Imagining a sustainable future: the role of aesthetic knowledge in shaping emergent thinking of sustainable development

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Abstract

Over the last decade, the sustainable development agenda has crept into mainstream societal discourse, with increasing acknowledgement of the triple-bottom-line approach of ensuring well-being in terms of economic, social and environmental concerns. However, as knowledge about the agenda continues to be developed, there are still a lot of vagaries associated with the concept, which in turn leads to difficulties in its enactment. Consequently, embedding sustainable development in the engineering curriculum can be problematic. By its very nature, engineering education is used to proffering a deterministic approach to understanding theoretical concepts. This dominant approach does not align well with the emergent thinking of sustainable development. Furthermore, the sustainable development agenda has much to do with engendering future thinking, and so it is very difficult to use conventional text-based approaches to help students visualise what a sustainable future might look like. The contribution of this article is a critical reflection of a series of student workshops aimed at promoting debates around developing a sustainable future. Students were encouraged to actively participate in shaping their thoughts about a sustainable future. To enable students to develop and articulate their thinking about such a nebulous concept as sustainable development, the workshops have been designed with "Open-space" format in mind. A range of artefacts from picture illustrations to wiki terms to art material and chill-out music have been deployed to stimulate active participation. In this article, attention is focused on critically appraising the role aesthetic knowledge plays in shaping thinking about sustainable development, and the role of educators in making this happen.

Keywords: aesthetic knowledge, participant observations, rich pictures, sensemaking, threshold concepts

Introduction

Since its inception in the 1980s, the sustainable development agenda has increasingly gained legitimacy in mainstream political, business and academic discourses [see e.g. 1]. From environmental concerns regarding global warming and climate change, to the sustenance of economic prosperity, and progress made on social justice, governmental and corporate policy-makers across the globe are gradually putting credence and effort into creating a more sustainable future. The higher education sector has also responded to this movement by incorporating critical aspects – namely economic, social and environmental perspectives – of the sustainable development agenda within the curriculum [see e.g. 2; 3, and 4]. Within engineering professions, there is increasing acknowledgement of the agenda in professional thinking, and there are ongoing debates as to how this might be reflected within professional codes of practice [see 5].

Given this backdrop, there is little value for this article to reiterate the importance of the sustainable development agenda in the education of engineering students; indeed, this is a well-rehearsed point.

Instead, the focus here is on how sustainable development concepts may be effectively taught to and learned by engineering students. Whilst the literature has been considerably comprehensive in its treatment of how the design of the curriculum, in terms of content and process issues [see e.g. 2; 4; 6, 7 and 8], can embrace the sustainable development agenda, the teaching and learning activities (including mediating tools and artefacts) used in the engineering education context have surprisingly been given scant attention [for exceptions, see e.g. 9 and 10]. Arguably, any strategic re-design of the content and process of the curriculum would remain futile without understanding how tools and artefacts can be deployed in a tactically effective manner to enhance the practices of teaching and learning for the benefit of students' understanding of such a complex concept as sustainable development. Thus, the contribution of this article is to offer some deeper insights into the role mediating tools and artefacts play in helping students appropriate the complexities of the sustainable development agenda so that a more holistic pedagogical approach may be garnered. To do this, the article draws upon critical reflections from participant observations of a workshop session aimed at developing leadership skills and futures thinking across three cohorts of postgraduate engineering project-management students in Sweden and the United Kingdom. The workshop was particularly designed to get students to create a rich picture of their visions of the future. Two types of aids were provided: visual images and wiki-terms to stimulate the students' mental frames and traditional art and craft tools such as empty A1 paper, coloured pens, glue and scissors. In a sense, this is not dissimilar to the backcasting methodology explained by Quist *et al.* [9] or the use of associative images as devised by Rehal and Birgesson [11]. The crux of this article revolves around a discussion of how these aids have enabled students to rapidly appreciate the difficulties of what it means to create a sustainable future and the process by which the students have generated the rich pictures of their visions of the future. The discussion highlights the limitations of conventional forms of instruction-based teacher-led learning objectives and reflects on the educational outcomes attained by such an exercise.

