Topologies of Activism for Science & Technology Education
EDITORIAL

Long Live Activism and Science Education!

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There is a growing feeling in the science education community that both science and education must develop their political capacities in order to face a growing ecological crisis and widening social inequality (Tolbert and Bazzul, 2017; Bencze and Carter, 2011). It is now becoming redundant to list the reasons why, but let’s just name a few: mass extinction, the rise of right wing populism and ongoing white supremacy, and growing privatisation of the natural/social commons. It seems that more and more educators are feeling a responsibility to gear their practice and scholarly pursuits to building just futures through activist work, critical pedagogies, and changing the very ethos of science education. The Journal of Activist Science and Technology Education (JASTE) supports this collective responsibility by publishing timely work of both emerging and established scholars and educators in the spirit of community and solidarity.

The journal recognizes that much of what motivates teachers and students to work toward better collective modes of living is on the level of the affective/aesthetic (Alsop and Dillon, 2018). This special issue entitled, Topologies of Activism was intended to re-centre justice education and activism as central themes of JASTE by inviting a diversity of views from the wider community. One general theme that came forward from the special issue contributions was the disconnect between the programmatic goals of science education and the institutional structure of science methods classes. Another theme that emerged was the need to specifically think about pedagogy/didactics as existing alongside an activist or critical stance. All in all, these papers show a healthy diversity of approaches to thinking about sociopolitical concerns in science education research and practice. Such diversity forces science educators to consider solidarity with different beings--students, nonhumans, researchers, etc.-- who do not think like us, interact with the world in the same way… yet nevertheless share common spaces and experiences in the world. Since all beings share some aspect of the material and social commons (Hardt and Negri, 2000); educators need to begin acting like solidarity is one of the default ontological/axiological positions of our shared world(s). And if so, activism is intricately tied to this fundamental aspect of being (solidarity) such that educators can resoundingly say: Long live activism in science and technology education!

To introduce the special issue we will give a brief introduction to the papers, and very briefly discuss the pertinent and pressing questions they raise.

Science Stand

The first article by Luis Paulo de Carvalho Piassi et al. discusses a Brazilian outreach initiative called “Science Stand” (for short), which connects science learning to pressing local issues and marginalized communities. One of the interesting aspects of Science Stand is that it provokes conversation between undergraduate students of science and diverse members of the general by engaging in demonstrations and playful activities. Its goal is to make science more accessible to those in low-income neighbourhoods by actively involving them in enjoyable, unique, transdisciplinary and interactive experiences. Such work is inspired by the lifetime work of Paulo Freire and a dialogic (and dialectical) approach to integrating science into everyday life. The reflections of the young creators of the various strands of Science Stand present
some of the important nuances of doing science-in-community work, as well as the hardships and inspirations that come with working with historically marginalized communities.

Science activism in our own backyard

Alberto Rodriguez’s article about transforming STEM education courses takes a serious and focussed look at the difficulties of one basic operation in preservice teacher education: implementing what is learned in science methods classrooms in internship/practicum placements at affiliated schools. One would think that there would be a modicum of continuity of culturally engaged and justice focussed science teaching transferring into practical contexts, of which the university has some institutional connection. Using personal experience, reflections, and documents such as emails, reports, and policy (some of which is not included in this version of the article), and drawing from Michel Foucault’s ideas of ethical self-reflexivity as a mode of resistance in the face of oppression, Rodriguez describes his self-reflexive struggle to find an ethical way through an institutional quagmire of platitudes, compromises, and practices of silencing. Rodriguez’s piece reminds science educators and researchers of the power and importance of positioning ourselves within our scholarship—whether the research be based on ‘the self’ or communities. It very much matters how educators take the time to think, feel, and act relationally and reflexively with their justice oriented work.

Motivation and Socioscientific Issues

EJ Karetny’s paper is a call to relate student motivation in science and environmental science education to socioscientific issues. Indeed what better motivator, than issues of collective existence to get students interested in science and environments? Karetny’s work broaches the almost taboo concept of morals in science. While science and ethics are often paired together, moral reasoning or sensibility, which is more intimately tied to questions of right and wrong and deep personal conviction, is seldom explored in mainstream science education (recognizing that the difference between morality and ethics is varied depending on who is speaking about them). Karetny’s article contends with a very salient issue for those educators interested in justice oriented science education: at some point educators need to depart from the frameworks of government, STEM, and even SSI frameworks, in order to get at serious moral and ethical questions in science education today.

