Science & Technology Education for Global Wellbeing

John Lawrence Bencze

Electronic version
URL: http://journals.openedition.org/dse/144
DOI: 10.4000/dse.144
ISSN: 2272-9968

Publisher
Presses universitaires du Midi

Printed version
Date of publication: 1 April 2013
Number of pages: 109-123
ISBN: 978-2-8107-0267-1
ISSN: 1296-2104

Electronic reference
URL : http://journals.openedition.org/dse/144 ; DOI : 10.4000/dse.144

Les dossiers des sciences de l'éducation est mis à disposition selon les termes de la licence Creative Commons Attribution - Pas d'Utilisation Commerciale - Pas de Modification 4.0 International.
Science & Technology Education for Global Wellbeing

Résumé :
Aux quatre coins du monde, la science enseignée à l’école semble être empêtrée dans un système économique mondial privilégiant l’enrichissement de peu de détenteurs de capital, principalement au détriment du bien-être de nombreux individus, sociétés et environnements. Par ailleurs, les domaines de la science et de la technologie professionnelle semblent liés à cette situation non durable. Dans les économies dites du savoir, l’accent est habituellement mis sur la création de désirs d’images idéalistes abstraites chez les consommateurs qui cachent souvent des caractéristiques problématiques pour les produits et services à but lucratif. Dans cet article, un cadre théorique visant à l’organisation de la science et de l’éducation technologique est discuté. Ce dernier pourra tenter d’aider à résoudre ces problèmes et, espérons-le, contribuer au bien-être personnel, social et environnemental général.

Mots-clés : science, éducation, questions socio-scientifiques, actions sociales

Abstract :
In many places in the world, school science appears to be enmeshed in a global economic system that prioritizes enrichment of relatively few holders of capital, largely at the expense of the wellbeing of many individuals, societies and environments. Associated with this unsustainable situation appears to be fields of professional science and technology. In so-called knowledge economies, much of the focus is on creation of consumer desires for idealistic abstract images that often occlude problematic features of for-profit products and services. In this article, a theoretical framework for organizing science and technology education is discussed that may help to address these issues and, hopefully, contribute to general personal, social and environmental wellbeing.

Keywords : science, education, socio-scientific issues, social actions
Introduction

there is considerable evidence of numerous significant threats to the wellbeing of individuals, societies and environments (WISE) that are linked to fields of science and technology. Many are concerned, for instance, about potential catastrophes resulting from predicted dramatic increases in global average temperatures over the next several decades (Lynas, 2008). At the same time, there are numerous health concerns with various manufactured products – including fast foods (Schlosser, 2001), pharmaceuticals (Angell, 2003) and household consumer goods (Leonard, 2010).

Given their association with fields of science and technology, some people may conclude that scientists and engineers are culpable for such threats as those listed above. In light of actor network theory (Latour, 2005), however, which posits that any one entity (‘actant’) can be considered to affect and be affected by a multitude of other actants in complex networks of interactions involving living and non-living entities, it may be that responsibilities for our crises must be shared by multifarious – and, perhaps, unpredictable – factors. Nevertheless, it also seems clear that not all actants are equally influential (Callon, 1986).

In that vein, there has been considerable recent focus on powerful effects of the global economic system and the relatively few financiers and companies – apparently often with support from government officials (Wolf, 2011) – that appear to strongly influence it (Bakan, 2004; Harvey, 2010; McMurtry, 1999; Reich, 2007). Indeed, it is apparent that financiers and corporations have, under an ethic of renewed economic liberalism (neo-liberalism), rallied many actors – including scientists, engineers, science educators, government officials and autonomous global organizations like the World Trade Organization – towards promotion of an economic basis for being and acting. Despite indications of its weakness in light of the global financial crisis of 2008, supporters of neoliberal capitalism seem to continue to wield considerable influence – apparent, for example, in the immense amount of government financial support businesses received in relation to that crisis (Harvey, 2010). In light of their overwhelming power, it seems daunting, therefore, to address threats to the WISE through direct actions towards financiers and corporations – although people engaged in the many Occupy movements persist against powerful opponents (Wolf, 2011).