This article is organised in three sections. A salient review of the literature is first presented summarising progress made in embedding sustainable development within the engineering curriculum in universities. Two fundamental issues are addressed in this review. Firstly, definitional perspectives of sustainable development are provided to illustrate just how dynamic and incomplete knowledge about sustainable development is. Consequently, this renders traditional, objectivised views on knowledge transfer somewhat inadequate. Secondly, the review exemplifies how the higher education sector has hitherto embraced sustainable development in the transformation of the engineering curriculum. It is maintained that much more focus has been placed on strategic concerns – including processes and policy frameworks in universities, and structural characteristics of interactions between universities, industry and wider society – than on the tactical approaches associated with the practices of teaching and learning. Following the literature review, the empirical context is described in the second section. Here, the rationale of the workshop and the significance of the visual aids and crafting tools are explained alongside a number of interesting observations. These observations point to the difficulties encountered by engineering students in dealing with the fuzziness of the sustainable development agenda, the benefits of using visual aids and empty spaces to create individual and collective knowledge beyond text, and the sense-making journey that students (and staff) go through during the exercise. Finally, the article concludes with a discussion of the role of the educator in unleashing the potential of using a variety of mediating artefacts to enable the students to grapple with emergent thinking about sustainable development.

Embedding sustainable development in engineering education in universities: where have we got to?

At its core, the sustainable development agenda, which rose to prominence after the publication of the well-known Brundtland report [12], is about ensuring a good quality of life for everyone, now and in the future [see also 13]. de Haan [14] deconstructed this agenda, suggesting that the attention placed on sustainable development stemmed from a stark recognition of ecological crises confronting modern-day society and the quest to remedy social injustice that prevents equal opportunities for every human being across the world. Of course, resolving these environmental and social problems requires

an understanding of economic perspectives as well [see e.g. 15]. The dominance of the economic imperative in policy-making is exemplified by the high-profile report on climate change – the Stern report [16] – which stoked fears that inaction would lead to the detriment of the global economy. Hence, the sustainable development agenda is colloquially referred to as the triple-bottom-line, ensuring the sustenance of profits, people and planet.

However, knowledge about sustainable development remains incomplete. There are still many aspects that require considerable debate and research in order to develop appropriate interventions. One such issue is the precise scale of the problems associated with sustainable development, and how far interventions should be undertaken by the present generation. Neumayer [17; see also 18], for example, argued that "both the natural and economic science of global warming is unable to provide unambiguous answers (p. 41)." Wackernagel *et al.* [19] noted that it is certainly difficult to establish what good practices need to be adopted by the present generation, because "Present demand that damages future supply will only show up in future Footprint assessments. The Footprint and Biocapacity thus derive directly from prevailing yields, and do not make adjustments for ''good'' or ''bad'' management practices (p. 276)." Therefore, societies are left to their own moral devices to establish the extent by which current consumption is checked in order to safeguard a more sustainable future; such moral judgements are framed within the so-called precautionary principle [see e.g. 17]. de Haan [14] encapsulated these moral judgements as he stressed on the nature of trade-offs when discussing the triple-bottom-line:

> "Despite a general consensus over the model of sustainability, a highly controversial debate rages over concretizing objectives, formulating priorities in acting, and developing strategies. Should the first priority be to maintain biodiversity, halt climate change and reduce consumption of resources, should the priority be to achieve a balance between poor and rich countries, or is economic development more important since it creates the conditions for more prosperity? Should we even ask such questions, or should we immediately insist on a balance? And can such a balance exist? The scientific and political differences in these questions are considerable (p. 20)."