Thinking big about computational thinking

This issue of JASTE also includes an article that addresses access to computer science education, for particular marginalized youth, specifically groups that are non-white, non-asian, and non-male. Rouhollah Aghasaleh, Patrick Enderle, and Anton Puvirajah do not shy away from the different contexts in which Latinx students find themselves in an age of populism and white supremacy. A way to resist the oppressive forces that differentially constitute the subjectivities of students (along the lines of privilege, dominance, race and sex/gender) is to allow students opportunities to participate in collective knowledge production. What these authors stress however is a conscientization that goes along with informal learning; and these happen through acts of authentication that move students toward ‘being subjects’ with knowledge relevant for their own emancipation. From feminist standpoint theory the authors maintain that projects related to Black Lives Matter, Donald Trump, and sexual violence are, at the very least, just as valid as projects related to global warming, engineering, and robotics. The article focuses on the experiences of three pre-service teachers and their experiences with a sociopolitically engaged STEM education framework geared toward computational thinking.

Didactic modelling for socio-ecojustice
Science education outside North America is often framed in terms of didactics or ‘scientific’ approaches to teaching and learning. Jesper Sjöström’s article attempts to elucidate a clearer vision of what a justice-oriented didactic approach could offer science educators. Add to this the German concept of Bildung, which has several nuanced explanations, one of which might be how theory and practice meet in self-reflexive and self-transformational ways. How do social justice frameworks therefore embody a didactics of science education (a scientific approach) for social justice? The question is: what would go into such a framework that claimed to satisfy the cultures and expectations of didactical reasoning? Sjöström draws from Vision I and Vision II science, as well as critical concepts like emancipation and subjectivation to attempt this important synthesis. A major question that Sjöström faces in this article, both implicitly and explicitly, is the following: How is it possible to make an ethically and politically engaged science education that can also be expressed as a ‘science’ of teaching? Why might such a didactical model, as a unique approach to science teaching, be absolutely necessary as part of the overall effort to create better futures through science education?

Going Up Against The Borg™

Lastly, Larry Bencze, one of the founding editors of JASTE, brings the context of neoliberal global capitalism into the context of science teaching and learning by suggesting that science educators need to think expansively about the meaning of teaching and learning under capitalism. STEPWISE is the framework Bencze uses to outline how a teacher might engage science teaching and learning for the wellbeing of communities and individuals. However, Bencze also notes that the possibilities open to science teachers often reproduce economic disparity and keep particular hegemonies and hierarchies in place—specifically those possibilities that involve individual actions or ethical concerns that are in the interests of capitalist (re)production. Bencze puts forward the thesis that science educators should begin to levy and employ similar technologies of power, communication, mediation, and valuation that capitalism uses, such as various kinds of networks and commodities, to ‘fight the battle’ against capitalist interests in science education. One of the strengths of Bencze’s contribution is precisely the expansive thinking required to imagine the ontological realities of capitalist relations—they are both terrible, unavoidable and largely constitute the space where educators live and work.

We, the editors, hope that JASTE always remains a place to take up the ‘community of the question’ of activism and science education. As well as all the messy-good affective, political, pedagogical, and material considerations that come to the surface when doing justice-oriented work in education. Long live the expansive relationships between equality as a radical democratic principle and science education!

Jesse Bazzul, Larry Bencze and Steve Alsop

References


Science Stand
A Brazilian Activist Science & Technology Outreach Initiative

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Responses
JASTE is a non-refereed, open-access, journal. We encourage reader feedback on contributions to it. Please send your comments, suggestions, etc. about this paper to either or both Luis Piassi (lppiassi@usp.br) or Giuliano Reis (greis@uottawa.ca). Thanks!

ABSTRACT

This article presents the theoretical and methodological aspects of the activist science and technology education practices of a Brazilian outreach initiative known as Science Stand. This learn-by-doing program is designed to connect science and technology to current global socio-ecological issues – such as animal rights, gender (in)equality, and climate change – through interactive activities created and performed by university students in public spaces located in marginalized communities in the Greater Sao Paulo Area (Brazil). In addition, we introduce several testimonies from project volunteers that support our argument concerning the role of science activism in advocating gender equity in science, fostering hope in the possibility of socio-ecological change, and promoting the democratization of science through widespread knowledge dissemination.

Keywords: activist science; science stand; ludic science; social activism; cultural manifestations; marginalized youth.

