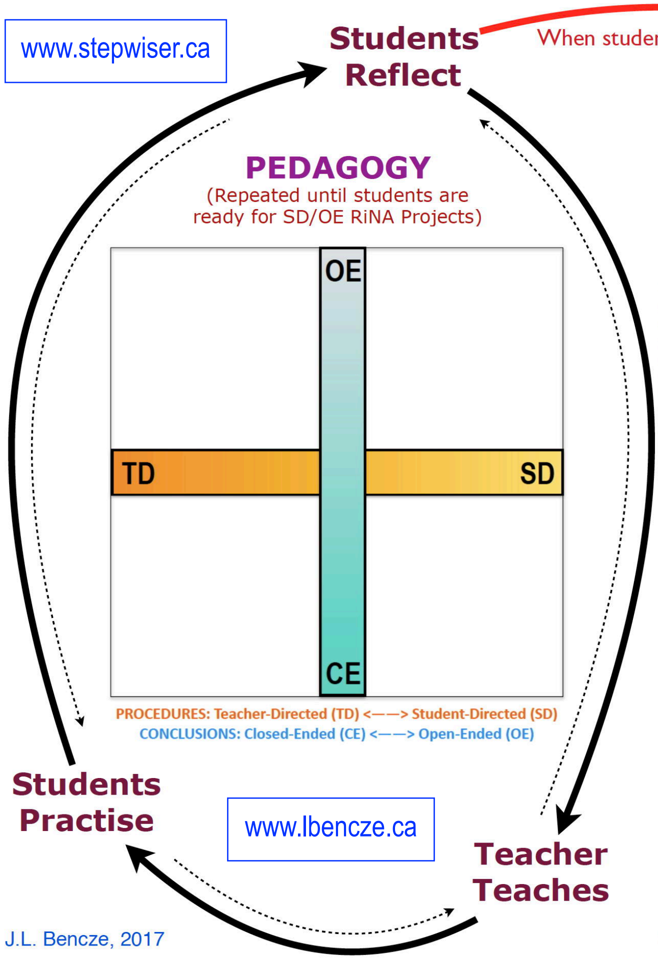
1. **SD/OE RiNA Projects**. The main goal of this schema is to get students to the point that they have expertise, confidence and motivation to self-direct (SD/OE) research-informed & negotiated action (RiNA) projects to address harms (e.g., from oil spills) they perceive in relationships among fields of science & technology and societies & environments (STSE). Such critical and active citizenship appears necessary because governments (and other powerful societal entities) have struggled to address such harms. Students can become highly motivated, as well as informed, by results of their own secondary (e.g., Internet searches) and primary (e.g., correlational studies) aimed at learning more about STSE relationships.

2. **PEDAGOGY**. Because school science systems tend to prioritize teaching/learning of 'products' (e.g., laws, theories & inventions) of science & technology (S&T), often supported by guided science inquiry activities, many students need the teacher to provide pedagogical lessons and student activities to help them develop expertise, confidence and motivation for eventually self-directing RiNA projects to address problematic STSE relationships. Such lessons and activities can be provided based on the cyclical schema here.

3. **Students Reflect**. Based on constructivist learning theory, which posits that each learner often has existing attitudes, skills & knowledge (ASK) in their brains that interact with incoming stimuli (e.g., sights, sounds, etc.) to construct ASK that are somewhat unique to each person. Such existing ASK can cause people to develop different conclusions based on the same experiences. Although some of their existing ASK may not be similar to that of professional scientists and engineers, we think they should be valued - since, for example, they may have such ASK because of their cultural background (e.g., Indigenous People). Valuing students' existing ASK also can *personalize* their RiNA projects - motivating them to conduct research and take actions. Because students often are not conscious of their existing ASK, however, it can be helpful to get them to reflect on past experiences relating to them and express them in different forms (e.g., via writing, drawing, etc.).