Thus, the incompleteness of knowledge about sustainable development presents a major obstacle to efforts made on incorporating sustainable development within engineering education. Traditionally, engineering degree programmes have adhered to a deterministic and technocratic view of knowledge as a packaged product that can be transferred from the teacher/expert to the student/novice, and solutions to perceived problems are generally only allowed a narrow margin for manoeuvre [see 7, 20 and 21]. Therefore, it is unsurprising to note that engineering students often conflate their understanding of the sustainable development agenda with technological solutions to environmental problems [see 10], and that their knowledge about wider societal and economic issues remain somewhat unsatisfactory [see 8]. Attempts have been made to redress this myopia found in engineering education, ranging from cursory treatments such as bolting-on aspects of social science on to engineering degree programmes [see 9], to calls for radicalising scientific education so that the emphasis moves away from conventional subjects based on normative science to designing the curriculum to enable students to better understand the complexities associated with sustainable development [see 22]. Indeed, from a pedagogical standpoint, because knowledge about sustainable development remains incomplete, the teaching and learning of such a complex agenda runs counter to the contemporary pedagogical practice of framing manageable chunks of discrete learning outcomes [see 23 for a critique of the problems with learning outcomes in higher education]. In a recent survey of sustainable development teachers, students and practitioners, Mulder [24] confirmed that the treatment of sustainable development was far from normative, and that there was not a singular, coherent view of a sustainable future. Thus, this makes the normal articulation of concrete learning outcomes challenging.

Nonetheless, progress has been made since the conceptualisation of the sustainable development agenda in the 1980s to overhaul higher education. For instance, Sammalisto and Lindhqvist [4] urged universities to undertake a root-and-branch review of all aspects of teaching, learning and research to see what is being done to integrate concepts of sustainable development within these activities. Moore [25] also suggested systemic transformation in higher education so that universities become effective change agents by creating sustainable development education beyond the classroom in a number of ways, including the need for universities to integrate sustainability into all university decisions and to

actively encourage transdisciplinarity and collaboration across all university functions of teaching, research and service. Wright [26] considered the significance of leadership from university presidents in promoting sustainable development practices across all levels of the university hierarchy. Martins and Mata [1] and Stephens *et al.* [3] reflected on the external interactions with universities and suggested that more could be done to involve stakeholders from industry and communities in activities that can promote wider understanding of sustainable development.

In summary, strides have been made in higher education in general, and engineering education in particular, to embrace the sustainable development agenda. Consensus is building around a number of recurrent themes. The contingent and emergent nature of knowledge about sustainable development has been acknowledged. Thus, instead of focussing on universal truths as is the case in conventional, normative science, the emphasis should be on transformative education, where students are encouraged to undergo a journey of self-discovery, to formulate their own learning outcomes as opposed to have teacher-led learning outcomes imposed on them, and to construct knowledge using their own experiences in the world juxtaposed by divergent points of view [see 24 and 27]. According to Colucci-Gray *et al.* [22], students would benefit by developing the ability to engage in scientific argumentation so as to articulate, and convince others, of their views about the 'truth' and to better handle conflicting positions in tackling the complexities of the sustainable development agenda. Students should also be given the space to engage in inter-disciplinary dialogue, and be exposed to a mixture of interactive methods, including role-play scenarios, case study analyses, and site visits to critically observe how practitioners cope with the agenda [see e.g. 10 and 28].

However, the attention hitherto has been on strategic concerns, where the focus has either been on structural characteristics of higher education to embrace the sustainable development agenda (i.e. the way universities organise internal processes and/or external relations) or the (re-)design of the curriculum. As a consequence, there is relatively less attention paid to the scrutiny of the (tactical) practices of teaching and learning of sustainable development. There seems to be a tacit assumption that as long as the strategic concerns have been addressed, the practices would be unproblematic. Therefore, the article contributes by offering deeper insights into one such practice of teaching and learning – the sustainable development workshop as part of a leadership course for engineering management postgraduate students. Specifically, the article presents a critical reflection of the tools and artefacts used during the workshop in order to explore the role these play in enabling effective knowledge construction and knowledge exchange.

The empirical context: the design and execution of the workshop and the outcomes

The original workshop formed part of an elective course entitled *Leadership and Communication* within an international masters-level programme in project management at the Department of Civil and Environmental Engineering at Chalmers University. The course is designed such that academic and industry experts are invited to run a day-long workshop on a specific theme each week of the course. Students then work in groups to complete a written reflection that demonstrates their learning of each of the weekly themes. The specific workshop that is reported here relates to the theme of "Leadership, futures thinking and sustainable development." The workshop was first carried out in February 2009, and subsequently repeated to a similar group of students at the School of Mechanical, Aerospace and Civil Engineering at the University of Manchester in November 2009, and later in Chalmers University in March 2010. The critical reflection presented here draws upon the observation notes of the educators involved collected over three cohorts of students and the reflective texts of the students. Each cohort comprised around 50 – 70 international and home students.