Introduction: Science in society or science for society?

Science is an essential element of society. It is “an important aspect of the lives of all citizens if they are to make informed decisions” (Gunstone, Corrigan & Dillon, 2007, p. 4). Nevertheless, it is not equally available to everyone. Thus, science outreach programs can help to fill this accessibility gap by taking science where it is less familiar (Laursen et al., 2007; Ecklund, James & Lincoln, 2012). In addition to becoming relevant to the lives of the people to whom such activities are aimed, they can also be transformative for those who deliver them, be them university students or academic professionals: they demand increasing understanding of the content of the activities delivered to the public and commonly favour interpersonal relationships among team members.
In Brazil, interest in the public dissemination of science only started after the arrival of Portuguese settlers in the 19th century, and the subsequent advent of universities, science museums, magazines, and a scientific observatory (Dantes, 2005). Nowadays, science outreach activities abound throughout the nation and have diverse purposes, from improving school science experiences to developing the quality of pre-service teacher training (Massarani & Moreira, 2003). The place and format of these initiatives – often interactive and itinerant – may vary, from demonstrations, experiments and lectures to theater plays and videos (Ferreira et al., 2007; Silva et al., 2009).

In the present article, we discuss aspects of one outreach program in Brazil, the Science Stand, which is managed by a pool of public universities1 and seeks to integrate science and technology activism by promoting educational “practices that aim to be more ethically and politically engaged and socially and environmentally responsive” (Alsp & Bencze, 2014, p. 2) in schools as well as poor (marginalized) communities and public spaces in the São Paulo Macrometropolitan region. This area (also known as “Macrometropole Paulista” [MMP] in Portuguese)2 corresponds to a radius of about 100 km from São Paulo city and is characterized by a population of approximately 33 million people living in intense socio-economic inequality (Haddad, 2009). It is the largest urban cluster in the Western hemisphere.

Science Stand promotes conversations amongst undergraduate students and the general public (i.e. young children, adolescents and adults) through traveling exhibitions, experimentation with everyday materials and recreational practices (Piassi, Vieira & Santos, 2017; Piassi, Santos, Vieira, Kimura, Vizachri & Araujo, 2018; Santos, Singh, Cruz, Piassi & Reis, 2019). In addition, it makes use of recreational activities (e.g. games, quizzes, movie debates, playful experiments, etc.) based on popular media that emphasize narratives of fantasy and science fiction to address social issues like gender equality, animal rights, and sustainability. It also focuses on encouraging access of low-income students to undergraduate and graduate university programs. As a result, Science Stand further creates space for science and technology activism by bringing “diverse groups together with sufficiently common but divergent educational and political commitments such that they can share and learn together as ‘subjects’ rather than ‘objects’ of educational processes” (Alsp & Bencze, 2014, p. 8). From a more Freirean perspective, the realization of such ambitious goals in a highly unequal society such as the MMP area is a revolutionary task in and of itself.

The process of disseminating scientific knowledge to the public often occurs in anti-dialogic terms, thus promoting and reinforcing a form of science indoctrination by “cultural invasion” (Freire, 2005, p. 93). In other words, if the public communication of science is not conducted in clear terms that facilitate questions and dialogue, it can turn science into a medium of academic proselytism rather than a tool for socio-ecological activism (Kerckhoff & Reis, 2014; Reis, Ng-A-Fook & Glithero, 2015).

In using creative methods that use natural science knowledge to address ethical, social and political issues, SS has the potential to create room for activism to flourish. Therefore, over the years, we have gathered testimonies from those involved the project, especially undergraduate students, with the objective of determining those pedagogical practices that enhance the activist nature of the activities developed.

Science Stand: An activist science and technology outreach program

The Science Stand project is an umbrella initiative made up of a collection of several programs, each of which is named after a female character from a popular media work, like science fiction movies or

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1 University of São Paulo (USP): USP East (School of Arts, Sciences and Humanities) founded in 2005; Federal University of São Paulo (UNIFESP): Campus Guarulhos (School of Philosophy, Letters and Humanities), and Diadema Campus (Institute of Environmental, Chemical and Pharmaceutical Sciences), established both in 2007; Federal Institute of São Paulo (IFSP): Campus Boituva, founded in 2002, converted into a higher education institution in 2009.

