Critiques of & Alternatives to *Inquiry-based Learning*

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Introduction

Among more prominent teaching/learning strategies promoted by scholars, government officials (e.g., via curriculum guidelines), educational consultants and teachers is *inquiry-based learning* (IBL). Indeed, IBL approaches have a long history in science education and, perhaps related to that, seem relatively entrenched in educators' and others' minds about how students should be educated in science.

Status of Inquiry-based Learning

On the one hand, there are many versions of what people say is an IBL approach. In his analysis of the extent to which teachers or students influence/control decisions about different stages of science inquiries, Lock (1990) suggests — at indicated in Table 1 — there may be at least 7 variations of "practical work" (what empirical [interactions with matter & energy] activities have been called in the UK).

TABLE 1: VARIATIONS IN CONTROL OF ASPECTS OF EMPIRICAL ACTIVITIES.

	Who Is Mainly In Control						
Elements of Practical Work	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Area of Interest	T	T	T	T	T	T	S
Statement of Problem	T	T	T	T	T	S	S
Planning the Investigation	T	T	S	S	S	S	S
Determining the Strategy	T	T	T	S	S	S	S
Carrying Out of Practical Work	T/S	S	S	S	S	S	S
Collation of Results	T	S	S	S	S	S	S
Evaluation/Interpretation of Results	T	T	T	T	S	S	S

Having acknowledged possible variations in forms of science inquiry activities in school science, it is — nevertheless — apparent that school science systems tend to prioritize uses of empirical activities to enable students to either 'discover' or perhaps believe they are discovering well-established 'products' (e.g., laws, theories and inventions/innovations) of fields of science and technology. Based on the framework in Figure 2, Lock (1990) suggested that most empirical activities in school science tend to be, essentially, relatively closed-ended (with pre-determined conclusions) — which often means that, in various ways, teachers need to 'scaffold' (e.g., suggest ideas, strategies, etc.) students' methods and conclusions. More recently, Schwartz, Lederman and Crawford (2004), for example, who have written much in this field, have said that IBL often can be characterized as follows:

Within a classroom, scientific inquiry involves student-centered projects, with students actively engaged in inquiry processes and meaning construction, with teacher guidance, to achieve meaningful understanding of scientifically accepted ideas targeted by the curriculum (p. 612).

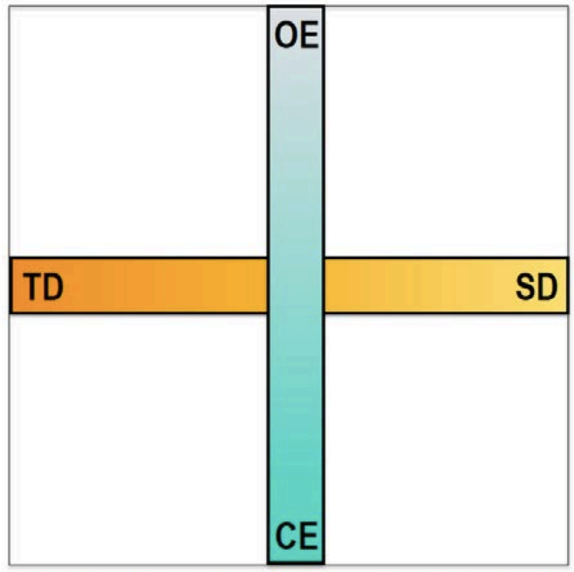

Figure 1: Variations in Learning Control.

Although science inquiry (and technology design) activities have helped many students to learn products of science and technology and more realistic conceptions of the nature of investigations and projects in science and technology (Duschl & Bybee, 2014), my review of literature relevant to various uses of science inquiry activities in school science suggest there are at least four categories of compromise with such activities (Bencze & Alsop, 2009) — each briefly reviewed below:

- Intellectual Independence. While students may believe they are controlling their empirical activities (SD/OE), teachers may – sometimes surreptitiously – influence or, even, guide students' decisions. Polman and Pea (2001), for instance, state: "To help support productive open-ended science inquiry, coaching strategies that allow for strong student voice *and* teacher influence are necessary" (p. 223). Doing so, however, may threaten students' *intellectual independence* (Munby, 1980); that is, their abilities to make decisions without dependence on authority figures (e.g., teachers).
- Depth of Learning. Although not all student learning needs to be SD/OE, too much teacher control (TD/CE) can threaten 'depth' (e.g., understanding and commitments) of students' learning. Wenger (1998) suggested, for instance, that depth of learning increases the more learners control both representation of phenomena and uses of their representations to attempt to influence phenomena. This can be understood in terms of the schema in Figure 2, which depicts translations between two general kinds of entities; that is, between phenomena of the 'World' and representations ('Signs') of them. The more *students* control both kinds of translations, the deeper may be their learning.

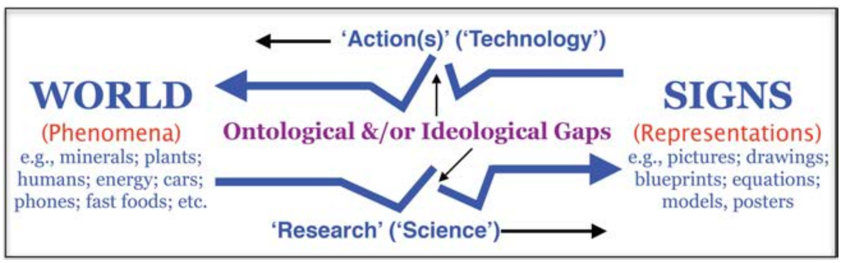

Figure 2: World ←→ Sign Translations.

- Views About Science & Technology. Excessive guidance – and, perhaps, especially *surreptitious* guidance – of students' World ←→ Sign translations can compromise their views about the 'nature of science and technology' (NoST). Studies of NoST are vast and complex, but too much guidance of translations in Figure 2 may – often tacitly – suggest to students that such processes are relatively fast and 1-directional (e.g., with few errors, new decisions, etc.). Studies of NoST suggest otherwise. Some important principles in this regard can be understood in terms of gaps indicated in Figure 2. Regarding *ontological* gaps, efficiencies of translations (e.g., degree to which a Sign fully represents aspects of the World) appears limited by differences in composition of phenomena (e.g., water) and a representation (e.g., photograph, diagram, description, etc.) of it. Perhaps more important, however, are *ideological* gaps; that is, intentional inefficiencies in such translations. It is common for advertizers, for instance, to purposely idealize commodities to promote desires for them. Genetically-modified salmon may be depicted as at the top of Figure 3, for instance, simply as bigger – and, therefore, providing more food for people – than wild salmon. In examining broader, more *contextualized*, representations of it like the network of relations including it at the bottom of Figure 3, however, we can see that – apparently through cooperation among entities such as bioengineers, salt water growing pens (and whomever developed those), a corporation (AquaBounty™), and government regulation policies – GE salmon also is associated with sea lice, which tend to harm GE and wild salmon while greatly enriching AquaBounty™ (Pierce, 2013). It is rare, unfortunately, for school science systems to educate students about such problematic pro-capitalist relationships among fields of science and technology and (members of) societies and environments (STSE) (Carter, 2008), which favour de-contextualized conceptions of products – such as laws, theories and inventions – of science and technology (Levinson, in press). Avoiding associations like those at the bottom of Figure 3 with inquiry and technology design seems *undemocratic*, limiting extents to which learners may fully comprehend science and technology and, therefore, make educated decisions about them.