The workshop runs over a whole day and is designed to allow students to undergo a transformative learning experience, enabling them to engage in a meaningful dialogue with their peers and teachers on their understandings and visions of a sustainable future [22; 27, and 28]. The "learning outcomes" of the workshop session were loosely framed around two key issues: (i) to explain various theoretical approaches to understanding leadership and communication, and; (ii) to discuss futures thinking and sustainable development within the leadership context. These two objectives serve more as a guide to signpost the activities of the workshop for the students, rather than as a managerial way of commoditising the learning experience [23]. Conventional didactic lecturing is kept to a minimum for

the workshop, except to introduce key theoretical concepts of leadership at the beginning (which the students would have heard about numerous times throughout the course) and more importantly, to induct the students into the format of the workshop.

As mentioned previously, the format of the workshop is designed to maximise opportunities for dialogue and self-discovery. To this end, a number of activities were incorporated. Firstly, ice-breaking sessions were strategically integrated to prevent monotony in the proceedings. These sessions were intended to build students' confidence in sharing their ideas with the wider group, and included such activities as "Identify the picture of leaders" and "What would you say in your interview for a leadership position?"[1] The focal point of the workshop, however, centres around the "Rich pictures" activity. After the theoretical preliminaries and some ice-breaking activities, students were tasked to:

- Firstly: physically re-shape the room by moving the tables and chairs to the sides of the room. Thus, a large empty space was created;
- Secondly: to organically form small groups (of no more than 8 members) and to individually reflect on their own vision of what a sustainable future could look like and to share their visions in their groups;
- Thirdly: to design a group poster to illustrate their collective vision of a sustainable future and to display the posters around the room to facilitate open discussions.

To generate a collective vision of the future and articulate this within a poster can be an extremely daunting task for students especially with an engineering background. The open and abstract nature of the activity may cause anxiety since engineering students have been trained, rightly or wrongly, to deal with discretely bounded problems. Therefore, to facilitate the process of developing their rich pictures, a wide variety of visual images representing e.g. poverty, work-life balance, water shortages, climate change, economic well-being as well as a number of "wiki-terms" defining contemporary issues (e.g. nanotechnology, biomimicry, intergenerational equity etc.) were printed on postcard-sized paper and scattered across the empty space of the workshop room (see Fig. 1 "Left" below).

Fig. 1. Photographs from the Swedish workshop in February 2009 (Left: at the start of the exercise; Middle: students making sense of the activity, and; Right: a group of students with their 'rich picture').

This organic manner of self-organisation follows the "Open-space" format developed by Owen [30], who based the idea on his observations of the effectiveness of coffee-break conversations outside the formal proceedings of conferences he had attended and organised. According to him, the "Open-space" format is a rapid way to encourage "situations where a diverse group of people must deal with complex and potentially conflicting material in innovative and productive ways. It is particularly powerful when nobody knows the answer, and the ongoing participation of a number of people is required to deal with the questions (p. 15)." Therefore, it seemed reasonable that such a format for the workshop would be beneficial to encourage students to grapple with the complexities and conflicting nature of the sustainable development agenda, in a very short space of time. We wanted the students to be actively implicated in creating a "new" learning space, hence the symbolic reshaping of the work space. To further enhance the experience, contemporary chill-out music is played in the background to

[1] "Identify the picture of leaders" involved getting students to name the pictures of various high-profile people (e.g. politicians, CEOs, celebrities etc.), which would include key figures from each of the national contexts. "What would you say in your interview for a leadership position?" was designed to get students to assume the role of a particular character, fictional (e.g. Harry Potter, Bart Simpson etc.) or real (e.g. politicians, CEOs, celebrities etc.), and they had to come up with a brief paragraph of no longer than 50 words to say why they were worthy to assume a leadership role. The ice-breaking sessions were meant to be interactive on the one hand, and to stimulate the students to appreciate emergent thinking with reference to leadership on the other [29].

simulate the environment of a lounge. Based on the observations of three workshop sessions, three critical aspects have transpired: the students' ability to *cope with emergence*, the role artefacts play in helping students *maximise sensible knowledge beyond text*, and the *diversity in the sense-making* abilities of the students. These will be elaborated in turn in the remainder of this section.