A potentially effective entry point into that powerful system, however, may be through school science – given its role, for example, in identifying and educating potential scientists and engineers, who appear to be essential for production and consumption of for-profit commodities (Bencze, 2010). In this article, therefore, after a critical review of involvement of fields of science and technology and science education in potential
problems for the WISE associated with neoliberalism, approaches for relevant school science reform are discussed.

The capitalist milieu

It may seem ironic, but publicly-funded school science does not appear to serve the general populace as much as the relatively few societal members who control capital. Such an orientation can, indeed, be detected in various curriculum documents. The National Science Education Standards document (NRC, 1996) in the USA, for example, describes one of the purposes of science education as “increas[ing] economic productivity through the use of knowledge, understanding, and skills of the scientifically literate person in their careers” (p. 13). The intention does not appear, however, to help all students become scientifically literate. Although there is considerable disagreement about the meaning of ‘scientific literacy’ (Kolstø, 2001), relatively few students achieve a level of expertise or motivation leading them to qualify for post-secondary science education and, eventually, careers as scientists, engineers and other professionals (Millar & Osborne, 1998). Indeed, a major thrust of school science, particularly at the secondary school level, appears to be to identify and educate the relatively few students who may pursue science and/or engineering in higher education and employment. A key element of this selection process apparently relates to students’ aptitude for abstract thought. School science systems tend to emphasize instruction in abstract products, such as laws and theories, of fields of professional science and technology (Bell, 2006). For example, in inquiry-based learning activities, students often are expected to discover – albeit with teacher scaffolding – science knowledge. Such discovery, however, can be difficult. As Wellington (1998) noted, “… practical work is still not a good tool for teaching theory … Theories involve abstract ideas which cannot be physically illustrated” (p. 7, italics in original). Based on constructivist learning theory, discovering abstractions depends on learners’ pre-conceived notions; and these, in turn, depend on their cultural capital (Bourdieu, 1986). Consequently, a focus on abstractions can prioritize selection of culturally advantaged students – thus contributing to preservation of traditional social class distinctions – which may be considered an undemocratic service provided by school science (Bencze & Alsop, 2009).
Once selected, advantaged students can then pursue higher education and careers in professional fields that require abstract thought. In so-called knowledge-based economies (societies), relatively small numbers of professionals – including scientists, engineers, accountants, lawyers, management consultants, investment bankers, authors, editors, art directors, video and film producers – are needed to provide symbolic analytic services (e.g., abilities to analyze and manipulate symbols, including words, concepts, numbers and graphics) (Reich, 2007). Such human resource services are quite useful in neoliberalism-influenced knowledge societies, which tend to focus on promotion of consumption rather than production of commodities. This can be understood in terms of the schema in Figure 1. In neoliberalism-influenced knowledge economies, largely because of increases in productive capacity and the consequent need to promote repeating cycles of consumption, emphasis is placed on the Representation end of the relationship. Included amongst these, for example, are engineers’ designs for new products and services. Many of these designs may be considered positive, such as those in fields of medicine – such as hip replacements (Weinstein, 2007). However, in knowledge-based economies, engineers and scientists are encouraged to be continually innovative – rapidly developing revised commodities (Ziman, 2000). Such expediency can, however, lead to compromises in quality. Although it is not the case for many manufactured products, it is apparent that numerous others contain potentially hazardous chemicals that tend not to be adequately tested (Leonard, 2010). Similarly, professionals associated with the pharmaceutical industry often compromise product quality – such as through testing of ‘new’ drugs that have only had minor modifications against placebos and by testing them with young subjects, who are less likely to experience negative side-effects (Angell, 2004). Perhaps more seriously, some companies have been known to encourage engineers to design products using less expensive and possibly inferior materials – as in the case of breast implants that were later found to contain silicone normally used for industrial purposes (rather than for humans).