2 Official information about the Macrometropolitan São Paulo (MMP) region can be accessed at https://www.emplasa.sp.gov.br/MMP (website in Portuguese).
novels. The programs (and the workgroups within each one of them) are tailored to engage specific audiences in the settings where they take place (Table 1).

**TABLE 1: SCIENCE STAND PROGRAMS (SUMMARY).**

<table>
<thead>
<tr>
<th>Programs</th>
<th>Target audience</th>
<th>Settings</th>
<th>Formats</th>
<th>Lines of interest (strands) and workgroups</th>
</tr>
</thead>
<tbody>
<tr>
<td>Joaninha</td>
<td>Children (up to 9 years-old)</td>
<td>Kindergarten/elementary schools</td>
<td>Recreative in-class interventions.</td>
<td>• Strand I (Social causes): Dian and Emma.</td>
</tr>
<tr>
<td>Alice</td>
<td>Pre-teenagers (10-14 years-old)</td>
<td>Junior high schools</td>
<td>Before and after school (science clubs and/or recreative interventions)</td>
<td>• Strand II (Artistic and cultural artifacts and practices): Lucia, Maria and Rita.</td>
</tr>
<tr>
<td>Pris</td>
<td>6-14-year-olds</td>
<td>Youth centers for children in social vulnerability</td>
<td>Science projects, recreative and/or artistic interventions and science clubs.</td>
<td>• Strand III (Accessible hands-on science): Annas and Lira.</td>
</tr>
<tr>
<td>Ellie</td>
<td>General public</td>
<td>Public settings (e.g. parks, squares, train/bus stations)</td>
<td>“Street science” exhibitions with low-cost experiments and prototypes.</td>
<td></td>
</tr>
</tbody>
</table>

The programs are generally coordinated by the most experienced undergraduate students in the group. Moreover, the team leader’s research interests are expected to be well aligned with the proposed activities of the group. As for the workgroups (or sub-groups) within each program, they are created mainly according to 3 different strands (or lines of interest):

- **Strand I: Social causes.**
  a. *Dian*: animal rights and sustainability ethics involving political reasoning about the human relationship with the environment. The name is an acronym in Portuguese for “Debates and Investigations about Animals and Nature” and it is also a reference to Dian Fossey, the North American primatologist and activist who was murdered due to her work defending gorillas in Rwanda.
  b. *Emma*: encourage and empower the presence, inclusion and valorization of women and minorities in the science arena. It is named after the English actress and activist Emma Watson.

- **Strand II: Artistic and cultural artifacts and practices.**
a. **Lucia**: deals with fiction, or the depiction and conceptualization of culture through the lens of imaginative fictional artifacts. The name is a tribute to the Brazilian writer Lucia Machado de Almeida.

b. **Maria**: ludic practices, related to playfulness, as toys, gaming, humor and other cultural elements of enjoyment, in the context of science. The name refers to the Mexican humorist Maria Antonieta de Las Nieves (Ramos, 2016).

c. **Rita**: rhythm and music culture and expression in its relations to science, including songs, dance, and related practices. The name refers to the Brazilian singer and composer Rita Lee.

- **Strand III**: Accessible hands-on science.
  a. **Annas**: development of simple and low-cost experiments and science prototypes with familiar materials of everyday life. Refers to Anna Maria Pessoa de Carvalho, Brazilian science education researcher, and to Ann Druyan, science communicator.
  b. **Lira**: development of robotic, electronic, and programming prototypes involving maker culture and open hardware and software platforms. The name is a reference to the Brazilian NASA aerospace engineer Jacqueline Lyra.

These strands have been modified over time in order to attract increased interest from potential volunteers in line with their academic and personal pursuits. These include eagerness to examine connections between science and cultural practices (such as literature, cinema and music) and the political dimensions of science (such as feminism, veganism, environmentalism). Several students, for example, have shown interest in the representations of women in science fiction and fantasy films, and this has led to the creation of the Emma group (part of strand I). Similarly, students interested in environmental issues or animal rights, are likely to find interest in joining the Dian group (also part of strand I). The Annas group (strand III) is an attractive option for those who are sympathetic to – or have a cultural identification with – the topics of creativity and practical experimentation in science. Groups can also be combined. For instance, the Emma-Lucia group was created to discuss gender issues in science through science fiction movies and novels. The success of these strands in engaging volunteers and the public at large has been a key reason for the existence and continuing expansion of the Science Stand project.

