper, energy, transport etc.), making more use of online tools and activities, and including conservation and sustainability concepts in course content. The lecturers can earn a green teaching certification label for their course, which is displayed in the university's learning management system.

In essence, according to AU, the concept of green teaching is mainly measured along three axes:

- Reduction of paper use, through a wide range of activities involving online tools and systems.
- Reduction of energy use, such as turning off lights, heating, computers, etc. when they are not being used.
- Other issues, such as including sustainability topics within a lecturer's own teaching discipline, to raise student awareness.

In the green teaching evaluation process, lecturers are awarded points based on their response to 25 items relating to the first axis, 12 items relating to the second, and 8 items relating to the final component; providing a total score out of 96. Based on their score, faculty members are provided a green certification label; one to four green apple icons (A score of 90+ yields four apples/gold label).

AU self-reports (i.e. website) that over 300 faculty members have engaged in the green course certification, including over 100 in the past year. Approximately 20% achieved the four apples/gold status. Other models of certificating "green teaching" can be found at Howard University, where lecturers can be rated on a two-tier system using a 'thumbs-up' label (CETLA (n.d.)); and at Duke University, which attempts to identify, on the basis of answers to 35 checklist questions, courses and lecturers that require instructional design advice to better meet the ideas of green teaching in (Green Classroom Certification. (n.d.)).

The CE4S developed by (Mann et al., 2010) addresses one of the barriers, a perceived paucity of resources which have been identified in the integration of sustainability into computing teaching. The CE4S framework has developed a structure that could be used by educators to identify and access resources that meet both the need of computing curriculum and also sustainable practices. It is an iterative process which includes brainstorming, categorization, synthesis, and group and individual application of the framework leading to further refinement. Furthermore, it consists of twenty-three questions grouped under six themes: Sustainability Philosophy, Sustainable Practice Philosophy, Sustainable Practice Guidelines, Curriculum Integration, Linking and Connection, and Disciplinary Issues. Additionally, the concept of the sustainable practitioner has been proposed in (Mann & Smith, 2008). Each discipline is coming to terms with what it means to be a sustainable practitioner. These are expressed as a statement starting "*A sustainable practitioner in <discipline> is someone who*….". This is accompanied by some short narratives that describe the desired behaviours in term of sustainability.

By comparing these pilot initiatives above, we have found that the checklist-driven activity does not encourage deep thinking. Furthermore, checklists need updating whenever a new measure can be identified. In contrast the CE4S framework is more mentally driven to provoke in-depth thinking while still concentrating on the education contents related to sustainability. However, there is a lack of in-depth exploration into the computing education/educator itself in terms of their sustainable development.

3. A SUSTAINABLE COMPUTING EDUCATOR

Given the above, we propose a perspective on how one might operationalize the CE4S framework in term of being a sustainable computing educator without resorting to a shallow thinking checklist of activities (Meola, 2004). The basic premise builds on the recognition that educators in general and computing educators in particular, face a myriad of decision points. Some of these decisions are daily (e.g. lecture content and delivery approach), others are periodic (e.g. how should student "product" be submitted for evaluation), while others are infrequent (e.g. textbook selection). Each of these decisions are considered from a multiplicity of perspectives, e.g. cost, convenience, comfort level/familiarity, pedagogy. We propose that computing educators introduce a new, additional perspective; sustainability.

In general, the awareness of a sustainability perspective in one's daily teaching activities can be poor or absent. Adding a sustainability perspective into the daily, periodic, and even infrequent decision making process can be challenging. We recognize that encouraging educators to reflect upon thinking and acting sustainably in their teaching regiment can be a delicate exercise. A technique in (Fincher et al, 2001) is outlined below, which allows an educator to encapsulate a pedagogical practice in a way that it can be shared between educators. The use of a 'practice bundle' can facilitate a group reflective process for thinking about, process review and diagnosis of issues preventing sustainable development.

The bundle format (Fincher et al, 2001)

1. Problem Statement
Each bundle starts with a formulation of a general problem to which the body of the bundle is a specific solution.

2. Body
The Body of each bundle is presented in a format that shares certain formulaic phrases. These are:

This Bundle	A phrase which captures the essence of the practice
The way it works is	A description of what is involved (this may be quite short, or many paragraphs long.
It works better if	Key criteria for success
It doesn't work if	Watchpoints for unsuitable (or undesirable) situations

Every bundle has these. Additionally, they may be supplemented by:

It doesn't work unless	Points which are absolutely required
You'll know it's worked if	Ways to check that the desired result has been achieved
Variations	Other ways this might work (mostly, but not always, we have observed these " in real life")

3. Solution Statement
Following the body of the bundle is a general solution which refers back to the initial problem statement.