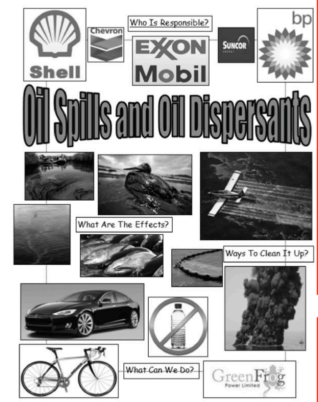
J.L. Bencze, 2017

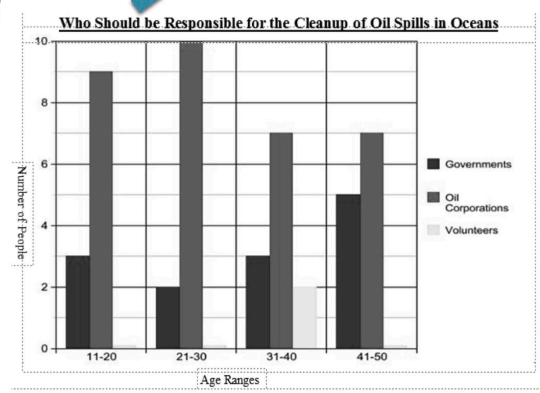
SD/OE RiNA Projects

Sample Student-led RiNA Project

A group of 11-th grade students carried out secondary research (e.g., Internet searches) about water and water pollution and then primary research (i.e., a survey of citizens' ages as they may affect their opinion on responsibilities for clean up of oil spills in oceans) and then, based on their findings, developed several actions (e.g., a poster [at right] and video posted to YouTube™) to educate people about water pollution and what might be done about it.

Student-led Actions





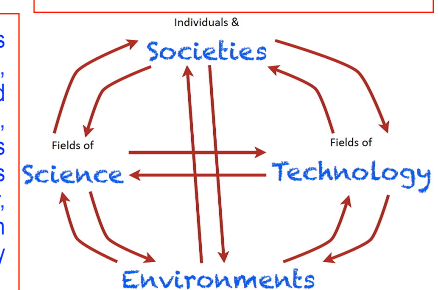
Student-led Research

Students' Primary Research (a study) to Supplement their Secondary Research

4. **Teacher Teaches**. Although students' pre-instructional ASK that they may have considered in the Students Reflect stage of this pedagogy should be celebrated, they also can benefit from learning some ASK developed by societies regarding fields of science, technology, engineering & mathematics (STEM). In this phase of the Pedagogy, we encourage teachers to use relatively teacher-directed and closed-ended approaches (e.g., lectures, slideshows, etc.) to teach students certain ASK about STSE relationships and, within them, typical RiNA projects that others have conducted. We recommend such direct instruction because it is apparent that many students (especially disadvantaged ones) are not able to discover such ASK through their own inquiries. One important thing to teach, for example, is STSE relationships in terms of actor-network theory (ANT) - noting that any one thing (e.g., a cell phone) is not an isolated entity but, rather, part of a larger network of living (e.g., engineers, companies), nonliving (e.g., mining machines) and symbolic (e.g., 'powerful') entities. In teaching about STSE relationships and RiNA projects, students also can benefit, though, from opportunities to evaluate taught ASK (e.g., by analyzing & critiquing sample RiNA project reports).

5. **Students Practise**. Although the teacher may have taught students various aspects of STSE relationships and RiNA projects and given them opportunities to evaluate taught ASK (and those they might learn from peers and elsewhere), students are likely to develop deeper attitudes, skills and knowledge by having more control over procedures (SD) and conclusions (OE) of RiNA projects. So, in this phase of the Pedagogy, students are asked to develop and implement plans for a small-scale RiNA project that addresses a problem they have identified in STSE relationships. We suggest that teachers can support such projects, but mainly only when requested by students. Often, though, students can benefit from suggestions for topics (problems and/or issues in STSE relationships) suggested by the teacher. Such suggestions can vary, for instance, from asking students to evaluate commodities they often purchase to giving students short descriptions of common issues (e.g., merits of nuclear vs. wind power). Many students also many benefit from having the teacher provide some practice lessons and activities about types of inquiry (e.g., studies vs. Experiments) and actions (e.g., personal vs. several social actions).

6. <u>STSE Relationships</u>. Although some people believe that scientists, engineers, etc. work separately from other people in societies, this is not realistic (see STSE model below). Government people, for example, regulate materials companies can include in their products, and capitalists (individual financiers & corporations) often fund STEM work - often influencing what and how products are developed and marketed. Transnational trade organizations (e.g., WTO) also can regulate how STEM fields are used and where work may occur. Many such ASK about STSE relationships should be taught in the Teacher Teaches phase. Students also can learn about them via secondary & primary research.



All above relationships may be considered 'positive,' 'negative' or 'neutral.'

7. <u>Research & Actions</u>. Students should learn, for example, to check that sources of ASK (e.g., websites) are not biased; e.g., via corporate ownership. They also might learn, for instance, that *correlational* studies (comparing changes in naturally-changing variables) are more ethical for STSE inquiries than experiments. Students also may learn that developing several cooperating actions (e.g., posters, videos, etc. promoted via social media (e.g., Facebook™ & Twitter™).