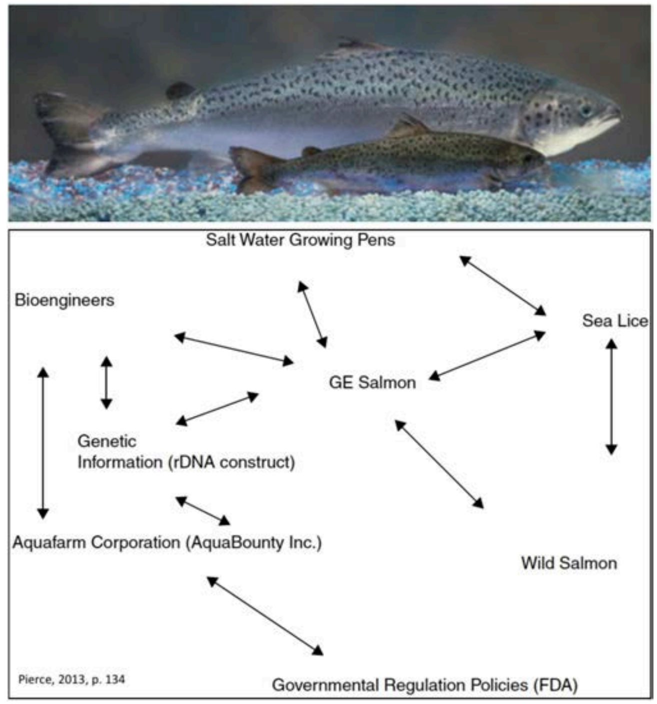

Figure 3: (De-)Contextualized Salmon.

- Inclusivity. Although teachers may recommend certain attitudes, skills and knowledge (ASK) in the context of student inquiries, there appears to be a tendency to encourage students to largely self-determine – through secondary (e.g., Internet searches) and/or primary (e.g., experimentation) research – conclusions that may correspond to those drawn by scientists and engineers. Such emphases can be problematic, however, for students with lower cultural and social capital (Bourdieu, 1986) – who may struggle to develop appropriate abstractions from concrete experiences. As suggested some time ago by Wellington (1998), "practical work is still not a good tool for teaching theory — theories are about ideas, not things. Theories involve abstract ideas which cannot be *physically* illustrated" (p. 7, italics in original). Such problems of discovery can be illustrated with regards to the image in Figure 4. Being able to 'see' what the aerial photographer of this mountain range 'saw' – that is, 'Jesus' – depends not so much on the black and white blotches as viewers' existing ideas. Similarly, students' abilities to discover particular abstract conceptions from concrete experiences depends on their existing ideas – presence of which, in turn, appears limited to their access to useful previous learning experiences, many of which arise mainly for students from advantaged backgrounds.

Figure 4: An Ambiguous Image.

Appropriate Uses of Empirical Work

It has long been agreed that learners can benefit from opportunities to link relevant concrete experiences with abstract attitudes, skills, knowledge, etc. (e.g., White, 1991). Given problems like those above, however, with inquiry-based learning approaches that prioritize expectations on students to learn important 'products' – such as laws, theories and inventions – of science and technology, we must wonder what may be better approaches for uses of empirical work in science education. Some alternatives to this, however, are addressed in Bencze and Alsop (2009) – with some brief notes from that chapter given below.

It seems clear that different educators and others will address problems noted above, including to ignore them, in different ways. That is fair. However, I suggest that such problems – and more – may be addressed through uses of the 'STEPWISE' framework for addressing major learning outcomes (e.g., STSE, Skills & STSE) in science and technology education (Bencze, 2017). Although this framework was initially conceived as a *tetrahedron*, its more sequential form in Figure 5 appears more practical in formal science education.