With regards to repeating cycles of consumption, there are arguments and evidence to suggest that neoliberal capitalist economic systems have placed considerable emphasis on promotion of engineering of consumer desires – particularly in people who can afford to purchase commodities (and, therefore, likely have few needs) (Barber, 2007; McMurtry, 1999; Usher, 2010). This can be understood in terms of the schema in Figure 1. On the one hand, it may be that natural ontological gaps exist, which are inefficiencies in translations from one ontological entity (e.g., a flower) to another (e.g., a photograph of a flower) (Roth, 2001). The potential for such misrepresentation increases, apparently, with increasing numbers of translations – from flower to photograph to drawing to algorithm, etc. (Pozzer http://www.theaustralian.com.au/news/world/french-uncover-20-breast-cancer-cases-related-to-faulty-implants/story-e6frg6so-1226233790061

This schema suggests that fields of science and technology have opposite aims; the former to generate Representations, while the latter uses Representations to generate new Phenomena (e.g., inventions). Given that interactions between Phenomena and Representations are reciprocal, the schema also suggests that fields of science and technology co-effect each other and, consequently, may be considered as one entity (Roth, 2001).
& Roth, 2003). On the other hand, it seems that neoliberal capitalist economic systems have, perhaps after capitalists’ promotion of commodity fetishism described by Marx (1992 [1867]), encouraged purposeful development of misrepresentations of for-profit commodities (‘Phenomena’). Drawing on the work of Baudrillard (1998), many authors (e.g., Barber, 2007; Norris 2011; Usher 2010) advise that marketers frequently attach idealized abstract images to their products and services – and encourage shoppers to base their purchases largely on those images, rather than on the (possibly-compromised) merits of the commodities. With reference to Figure 1, these abstractions are ‘Representations’ for the Phenomena to be sold. When we purchase a car, for instance, the focus may be on it being ‘fast,’ ‘cool,’ ‘beautiful,’ and/or ‘environmentally-friendly’ (Klein, 2000). Such abstractions may not be so much derived from the commodities, however, as applied to them. In other words, they may have little, if any, real connection to those commodities. Nevertheless, as Baudrillard (1998) suggested, consumers in socio-cultural market contexts may be unable to distinguish between the abstract images and the actual products – a condition he called hyperreality. They may, in other words, be consuming material-semiotic entities – with the emphasis on the semiotic (symbolic). Freed from the bounds of real connections to phenomena, signs and symbols are then relatively easy to manipulate (Latour, 1987). Marketers can, therefore, frequently create innovative new images to attach to for-profit commodities – encouraging consumers to discard older (often relatively new) products in favour of ones with the latest brand identities (Barber, 2007; Leonard, 2010). Moreover, with consumers’ repeating foci on idealized abstractions, they may pay less attention to compromises to the actual products and services – such as those described in the last paragraph.

Capitalists’ focus on consumerism in those with few basic needs appears to be quite intense. In Consumed, for example, Barber (2007) suggests that consumerist enticements are: ubiquitous (everywhere); omnipresent (always there); addictive (creates reinforcements); self-replicating (spreads, ‘virally’); and, omnilegitimate (self-promotional). A particularly noteworthy (and worrisome) feature of such intense emphasis on consumerism is capitalists’ concentrated efforts to instill a consumerist ethos in children – with the hope that they will become consumers for life (e.g., Bakan, 2011; Barber, 2007; Norris, 2011; Usher, 2010). In that vein, Barber (2007) argues forcefully that capitalists’ current tactic for encouraging consumerism involves promotion of infantilization; that is, an appeal to childish personal possessiveness in children and, moreover, in adults. With reference to Figure 1, this may be realized largely through semiotic messages in Representations associated with commodities (Phenomena). He advises, essentially, that material-semiotic commodities are associated with such infantile qualities as easiness, simplicity and speediness. Consumer participation may be easy, for example, in the sense that it often is vicarious, as when people devote considerable time and emotional involvement in media (e.g., television and movies) presentations. It may be simple, for example, when
emphasis is placed on viewing images rather than reading detailed and complex text. Finally, speediness is evident, for example, in the rapidity of scene changes in various forms of popular entertainment. Bakan (2011), in *Childhood Under Siege*, suggests that such techniques have been highly addictive, particularly for children, and laments that the “erosion and sometimes outright destruction of our capacity to protect children from economic activities that might cause them harm … is arguably the most chilling effect of the turn to neoliberalism” (p. 10).