Breaking with the tradition of objectivised knowledge transmission: coping with emergence

Early on, we highlighted the tension between the traditions of engineering education that emphasises the transfer of objectivised knowledge commoditised in discrete, manageable chunks, and the fuzzy and emergent nature of knowledge about the sustainable development agenda. In this connection, our first striking observation is the level of discomfort shown on most of the students' facial expressions, and in their body language, at the initial stage of the "Rich pictures" activity. Indeed, students have remarked that they are used to dealing with textual and numerical information, and struggle to draw a picture of, or freely describe, "fuzzy knowledge" [20]. The open-ended nature of the activity was met with some resistance at the outset because students did not know "what the teacher wanted." It was as if students had been programmed to be subservient to the powers of the teaching faculty since they perceived that the educators held the key that unlocked the deep chambers of knowledge. Therefore, it was crucial that we empathise with the students' abilities to cope with this emergent process by reassuring them that "there really isn't a right answer" and that all forms of posters will be held with equal regard whether these were artistically-inclined or textually-framed.

Nonetheless, it was observed that the act of getting students to move the physical objects of tables and chairs, and the scattering of the visual aids and tools that enabled the production of the "Rich pictures", not only generated a certain level of intrigue among the students, but also bestowed ownership of the activities and events to them. We noticed that with this symbolic ownership followed a sense of responsibility in the outcomes. The fact that students had to walk about and select among the scattered images and reach out for the marker pens, glue and flipchart paper on the floor, choose where and how they would work meant that students quickly grasped what the activity was about. Whilst the "Open-space" format was theoretically designed to encourage interaction, dialogue and collective reflection, it was clearly evident and heartening to note that this actually occurred very rapidly at the start (see Fig. 1 "Middle" above). It was found, on every occasion that the workshop was run, that students moved very quickly from a zone of discomfort with the fuzzy nature of the task to a zone of discovery and dialogue where students focused their attention on discussing the nature of the visual images. These observations contradict studies showing that engineering students are not particularly keen on pedagogical practices outside the didactic lecture, especially if these entailed an intense level of interaction [see e.g.31].

Another point worth mentioning here is the uniqueness of this activity for the students (mentioned in the majority of their logs and course evaluations). The literature has so often expounded the need for consistency and coherence of approaches across an entire curriculum and that active participatory approaches should be encouraged as far as possible [see e.g. 9 and 10]. Arguably, it is perhaps due to the uniqueness of this activity, which takes the students by surprise, that it enables such rapid turnaround from their zone of discomfort to achieving a zone of discovery and dialogue. Had such an approach been commonplace across the curriculum, students might end up in a zone of disenfranchisement with the activity and not see the point of engaging with the discussions [see 24].

Artefacts and the role of aesthetic knowledge: maximizing sensible knowledge beyond text

In the preceding subsection, it was established that physical objects (or artefacts) matter in getting students to engage meaningfully in generating the "Rich pictures" about their visions of what sustainable future means for them. So, whether this referred to the process of moving the tables and chairs to create an open space, or the visual images on the floor that compelled students to circulate effectively around the room and form their groups organically, artefacts retain latent power in stimulating a response from students. The role that artefacts play in pedagogical practice is certainly under-explored [see e.g. 32 for an exception]. Here, we experienced another striking observation. Despite claims of preference for textual and numerical information, it was interesting to note that students across the three cohorts tended to place more emphasis on the visual images containing

pictures as opposed to the "wiki-terms" or images that contained text. Perhaps the fact that the activity was named "Rich pictures" influenced the students' decisions as to what the outputs should look like, although at no point was there any mention of the need to use the visual images in their final posters. In fact, on numerous occasions throughout the workshop, the point was reiterated that they did not have to use any of the visual aids provided – indeed a number of students enjoyed the visual images so much that they decided to take some home as a souvenir from the workshop. Some of the students even availed themselves of supplementary artefacts, e.g. plastic mugs and bits of garbage to enrich their posters with.