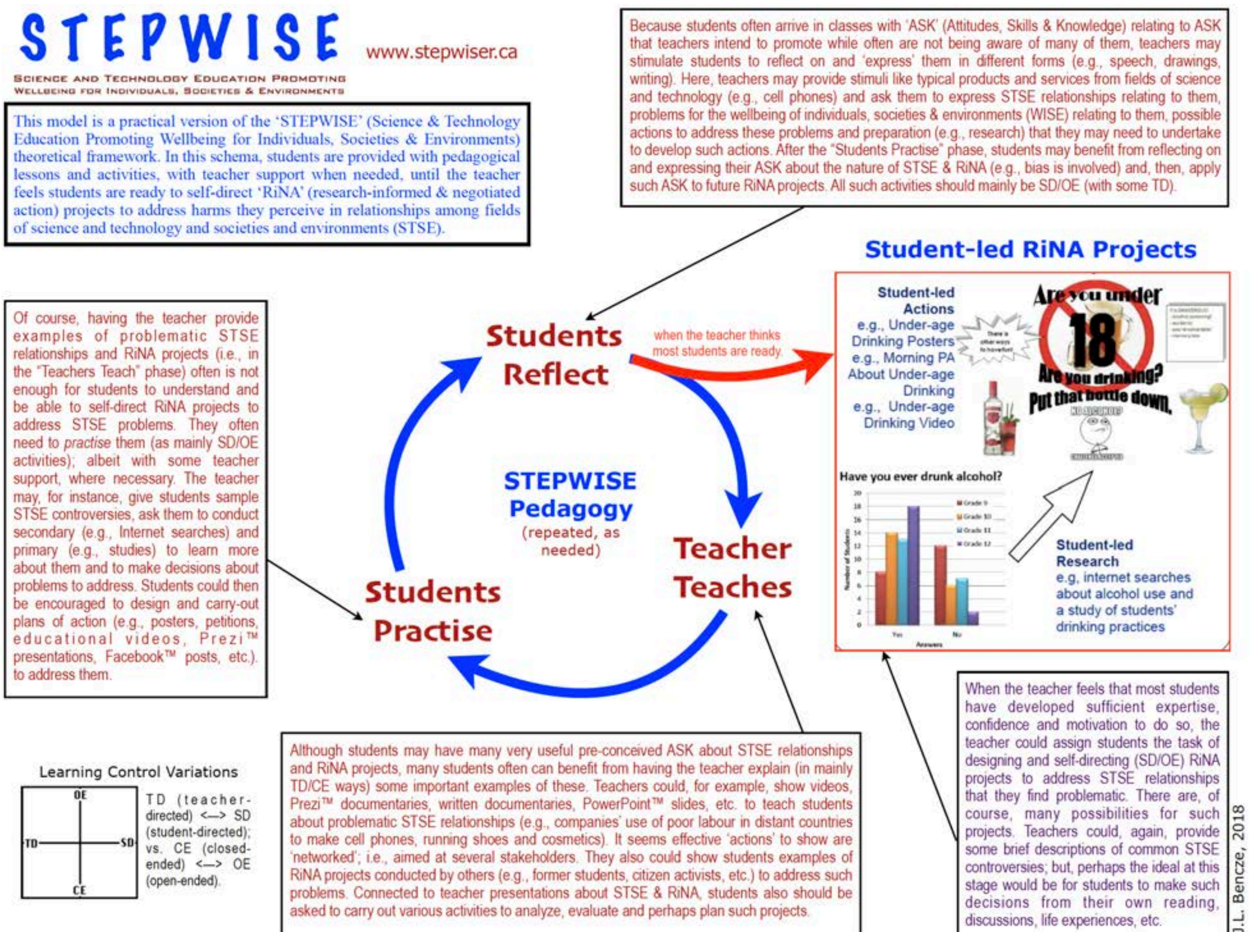

Figure 5: STEPWISE Framework for Promoting SD/OE RiNA Projects.

Although the STEPWISE framework is designed to address all or most learning outcomes in science education, its prime focus is on helping students to develop expertise, confidence and motivation for self-directing 'research-informed and negotiated action' (RiNA) projects aimed at eliminating or, at least, minimizing harms in relationships among fields of science and technology and societies and environments (STSE). To supplement notes in Figure 5, some ways – among several – in which the STEPWISE pedagogy and student-led RiNA projects may address problems in uses of inquiry-based learning of pre-determined laws, theories, inventions, etc. are provided below:

STEPWISE Pedagogy

Students Reflect. Because this involves encouraging students to 'express' (e.g., say, write, draw, etc.) – without interference from the teacher – their existing (often pre-instructional) ASK about common phenomena (e.g., cell phones) linked to science and technology (S&T), students may develop some *intellectual independence* (II), for example, such as in terms of prioritization of their personal ASK and perhaps confidence and habituation to do so.

Teacher Teaches. Because many students are likely to struggle to discover through their own inquiries ASK about which they may lack existing conceptions, sometimes or often due to relatively disadvantaged backgrounds, they can gain broader – often more problematized – ASK about STSE relationships, including in terms of S&T knowledge and NoST knowledge (as at the bottom of Figure 3). Such more direct instruction also can contribute to II, in the sense that they will be less dependent on authority figures for access to (e.g., via self-discovery) often hidden or ignored useful ASK. At the same time, to supplement more direct teacher instruction, we suggest also encouraging students to analyze and evaluate claims of teachers and other authority figures, also contributing to II and, moreover, perhaps beginning to deepen student learning – in the sense of them having some controls over uses of abstract ASK (Sign → World, Figure 2).