Given the ubiquity of neoliberal-influenced emphases on consumerism, it may, perhaps, be unsurprising to find it evident in schooling. Giroux and Giroux (2006), for example, suggest that schooling promotes consumer character in at least two respects; that is, by encouraging: i) compliance in following executive labour instructions and ii) enthusiastic and unquestioning purchasing of commodities. Science education appears to contribute to such consumer characteristics in various ways. A general orientation towards compliance seems to be fostered, for example, by the extent to which school science inquiry activities often are regulated by teachers and/or texts. Bell (2006) claims, for example, that school science’s intense focus on instruction in products of science and technology often involves “cookbook approaches to laboratory exercises, using authoritarian teaching modes” (p. 430). Although there are cases in which learning control is ceded to students (Lock, 1990), over-regulation of empirical activities may condition students into assuming that questions, methods and conclusions are best given by authorities. To reinforce such consumerist tendencies, moreover, fields of professional science and technology – which are major instruments of production and marketing of for-profit goods and services – often are portrayed as highly logical, efficient in achieving truths and unproblematic with regards to their effects on individuals, societies and environments. Allchin (2003) concluded, for example, that historical representations of science in science textbooks frequently presented students with various “mythconceptions” about science, including: Monumentality: scientists appear as ‘larger-than-life’ heroic figures, often working alone and, moreover, their work is seen as very difficult, but very important; Idealization: false starts, complexities and biases are absent; Affective drama: the excitement and emotional elation of ‘discovery’ are exaggerated; and, Explanatory and justificatory narrative: conclusions are seen as final/unchanging and correct” (pp. 341-347). With such idealistic views about science, students may develop a certain level of trust in scientists (and other symbolic analyzers) – and, therefore, may develop enthusiasm for consuming the commodities they help develop and market.

Capitalists’ emphasis on consumerism through promotion of idealized hyperreal images may be highly successful from their perspective, but perhaps highly problematic for the wellbeing of many individuals, societies and environments. McMurtry (1999) claimed, for instance, that we are in a ‘cancer’ stage of capitalism – in the sense that a few individuals (like cancer cells), although resembling us, are free to roam about the body (like the Earth) enriching themselves at others’ expense. With regards to Figure 1, consumption of
idealized Representations may be serving as a ‘smoke screen,’ occluding our view of problematic Phenomena. Leonard (2010) suggests that, while we may gain senses of beauty, style and prestige from various personal care products, including shampoo, hair spray, deodorant and lipstick, we are risking our health and that of others – since many of the ingredients of such products have been shown to be toxic and most of them have not be subjected to significant toxicology tests. Similar concerns have been voiced for other products that often are marketed with positive, hyperreal, images; including: cigarettes (Barnes, Hammond & Glantz 2006); pesticides (Hileman, 1998); genetically-modified foods, etc. (Kleinman, 2003; Krinsky, 2003); and, pharmaceuticals (Angell, 2004). Meanwhile, because of corporations’ right to externalize (shift to others) many of their costs, citizens often are expected to bear responsibility and costs for negative side-effects of their for-profit commodities. About this practice, Bakan (2004) advised that “the corporation [often actualizing neoliberal ideals] ... is an externalizing machine, in the same way that a shark is a killing machine” and that this makes it “potentially very, very damaging to society” (p. 20).

Towards communitarian school science

To the extent that school science is a contributor to capitalists’ often destructive emphasis on consumerism, as argued above, it needs to be dramatically reformed in ways that may benefit the wellbeing of individuals, societies and environments. Given capitalists’ focus on personal possessiveness, an alternative may be a shift towards communitarianism; that is, belief that it may be best for societies if rights and responsibilities of individuals are balanced with those for communities (Etzioni, 1996; Fuller, 2002; Peters, 2011). In light of the apparent immensity of capitalists’ influences on societies, however, a move towards communitarianism may require, as Freire (1997) recommended, proactive efforts at critical conscientization – deep citizen awareness, for example, of societal power structures (McLaren, 2000). In the last few decades, considerable progress appears to have been made in this regard – in terms, for example, of curricular and instructional focus on Socially Acute Questions (SAQ) (Simonneaux & Simonneaux, 2012), socioscientific issues (SSIs) (Sadler, 2011), and issues associated with relationships among fields of science and technology and societies and environments (STSE) (Pedretti & Nazir, 2011).