Figure 1. The practice bundle format (Fincher et al., 2001)

We provide the following four different examples of practices for such a sustainable thought review and diagnosis process:

- Textbook Selection
- Lecture Delivery
- Submission and Marking of Student Product
- Search Information

Rather than repeating, we only use the practice bundle format to present the first decision point, i.e., textbook selection.

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to a sustainable course content practice and how to support secondary computing teachers in their quest to keep their course content timely.

Other bundle practices can reference the textbook selection practice processes by replacing the topic of decision point, while we provide the motivations and possible options for other three examples.

3.1 Textbook selection

This bundle allows one to facilitate a group reflective process on the infrequent textbook selection decision. The possible options include:

- Current edition, hard copy book. This traditional approach is typically the most expensive for students.
- Non-current edition, hard copy book. Edition, *i-1* is often acceptable for undergraduate use. Furthermore, student cost is typically a small fraction of the cost of the current edition.
- Current edition e-book; rental or purchase.
- Non-current edition e-book. This choice is often free through university libraries and/or publisher websites.

Without adding sustainability into the mix, this is already a difficult decision. Pedagogically, hard copy books are considered superior to e-books e.g. highlighting, note taking in margins. Hard copy, current editions can be too expensive, encouraging students to forego their purchase. E-books, while cost effective or free, do not persist on students' bookshelves after their semester of use, preventing their use as reference material in the future.

Considering sustainability as an additional perspective further complicates this decision. Old hard copy editions are purchased and shipped individually by students vs the bulk purchase and shipping of a current edition. E-book use requires an increase in electricity demand. This in turn leads to a consideration of where one's electricity comes from: clean hydro (e.g. New Zealand) or the burning of coal (Ohio, USA).

While instructors, even when introducing sustainability into their decision process, can arrive at their choice individually, there is great benefit to employing a group reflective process. Though CE4S simply recommends a group application, we are partial to the Practice Bundle format described by Fincher et al.

The way it works is to allow a coordinator (e.g., a senior academic) to arrange a face-to-face group reflective meeting with several faculty members. Each member completes a self-evaluation questionnaire on how they select a textbook and what are the rationales behind their choice. The coordinator, after briefly reviewing them, lays out the different choices. He /She then leads a discussion on an option-by-option basis according to a multiplicity of perspectives such as cost, convenience, comfort level, pedagogy, and also sustainability. The comparison table below may be employed. The different considerations are noted and a further thought provoking discussion on which choice is more sustainable can be elicited and elaborated to the group members.

Table 1 The comparison of textbook selection options

Textbook options	Cost	Convenience	Comfort level	Pedagogy	Sustainability
Current edition, hard copy					
Non-current edition, hard copy					
Current edition e-book					
Non-current edition, e-book					

It works better if the facilitator emphasizes the subjective nature of the textbook selection and the fact that these are perceptions to which each person is entitled. The goal is to improve the think, selection and decision process in term of sustainable development, and to diagnose potential issues preventing one from thinking and acting sustainably. It is also an opportunity for each member of the team to experience a form of in-depth thinking review and metacognition, which might lead participants to learn something new about themselves in the process.

It also works better if the exercise is conducted in a spirit of openness and generosity and manages to avoid judgment and defensiveness. At the conclusion of the meeting, the facilitator summarizes the outcomes and thanks the group members for their contribution to the process.

It doesn't work unless group members are willing to take personal risks by exposing themselves to honest criticism, are prepared to be honest and direct about opinions of colleagues, and have some commitment to learning from the process. It makes demands of the facilitator, who can fail to read the situation carefully, manage the criticisms, and resolve the issues that arise in a positive and active manner.

Finally, the facilitator could motivate the participants to further explore this decision point by reading additional relevant papers. For example, an interesting review of the role of textbooks in Computer Science (Dale, 2010) and the comparative studies between e-books and printed books in (Kozak & Keolelan, 2003 and Nelson, 2008)

3.2 Lecture Delivery

Though lectures happen more frequently than textbook selection, instructors tend to utilize one lecture delivery approach as their primary methodology. While one can engage in a Practice Bundle to examine one's options in this domain, we limit our discussion of this topic as well as the next two topics to the potential trade-offs when one introduces sustainability into the decision making mix.

The options typically include:

- Chalkboard/Whiteboard: The choice here is between a digital or projection technology vs instructor handwriting. If one elects instructor handwriting, the choice between chalkboard and whiteboard is usually dictated by the constraints of the assigned room. Current education research considers instructor handwriting to be pedagogically superior since lecture delivery speed roughly matches student note taking speed (MacLaren, 2014). Chalk would be a more sustainable choice over whiteboard markers – chalk does not dry out, nor end up in a landfill.
- Digital Projection (e.g. PowerPoint): The ultimate convenient reuse approach. (Especially if one employs textbook supplied slides vs instructor created slides.) This choice, though, requires two electricity using devices.

