Some Findings About Research

Students Reflect. In the first phase of the STEPWISE pedagogy, students 'express' (e.g., as speech, writing, etc.) their existing attitudes, skills, knowledge (ASK) after reflecting on *phenomena* they have experienced; so, they are developing *representations* and doing 'research.'

- Asking students to reflect on familiar *phenomena* (e.g., commodities, like cell phones) gives them lots to note.
- After teaching students about *actor-network theory* (ANT), they can develop actor-network maps as more complex representations of STSE relationships.

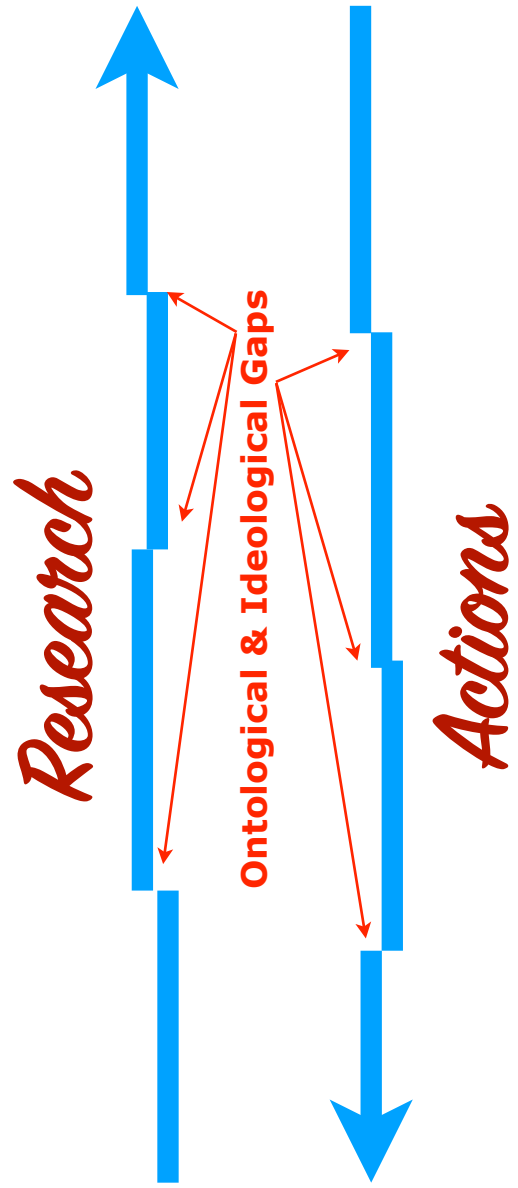
Students' Research. 'Primary' research means to collect data to develop representations of phenomena; while gathering others' representations is 'secondary' research.

- Many students can benefit from being taught different ASK about research, including skills (e.g., measuring).
- Although many students are familiar with experiments, they often need to be taught about *correlational* studies as ethical and/or practical forms of research for investigating possibly-harmful STSE relationships.
- Many students also need to be taught about realistic characteristics of the nature of science; e.g., methods often are not linear, due to errors, needing revision.
- Most students likely need to be taught about *ontological* gaps; that is, inconsistencies in translations between phenomena and representations due to differences in composition of the two (e.g., water vs. drawing of water).
- Most students need to be taught about *ideological* gaps; that is, intentional inconsistencies in translations between phenomena and representations - such as when scientists arrange a graph to exaggerate effects.
- Students should be encouraged to conduct primary research - both on existing phenomena and after actions.

Teacher Teaches. Although students can discover some ASK about phenomena, many - especially disadvantaged ones - need the teacher to directly teach some essential ASK; such as: effects of powerful people (e.g., financiers) on scientists, sometimes leading them to compromise methods and, therefore, findings (e.g., about climate) - which can lead to STSE harms (e.g., destruction from climate change).

REPRESENTATIONS

(e.g., photographs, sketches, blueprints, models, equations, posters, etc.)



PHENOMENA

(e.g., water, minerals, microbes, plants, animals, humans, cell phones, cars, etc.)

Some Findings About Actions

Teacher Teaches. In this phase of the STEPWISE pedagogy, students may be taught about research-informed & negotiated actions (RiNA) carried out by others to address harms they perceive in STSE relationships.

- Many students, especially disadvantaged ones, can benefit from direct teacher instruction about actions people have taken to address possible harms in relationships among fields of science & technology and societies & environments (STSE).
- Many students can benefit from being taught about types of action they could take, including: *educational*; *lobbying power-brokers* (e.g., letters/petitions to companies and/or governments); *public service acts*; *blockades*; etc.
- Many students can benefit from being taught that one can act on individuals, on groups (e.g., communities) and/or on organizations (e.g., companies, governments).
- Many students can benefit from being taught that one can act in direct (e.g., talking to people) &/or indirect ways (e.g., through posters, videos, social media posts, etc.).
- Many students can benefit from being taught that a network of several mutually-supportive actions at once may be most effective in achieving desired results.
- Given problematic nature of many commodities in societies, many students can benefit from being taught to develop and implement technology designs that not only work (e.g., clean stains) but also promote wellbeing of individuals (e.g., no toxins), societies (e.g., equity) and environments (e.g., low carbon footprint for distribution).

STSE Actions. Students are encouraged to self-develop and implement actions based on their research, education and negotiation among peers.

- Students can be motivated to act on STSE harms if findings from their research indicate harms.
- Students can be motivated to act on STSE harms if initial &/or some positive action results occur.
- Most students appear to be most comfortable with educational actions and indirect ones (e.g., videos).
- With practice - and, especially, with positive outcomes - students often take more direct and multiple actions.