Although STSE education has focused students’ attention on some significant potential social and environmental problems associated with fields of science and technology, including, for example, those pertaining to cell phone uses (e.g., Pouliot, 2008), climate change (Simonneaux & Simonneaux, 2009) and genetics issues (Dawson & Venville, 2010), emphasis has tended to be restricted to making students aware of different stakeholders’ positions and then encouraging them to develop reasoned arguments to defend their personal stances on issues. Much less emphasis has been placed on encouraging and enabling students to
engage in sociopolitical action projects aimed at overcoming potential personal, social and/or environmental problems associated with fields of science and technology (Hodson, 2003, 2011; Santos, 2009). Limiting students to personal decision-making on such potential problems seems to align well with neoliberalism – with its focus on individualism.

There are many reasons to transcend a focus on personal decision making with regards to STSE issues. Again (refer above), from a communitarian perspective, ‘spending’ at least some of one’s cultural capital (Bourdieu, 1986) on common wellbeing may, at least, pay ‘dividends’ to the benefactor. Related to that, actions may help learners to develop deeper, more complex, understandings of STSE issues – given that deep, committed, learning appears to be associated with personal engagement in reciprocal Phenomena > Representation relationships (see Figure 1) (Wenger, 1998). If students were, for example, to form representations (e.g., conceptions) about STSE issues such as climate change through their own explorations (e.g., via the internet) and, then, through negotiation of such representations with others, formulate and implement actions on them (e.g., letters to politicians), they may develop deep, committed, understandings of issues pertaining to climate change (Hayden et al., 2011). Moreover, potential problems like global warming seem so serious (Lynas, 2008), that immediate development of an activist citizenry seems necessary (Hodson, 2003, 2011).

Because sociopolitical activism has not, apparently, been given high priority in science education policy documents, research or practice (Hodson, 2011), there is a dearth of educational frameworks for preparing students for such activism. The schema in Figure 2, which has been used as a basis for educational research in development for the last five years, may serve as one such framework (e.g., Bencze & Carter, 2011).

As illustrated in Figure 2, the ‘STEPWISE’ framework, encourages students to ‘spend’ some of their cultural capital – in the form, for example, of their STSE Education, Skills Education, Products Education and outcomes of Students’ Projects – to promote, through STSE Actions, possible improvements to the wellbeing of individuals (beyond themselves), societies and environments. This is indicated in Figure 2 by all of the arrows from the peripheral elements (e.g., STSE Education) of the model’s tetrahedron pointing towards its centre; that is, at STSE Actions. This model was conceived with the recognition, for example, that common science curriculum learning domains, such as Skills Education and Products Education, are co-dependent (Hodson, 2003) – which led to use of the two-directional arrows between all of the model’s elements. Placing STSE Actions in the centre of the tetrahedron was meant to prioritize a communitarian ethic in science education. Additionally, Students’ Projects and Skills Education, on the one hand, and STSE Actions and STSE Education, on the other hand, which are pairs of learning domains that often are discussed together, were separated from each other – because of the belief that the former in each pair should be considered more student-directed and open-ended (Lock, 1990) than the other member of each pair.
Figure 2

The teacher helps students to develop more realistic conceptions about relationships among fields of science & technology and societies & environments (STSE), which would include the nature of science & technology (NoST). This education should include positive and negative aspects, but should carefully indicate the seriousness of some negative ones. For example, students should be taught that business-science partnerships (e.g., contracts, patents, intellectual transfer agreements) can lead scientists and engineers to solely work on for-profit ideas and products, compromises the reliability and validity of their experiments, etc. (e.g., by reducing the numbers of trials) and avoid publishing data that would cast a negative light on for-profit products. Many food products, for example, contain possibly harmful substances - such as colourings, flavourings and preservatives. Some more positive aspects include that science & technology have developed many useful surgical techniques and instruments. However, where there are STSE-NoST problems, students should be encouraged to try to reduce or eliminate them.