Students Practise. In this phase, although the teacher may provide student-requested supports, students are expected to have much more control over RiNA projects, which can deepen their learning and contribute to their II – in that they would have more control over translations in both directions in World ←→ Sign relationships (Figure 2). A very important nuance to this claim, however, is that students' translations – and, therefore, their II – would not be limited by their pre-instructional ASK; but, rather, would be enhanced by some direct instruction from the teacher in the *Teacher Teaches* phase in Figure 5. To *optimize* students' II, however, instruction in the *Teacher Teaches* phase should not pertain directly to – and, therefore, *interfere* with – students' RiNA topics in the *Students Practise* phase.

Although students may engage in various kinds of RiNA projects in this (and the student-led) phase, two types of – apparently comparable (Lewis, 2006) – empirical activities seem to address many of the problems noted above for inquiry-based learning; that is, i) *deductive* science inquiries (e.g., studies & experiments that are (mainly) World → Sign translations based on relatively explicit pre-conceived ASK); and, ii) various kinds of personal and social actions (including alternative, hopefully more sustainable and just, technology designs [inventions/innovations]), which mainly involve Sign → World translations (Figure 2). In a sense, both types of empirical activities promote 'application-based (vs. inquiry-based) learning' (ABL), given that students would be applying/evaluating ASK from their reflections, teacher instruction and research.

Student-led RiNA Projects

Within limits of formal education (e.g., needs for student assessment/evaluation), relatively fully-led RiNA projects should extend and deepen benefits claimed above for those in the *Students Practise* phase.

References

Bencze, J.L. (ed.) (2017). *Science & technology education promoting wellbeing for individuals, societies & environments*. Dordrecht: Springer [goo.gl/q98JRv].

Bencze, J.L., & Alsop, S. (2009). A critical and creative inquiry into school science inquiry. In W.-M. Roth & K. Tobin (Eds.), *The world of science education: North America* (pp. 27-47). Rotterdam: Sense.

Bourdieu, P. (1983). The forms of capital. In J. G. Richardson (Ed.), *Handbook of theory and research for the sociology of education* (pp. 241-258). New York: Greenwood Press.

Carter, L. (2008). Globalisation and science education: The implications for science in the new economy. *Journal of Research in Science Teaching, 45*(5), 617-633.

Duschl, R.A., & Bybee, R.W. (2014). Planning and carrying out investigations: An entry to learning and to teacher professional development around NGSS science and engineering practices. *International Journal of STEM Education, 1*(12), 1-9.

Levinson, R. (in press). Realizing the school science curriculum. *The Curriculum Journal*, .

Lewis, T. (2006). Design and inquiry: Bases for an accommodation between science and technology education in the curriculum? *Journal of Research in Science Teaching, 43*(3), 255–281.

Lock, R. (1990). Open-ended, problem-solving investigations: What do we mean and how can we use them? *School Science Review, 71*(256), 63-72.

Munby, H. (1980). Analyzing teaching for intellectual independence. In H. Munby, G. Orpwood & T. Russell (Eds.), *Seeing curriculum in a new light* (pp. 11-33). Toronto: OISE Press.

Pierce, C. (2013). *Education in the age of biocapitalism: Optimizing educational life for a flat world*. New York: Palgrave Macmillan.

Polman, J.L., & Pea, R.D. (2001). Transformative communication as a cultural tool for guiding inquiry science. *Science Education, 85*(3), 223-238.

Schwartz, R.S., Lederman, N.G., & Crawford, B.A. (2004). Developing views of nature of science in an authentic context: An explicit approach to bridging the gap between nature of science and scientific inquiry. *Science Education, 88*(4), 610-645.

Wenger, E. (1998). *Communities of practice*. Cambridge: Cambridge University Press.

White, R.T. (1991). Episodes, and the purpose and conduct of practical work. In B.E. Woolnough (Ed.), *Practical science* (pp. 78–86). Milton Keynes: Open University Press.