At this point, it is noteworthy to recount an event that occurred during the Manchester workshop. Once the posters were produced, students then placed these on the walls around the room, transforming the space into an ad-hoc "art gallery." Students were then tasked to "vote with their feet" and stand by the poster of their preference. This was really done so that some order was achieved in the room; in reality, students were free to circulate around the room and continue with the dialogue whilst we went round to discuss the posters with students (see Fig. 2 below for three examples of the "Rich pictures" produced). One particular image caused great controversy among the students – that of Thomas Beatie, a female-to-male transgendered person who made headlines as the world's first pregnant man in 2008 (see Fig. 3 "Left" below). A number of students had protested at the use of this particular image because it was deemed "unethical", "immoral", "counter to our religious beliefs", and "unnatural," emotive expressions used by engineering students! A rather lengthy exchange of views lasting up to 20 minutes ensued afterwards, and another group of students joined in to see what the commotion was about. Eventually, another student singled out an image of human evolution and suggested that countless number of hours sitting in front of a computer was equally "unnatural." Without our intervention, the students had generated and engaged in a debate on the optimism and limitations of technological advances, the role of engineers in an ethical space, and the still taboo gender issue.

This, in our view, convincingly demonstrates the power artefacts have in unlocking what scholars term as "aesthetic knowledge," where knowledge is "symbolic, consisting of knowledge in the form of signs and symbols [... and] experiential, consisting of feelings and embodied experiences that emerge through knowledge use (p. 689) [33]." Indeed, knowledge remains incomplete if it does not capture the imagination of the senses [34]. In this respect, we have observed how the artefacts – the sight of the images, the sound of the background music, and the conflicts that arose between hearts and minds during the discussions – all form part of the transformative learning experience necessary to inculcate an understanding of the complexities of sustainable development. For Gherardi [35],

> "Learning thus becomes an epistemic relation with the world, and it takes place as much in people's minds as in the social relations among them, in the oral, written and "visual" texts which convey ideas and knowledge from one context to another [... knowledge] also comprises the ideas of knowing how to do, live, and listen (p. 352; 354)."

Fig. 2. Examples of "Rich pictures" produced.

Fig. 3. Examples of visual aids used (Left: a picture of a pregnant man; Middle: sign hung on a fence at a construction site, and Right: a picture depicting human evolution).

Reaching the threshold of understanding: dealing with divergence of sense-making

Sustainable development is a troublesome concept to teach. We have shown how the workshops have stimulated students' interest in the subject, at least to engage with meaningful and sometimes controversial discussions, far more quickly and naturally than conventional text-based approaches to higher education. Of course, what escapes our discussion so far is how the "Rich pictures" themselves contribute to additional materials (artefacts) that allowed students to keep the dialogues alive (and hopefully for a long time after the workshop). Yet, it would be naive and even hubristic to suggest that the execution of the workshop itself would offer a universal panacea for knowledge creation, however incomplete, of sustainable development to the students. It is inevitable that some students will have appropriated many more of the concepts than others at the end of the workshop. What is significant, however, is how the workshop described in this article can help expedite the process of transformative learning, especially in terms of an emergent subject such as sustainable development. Meyer and Land [36] coined the phrase "threshold concepts" and, citing Biggs [37], argued that "rationalist, universalist (and even dialogic) positioning were inadequate to move students on from their stuck places, owing to the incapacity of rationalist approaches to tolerate the unknown and the uncertain (because unknowable), the affective (because non-rational) and the contextualised/local (because non-universal) (p. 378)." Arguably, this is certainly the case with developing learning objectives, strategies and practices to *teach* sustainable development; and it is suggested that the artefacts used during the workshop, alongside its organisational issues, have contributed to encouraging students to cross that threshold. Nonetheless, the question remains as to how one would know how much students have understood without the instruments of formal assessment. Indeed, this is not the concern of the present article, but a worthy opening for a future line of inquiry. It was observed, however, that the workshop enabled a collegiate relationship to be fostered between the students and the teachers. Through the open-ended nature of the discussions that developed through the course of the workshop, more experienced students were able to share meaningful discussions with those who possessed less experience, and this was achieved momentarily without the burden of formal assessment.