Next, we discuss in more detail the characteristics of each one of the programs – Joaninha, Alice, Pris and Ellie – and also present the testimonials of selected participants (university students) on the perceived impact of their participation in the programs.

**Science Stand: Changing Testimonials**

**Joaninha (Ladybug)**

This is a program created for early childhood audiences, specifically children up to six years of age from public schools in low-income communities. The name is an acronym in Portuguese for “Playing, Observing, Learning, Narrating: Investigations about Nature, Humanities and Arts,” which points to the goal of developing playful activities that encourage young children to reflect on topics related to nature and culture. The following themes have been examined since the program was created in 2014: astronomy, animals, logic, and animation. The successful experiences stemming out of the Joaninha program have been published elsewhere (Araujo, Pimentel, Luhman, Piassi & Santos, 2016; Santos & Piassi, 2016; Reis, Silva & Piassi, 2018; Silva, Araujo, Piassi & Santos, 2018).
In the context of the Joaninha program, the workgroup Dian (strand I) is of particular interest from an activist science and technology education perspective. Over the years, it generated playful activities that addressed ethical and environmental problems by using board games, miniatures, role-playing, quizzes and other playful activities. In some of the activities performed in 2018, the group presented plays and played mime games based on nature photography of the Brazilian jaguar. As a result, participants (both university students and the general public) had a chance to debate deforestation, the ethical problems associated with zoos, the socio-ecological impact of raising animals for consumption, and to address questions concerning emotions in non-human animals (Peixoto, Vizachri & Piassi, 2018). Music and singing were also used to generate discussions about the importance of bees and how they are affected by the indiscriminate use of pesticides, a topic that is relevant globally (Reis, 2014).

As part of university students’ involvement as mediators between the proposed science activities and the public, they are encouraged to start their own undergraduate research, suggest the development of new activities and participate in academic conferences. Consequently, in joining the group, they also have the opportunity to grow as researchers and concerned citizens:

[Joining the group Joaninha] promoted a real transformation in my eating and consumption habits, because it has stimulated me to want to stop eating meat or reduce its consumption and also to be mindful of products I buy, especially personal hygiene products, that do animal testing, and I started to choose other options. (Anita3, 19-year-old female undergraduate student in Environmental Management)

The same participant also added that, “when I, for example, talk to my mother, it is noticeable that I am trying to encourage her (...) to think the same way I do: that animals deserve to have rights like us, that they are like us.” Thus, it is possible to observe that the students’ involvement with the group Dian promoted significant changes in her lifestyle as an individual consumer and member of a family (i.e. beyond school). (The family-based perspective of youth consumption is an important one and is deserving more attention [Reis, 2018]). The experiences of this the group have resulted in 3 out of the 8 current mediators becoming vegan after joining the group – one of which is now producing a documentary about the vegan lifestyle in order to promote it.

Alice

Alice is a program designed for junior high school students, aged 11 to 14 years of age (Gomes & Piassi, 2018; Piassi & Kimura, 2016). The name is an acronym in Portuguese for “Art and Ludic in the Investigation of Science in Schools.” The female character Alice (from the book Alice in Wonderland written by Lewis Carroll in 1865) was chosen to represent this program because of her curiosity and interest in unusual phenomena. Activities that have been carried out in the context of the Alice program include literary science clubs, workshops and exhibits of accessible low-cost experiments, recreational art-science projects, prototyping (i.e. simple artifacts building) and robotics workshops, and environmental and sustainability activities. The program began in 2015 in a public school in São Paulo, with activities held one hour before regular classes, between noon and 1pm. The enrollment in the activities is voluntary and involves students from the sixth to the ninth grade. The meetings occur once or twice a week. From 2018 onwards, the main focus of the group has been on the development of a science club for girls within the Emma group (strand I).

There are two workgroups in this program that are of particular interest for this paper. The first one is Rita (strand II), which is mainly about music and musical culture. The name is an acronym in Portuguese for “Rhythms in Technology and Art-Science Research.” It is a group that works with the cultural dimension of music and other rhythmic manifestations (such as dancing, poetry reading, etc.) in their multiple connections with the sciences. Besides the incorporation of scientific elements in song lyrics, there is interest in the different approaches used by artists to manifest science, like rhythm and iconography (i.e. the use of images and symbols) (Gomes & Piassi, 2016; Gomes & Piassi, 2018). In this way, pop-