Students use their education (i.e. STSE/NoST, Skills, Concepts & Project findings) not only for their own benefit but also for addressing STSE issues. Such actions are intended to reduce or eliminate such possible problems as use of toxic chemicals in toys, foods, cigarettes, plastic bottles, etc. Actions may include educating others, changing personal choices, lobbying power-brokers, inventing positive alternatives and disrupting STSE issue situations.

STSE Education

Science & Technology Education Promoting Wellbeing for Individuals, Societies & Environments

STSE Actions

Students design & conduct open-ended science inquiry & technology design projects, enabling them to create their own knowledge. Findings from their projects can motivate & direct their STSE Actions, e.g., if their study of students’ reasons for smoking included peer pressure, they could take action to encourage esteem or peers to glamorize non-smoking activities.

A key characteristic of STEPWISE is that all elements in the framework are left with students and are affected by all others. But, also, orienting all learning towards STSE Actions gives students motivation for learning knowledge and developing skills and attitudes.

STSE Projects

The teacher helps students to develop deeper understanding of ‘products’ (e.g., laws & theories) of fields of science & technology. Perhaps starting with an STSE issue context (e.g., issues about ‘energy’ drinks), students would then be motivated to learn about bacterial action in tooth decay.

Products Education

http://www.stepwiser.ca
stepwiser.ca@gmail.com

This figure is published with the permission of Springer. It has been first published in the article: Bencze, JL (2011). Students’ Research-Informed Socio-scientific Activism: Re/Visions for a Sustainable Future, Research in Science Education, 42, 1, 129-148.
In light of constructivist learning theory, which posits that students would not begin instructional sessions in schools without pre-conceived notions relating to what may be taught (Osborne & Wittrock, 1985), students could self-direct their learning and start at any element in the STEPWISE framework. This may be particularly the case for advantaged students, who tend to be rich in cultural capital (Hodson, 2011). Many other students, however, may require more teacher guidance – and we have found this to be the case (e.g., Bencze, Sperling & Carter, 2012). Using the framework directly as it appears in Figure 2, moreover, can be complex for students and teachers – in that learning can start at any point in the tetrahedron and that learning in any one domain (e.g., Skills Education) may both affect and be affected by learning in every other domain.

Although there may still be much to learn about use of the STEPWISE framework in educational practice, our experiences with it (e.g., Bencze & Sperling, 2012; Bencze et al., 2012) suggest that a few major principles may help educators, educational researchers, policy makers and others in efforts to promote sociopolitical actions to address STSE issues. As a supplement to the text provided in Figure 2, brief explanations, with examples, of some such principles are provided below.

- **Begin by facilitating students’ collaborative reflections about familiar STSE issues.**

 As mentioned above, based on constructivist learning theory, students can benefit from expressing their pre-instructional ideas, attitudes, etc. pertaining to school subject matter. Students could, for example, be given a random selection of file cards that each contain possible STSE actions, including oppositional statements, such as: “We should avoid cigarette smoking because of the health risks” vs. “It’s OK to smoke cigarettes because the pleasure outweighs the health risks” and “Governments should allow companies to incinerate solid wastes” vs. “Governments should make it illegal for companies to incinerate solid wastes.” After personally ranking the statements, the students should then be invited to attempt to convince other students to take cards/statements to which they disagree in exchange for those to which they agree. When students feel they have exhausted exchange possibilities, they could be asked to write a general statement about their STSE preferences (Bencze, 2011). In implementing such exploratory activities, it is clear that students may take positions that teachers find antithetical to communal wellbeing. While this may be troubling to some, it seems undemocratic that teachers insist on particular stances with regards to issues – which, by their nature, are contentious.