The comparison table below may be employed.

Table 2 The comparison of lecture delivery options

Lecture delivery options	Cost	Convenience	Comfort level	Pedagogy	Sustainability
Chalkboard					
Whiteboard					
Digital projection (data camera)					
Digital projection (Powerpoint presentation)					

For exploring this decision point further, individuals or practice Bundle participants) can be referred relevant papers such as Hill et al. (2012), MacLaren (2014), Peluchette & Rust (2005) and Friedland & Pauls (2005).

3.3 Submission and Marking of Student Product

This topic, more than the above two, has special considerations with regard to computing education. Frequently, student submitted artefacts are (hopefully) working programs. Hence, it almost goes without saying that an electronic submission is required.

The choice point is whether students should also submit printed hardcopy. Online grading systems lack the flexibility (i.e. any moment, any place marking) and richness that can be achieved by a conscientious grader armed with a red pen.

The comparison table below may be employed.

Table 3 The comparison of artefact submission and marking options

Artefact Submission and Marking	Cost	Convenience	Comfort level	Pedagogy	Sustainability
Hard copy submission and marking					
Online submisson but marking on hard copy					
Online submisson and marking					

As noted in MacLaren (2014) the rise of more usable pen based tablet computers now provides a further option (i.e., 3rd option of online marking) which could be considered in this evaluation.

Further exploration of this decision point can be found in papers by Liversidge (2009), Lloyd (2011) and Schomisch (2012).

3.4 Search Information

Students often joke that all of education can be boiled down to learning one word: "Google." One author recalls that in a paper where the current hard copy edition was the selected textbook, one student who could not afford the book would simply perform a search on the lecture topic of the day and read entries (online lecture notes, Wikipedia) in parallel to the lecture. Not surprising, this student often asked the best questions as he struggled to synthesize both the lecture and the searched materials.

What is less well understood is that every use of a "cloud" service contributes to climate change. Large cloud-based server farms are electricity intensive industrial sites. A search followed by a site visit is virtually twice as expensive as utilizing a bookmark. When considering the mantra of reduce-recuse-recycle, browser bookmarks fall under the reuse category.

Just as we teach students how to read (deeply), analyse a problem and write cogently, we should also teach (and model) how to search appropriately.

The comparison table below may be employed.

Table 4 The comparison of information search options

Search Information	Cost	Convenience	Comfort level	Pedagogy	Sustainability
Internet Search					
Internet Search with Browser Bookmarks					

For exploring this decision point further, individuals and practice bundle participants can be referred papers such as Brophy & Bawden (2005), Anglada (2014) and Jansen& Spink (2006).

3.5 Discussion

Regardless of what conclusions one comes to with the above four decision points, it is always useful to discuss your decision and your decision process with your students. While not the same as participating in a reflective process with one's peers, one may still gain valuable insight. More importantly these discussions sensitize students to the daily trade-offs we make in our micro level activities, even in the educational setting, that have impacts for sustainability. These discussions therefore can contribute to learning and teaching sustainability in a computing discipline context.

One author learned more about the online vs paper submission issue from a student discussion. At least according to information provided by a paper-producing consortium, in North America, paper production compares favorably to additional coal-generated electricity utilization. Paper has a relatively tight reuse cycle and is essentially renewable. Coal, from mining to burning has few sustainability-based advantages, except possibly transportation distance to market. Hence, printing hardcopy is not as un-sustainable as one might initially have considered.

4. CONCLUSIONS

In this paper we have argued that the sustainable computing educator is someone who makes explicit the daily choices and trade-offs we make in an educational setting and their impacts for sustainability. In this way sustainability becomes not about adhering to a manifesto driven checklist, but an actively lived reality. Students can thereby relate sustainability thinking both to their discipline and the learning context.

By highlighting how one introduce sustainability choices through a selection of practice bundles, we hope to help operationalise the work of the sustainable computing educator. Our hope is that computing educators will use these examples or better yet create new practice bundles to embed sustainability awareness into their courses with a minimum of effort.

The benefits of translating the significance of daily actions and technological choices is hopefully more evident to ourselves as computing educators. Sustainable practice means adding a new axis of consideration to both frequent as well as infrequent decision points instead of simply following checklists. Optimally, individual conclusions are improved through the participation in a group reflective practice. Finally, we hope that our approach to operationalize sustainability in computing education will help build a more thoughtful sustainability awareness in our students.

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