3 The names are fictitious and inspired in Brazilian singers or actresses, and were given in alphabetic order along the text.
music videos can be used to provoke reflections about the relationship between women and science, and rock songs from the 1960s and 1970s become useful resources to discuss public understanding of astronomy and space missions (Gomes, 2016). In other words, teachers and students are invited to consider the complex conceptual, epistemological and sociopolitical entanglements of science, technology, society and the environment. In informal conversations, a factor usually mentioned by students as relevant for their positive learning experience in the program is the collaboration with other volunteers. The team work developed contributed to the development of students’ academic skills, allowed them to put into practice what they had learned in theory and gave them a chance to interact with children and adolescents in informal settings. Although one cannot affirm that volunteers saw themselves as militants of a social cause through their work, it is clear that music can be a powerful mobilizing element. Much work remain to be done in regards to quality and duration of the engagement in socio-ecological causes mediated by music.

The second workgroup of interest for our argument is Emma (strand I), the name being an acronym in Portuguese for “Studies on Women and Minorities in Art-Science.” The goal of this group is to employ mechanisms by which films, television shows, video clips, comic books and science fiction can contribute to structuring and strengthening participants’ capacities to become aware of gender issues related to science and technology. Within the Alice program, Emma is currently supporting the development of two science clubs for girls: *Pueriae in Scientia* (elementary public school) and *Lab das Minas* (intended for public high school students). There, university students prepare and carry out activities (e.g. experiments, debates, games, etc.) and collect and analyze data for their own undergraduate research. Although this process is often seen as challenging by university students, once they succeed in involving the public on the proposed activities, they develop not only their self-confidence, but also a sense of ownership to what they have accomplished collectively. Below, we have some excerpts transcribed from audio testimonials collected from a mobile messenger application group of the project, during the final collective assessment in 2018.

“I’ve been here for almost three years, right? And it was the semester that I liked the most, because I think we were really able to do the things we wanted to do from the beginning and achieve goals that we had not been able to achieve. (Beth, female, undergraduate student in the Leisure and Tourism program, 20 years old)

“I got attached to this place, guys, I got attached to the girls. The girls hugged me today and I was feeling so bad like... [sobbing] ... I don’t know, I got attached... This is so good, being part of something that is being build, we built this together, guys... (Cassia, female, undergraduate student in the Natural Sciences Teaching program, 23 years old)

Although the science clubs aim to engage teenagers in science, they end up functioning as spaces of mutual empowerment that have a great impact on the lives of all participants. University students create strong bonds with themselves and also with their audience (i.e. school-age teenagers who participate in the projects). These ties create a sense of sisterhood among girls, which strengthens them as women scientists and contribute to overcoming personal limits:

“I think that the fact that we go twice a week [in the science club] has made the group come together more... I also like this proximity, even us here, we’re very close now. (Dira, female, undergraduate student in the Natural Sciences Teaching program, 22 years old)

“Sometimes I do not integrate myself so much, sometimes I don’t talk to anyone, but nevertheless I felt a bond with them [teens who participate in the club], you know, like having times when we laugh, having moments that I... You know, I really admire the girls, and I think I admire it too because I had all this vision of each of you giving opinions about different things and such. (Elis, female undergraduate student in the Public Policies Management program, 22 years old)

Elis’ initial difficulty to socially integrate with other people in the group likely impacted her perception of being suited for this type of work – both academic and scientific in nature. Eventually, her decision to continue to participate in the activities indicated her belief in being able to work in science.
field. Here, it is reasonable to assume that her change in perspective was also motivated by the bonds she developed during the time spent with other girls in the program. The sense of intimacy and mutual admiration that the work can provide to participants attests to the importance of these spaces for the construction of participants’ identity as both women and scientists-to-be.

What I can say from my personal experience, I was a little unmotivated with this part, I love science popularization, I love science, only that I was unmotivated, and then when I came I thought I was going to remain in the same situation, I was not very satisfied, but I think precisely because it has a very different dynamic, because it has a discussion space, it is not something I just go there for the activity because they told me to do it and it’s over, no, we would sit here and try to kind of have a bond and think about what we were doing here and that for me is very important. (Elis)

I hung out here, people, I got attached to the girls, our girls hugged me today and I felt very upset [sobbing], I do not know, I got attached. (Fernanda, female undergraduate student in the Natural Sciences Teaching program, 23 years old)