- **Teach Products Education in concert with STSE Education.**

 Although STSE Education often is used as a context for motivating students to learn products of science and technology (e.g., Castano, 2008), linking it to Products Education based on the STEPWISE framework can (should) be oriented to motivate students to act on STSE issues. Students can, for example,
be engaged in case methods (documentaries, plus student activities) involving various stakeholders’ positions about STSE issues (e.g., those for and against breast implants) and then asked to consider appropriate actions to address the issues (Santos, 2009). In dealing with such issues, students may decide that it would be beneficial for them to learn more science knowledge (Products Education), and they may decide that such learning may help them in deciding on appropriate actions.

Provide students with a critical STSE Education.

School science tends to portray professional science in the most positive light, suggesting that it is, for example, highly logical and removed from cultural influences (Allchin, 2003; Hodson, 2008). Students holding such views may not be highly motivated to act on STSE issues, perhaps because they have significant trust in fields of science and technology. Indeed, our research suggests that students holding more Naturalist-Antirealist views about science on Loving’s (1991) Scientific Theory Profile (STP) have greater tendencies to act on STSE issues than students holding more Rationalist-Realist views about science (Bencze et al., 2012). Given our discussion above (refer to Figure 1 and associated text), it would be appropriate for teachers to provide students – among various possible strategies – with case methods depicting situations in which idealized Representations are used to promote consumption of potentially problematic commodities (Phenomena). Students could, then, be encouraged to suggest and possibly implement plans of action to address issues concerning them about these cases.

Provide students with an apprenticeship for research-informed activism.

Although providing students with an STSE Education, perhaps using case methods, can motivate them to act to address corresponding issues, we suggest that they may be particularly motivated to act when they self-generate claims about STSE issues – through, for example, student-directed and open-ended correlational studies and/or experiments (Bencze & Sperling, 2012; Bencze et al., 2012). With reference to Wenger’s (1998) knowledge duality theory, deep attachments to and learning about concepts, skills, etc. arise particularly when learners are personally engaged in reciprocal interactions between Phenomena and Representations (refer to Figure 1) – such as when they conduct studies of relationships between students’ cell phone uses and gender (Phenomena > Representations) and then use their findings to develop and enact campaigns to educate peers about controversies regarding cell phone uses (Representations > Phenomena). Many students struggle with conducting such self-led research-informed activism; and, for that reason, we have found that they often benefit from apprenticeship activities to prepare them for such projects. It has been
particularly helpful to provide students with examples of research-informed activism and to guide them in small-scale research-informed activism projects prior to asking them to independently conduct such projects (refer below).

- **Facilitate students’ self-led research-informed activism projects.**

Finally, if students are to develop deep and personal attachments to STSE issues and actions, they need to be encouraged and enabled to conduct such projects independent from guidance of teachers and other authority figures. It may be that when students are engaged in such praxis – critical reflective practice – in personally-relevant contexts that they are free of oppressive forces of powerful others (McLaren, 2000). In our work (e.g., Bencze & Sperling, 2012; Bencze et al., 2012), few teachers have been able to restrain themselves from guiding such projects. Nevertheless, in light of our arguments for a significant measure of student autonomy (summarized above), we urge educators to continue to encourage and enable such self-led research-informed activism.

**Summary and conclusions**

The curricular and pedagogical framework, ‘STEPWISE,’ described above should not be taken as a panacea for all goals, perspectives, etc. for/about science education. Nevertheless, in contexts where possessive individualism dominates, it seems to represent a reasonable approach for encouraging and enabling students to ‘spend’ at least some of their cultural (and social) capital on what they perceive to be common good. Indeed, it may be quite appropriate where the dominant discourse involves repeating cycles of consumption of for-profit goods and services that are, to a great extent, compromising the well-being of many individuals, societies and environments. Of particular note is its emphasis on encouraging and enabling students to conduct self-led primary and secondary research as sources of motivation and direction for taking action to address potential problems associated with relationships amongst fields of science and technology and societies and environments (STSE). Given the severity, for instance, of many potential problems – such as devastation due to climate change and health problems from poorly-regulated foods and pharmaceuticals – associated with STSE relationships, it appears we need more activist citizens to confront such problems.
References bibliographiques