Discussion and further lines of inquiry

A qualitative exposition of an "Open-space" workshop format in encouraging postgraduate engineering-management students to appreciate the complexities of sustainable development has been presented in this article. The analysis suggests close alignment between what was achieved in the workshops and the calls for transformative learning and collaboration in the teaching and learning of sustainable development. The insights offered thus far have deliberately steered clear from the role of the educator in order to elevate the status of the artefacts used during the workshop, so as to explore the role these play in unleashing aesthetic knowledge to facilitate crossing of the threshold of understanding sustainable development. Indeed, in many respects, the educators remained silent witnesses at least within the confines of the participant observations detailed in this article.

Nonetheless, the role of the educator is not a diminished one in this context, it is merely different. The workshops certainly would not have materialised without the organisational efforts of the educators in the first place. But this is also potentially problematic, since the choices of what images to include, what background music to play and how the workshop is loosely orchestrated remain within the firm grasp of the educator. Thus, do the students really own their transformative learning experience? Or do they remain in a hapless state, where the social construction of their knowledge is merely the fruits of an elaborate puppetry exercise? There is certainly insufficient space here to extend a discussion on the power relations between the educator, the learners, and the artefacts used in the workshops described. Indeed, more work needs to be done to examine the role of the educator's value systems, and how these intertwine with the content, processes, tools and artefacts used in the construction of knowledge.

Yet, the purpose of such undertaking also needs further scrutiny. What is the aim of examining the pedagogical practices here? Is there really scope for abstracting the experiences discussed in this article into generic strategies that can be adopted across engineering higher education? Or is the scope simply restricted to personal reflection of a contextually-specific occurrence, and that the only possible attainment is personal refinement of the practices, tools and artefacts deployed? Given the contingent

and emergent nature of knowledge about sustainable development, it is perhaps realistic to consider the latter as the only feasible option, that the teaching and learning of sustainable development will forever remain a precarious subject to broach [35].

Conclusions and recommendations

In conclusion, we have reported observations of a series of workshops designed to educate postgraduate engineering-management students at our respective institutions in sustainable development. The contingent and emergent nature of knowledge about sustainable development have been recognised in developing the format of the workshops. An "Open-space" format was adopted to avoid the prescriptive nature of knowledge transmission that typifies traditional engineering education. It is suggested that such an approach enabled both the students and educators to profit from the experience. Specifically, the contribution of this article lies in the qualitative analysis of the role of artefacts in constructing (aesthetic) knowledge about sustainable development. Here, a number of preliminary conclusions were reached. Firstly, engineering students are often overwhelmed by such threshold concepts as sustainable development. Engineering students claim to relate better to textual and numerical information, packaged within discrete, concretised and commoditised chunks of knowledge. Therefore, the workshops described here offered a creative way to provide some foundational basis for educating in sustainable development. Such an approach was found to cohere with general calls for greater collaboration and steer towards transformative learning experience where sustainable development education is concerned. Secondly, visual images in the form of pictures were, in practice, favoured instead of text. This is a critical finding to help guide educators in preparing appropriate materials for running such a workshop. Thirdly, the permutations of textual information, images, background music and dialogues that develop among students and between students and educators, however haphazard, go some way to encourage sensory engagement among the students. This is a more holistic way of creating knowledge since the tools and artefacts used allowed for the mutual and collective construction of aesthetic knowledge. What is not known, however, is how the students actually related to each and every artefact in isolation, and whether there are more effective combinations to be secured. Finally, there are a number of areas that would benefit from further inquiry, including the need to investigate the role of the educator in pursuing such a pedagogical approach, the negotiation of power relations between educators and learners in such contexts, and the possibility of formalising such practices for greater, more generic adoption.

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