Fernanda (see last quote above) felt particularly upset for leaving the project to join another group. Her discourse suggests that her connection with the group goes beyond her interest in the activities. Once again, the value of emotional bonds emerged as a facilitator of the joint construction of knowledge. It also helped participants to engage with the activities by making sense of them, which in turn is in line with Freire’s (2005) notion of liberating education. Additionally, participation in the club might have offered participants a glimpse of the social roles of science, which was a frequent discussion topic. This is another aspect of the activist science nature of the Science Stand program since not all undergraduates come from a science-related program. As a result, students could start acting more as subjects – rather than objects – of the educational process, thus disrupting the discrimination that women are faced in science and that ends up discouraging them from pursuing or advancing a career in science (Carr, Helitzer, Freund, Westring, McGee, Campbell, Wood & Villablanca, 2019; Todd & Zvoch, 2019).

**Pris**

This is a program aimed at children and adolescents between ages 6 and 14 who experience social vulnerability. The name is an acronym in Portuguese to “Recreational Projects of Social Inclusion in Sciences Integrating Ludic, Literature and Arts.” It is a reference to Philip K. Dick’s character Priscilla “Pris” Stratton in the novel *Do Androids Dream of Electric Sheep?* and also in the film based on it, Ridley Scott’s *Blade Runner* (2010). In the plot, the character Pris is one of the replicating androids that live in a vulnerable context and fights for the right to survive. The program works with young people attending a Youth Centre (YC), a non-formal educational space dedicated to the care of vulnerable children and adolescents. The YC is located in a neighborhood that faces socio-economic and environmental vulnerability due to problems related to soil contamination in the region. Given the context, several groups such as Emma, Lucia, Maria and Dian have developed activities for the YC public, mostly ludic interventions that seek to stimulate a critical reflection on subjects like gender equality, animal rights and environmental awareness (Alves, Souza, Santos & Piassi, 2017; Cruz & Gomes, 2019; Pupo, Gomes & Piassi, 2017; Santos & Piassi, 2018; Santos, Singh, Cruz, Piassi & Reis, 2019).

Maria is an acronym in Portuguese for “Manifestations of Amusement and Recreation in Inquiring Art-Science” and is a reference to the Mexican actress and humorist María Antonieta de las Nieves. The group focuses on the study of the ludic practices related to gaming, humor, toys and other ludic artifacts and practices in the context of science (Miranda & Piassi, 2016; Ramos, 2016).

Well, when I think about my major, which is Public Policy Management, I’m going to have to work with a lot of people, organizations, leadership position, and being in Maria... In my head it’s like a smaller space that I’ll have to face it when I go to the job market. So, I think that for me as a person helps me a lot until I have self-control, that organization issue. (Giovana, female undergraduate student in Public Policy Management, 25 years old)
I identify myself a lot with the ludic, which is a business that has been there since childhood, and is one thing that I believe works. The playfulness, I believe it can change and transform lives. (Helena, female undergraduate student in Public Policy Management, 21 years old)

From these short testimonials, it is possible to observe that the undergraduate students involved in the Maria group, and within the Pris program, report feeling engaged and satisfied in carrying out the activities geared towards socially vulnerable children. In addition, the experience gained was seen as relevant both professionally and academically as participants have expressed wish that the activities they developed with the youth could promote social change in the community. And what is activist science and technology without hope?

Ellie

The name is an acronym in Portuguese for “Ludic Exhibitions of Outreach Itinerant Laboratories.” It is named after Eleanor Arroway from Carl Sagan’s book Contact (1985) and the subsequent film of the same name directed by Robert Zemeckis (1997). The program is characterized by traveling exhibition stands, where experiments and devices built with low-cost materials are displayed and stored (Piassi, Vieira & Santos, 2017). The main purpose of the activities is to bring science and the public closer together by familiarizing them with materials with which they are in daily contact. More importantly, these activities are designed to demystify science, the practice of which is believed to be restricted to the use of expensive materials and equipment by highly skilled specialists. Thus, the model of interventions adopted by the Ellie program is to decentralize scientific dissemination practices in urban centers without requiring major financial or architectural investments (Alves, Silva & Piassi, 2017). The exhibitions can take place in several contexts and locations, as parks, trains stations, schools, and community events. Unlike previous programs, the Ellie activities do not have a fixed programming because they are performed to general (unspecified) audiences, including the blind. The creative aspects involved with the line Annas (strand III) are well suited for the goals of the Ellis and were highlighted by one of the participants:

I like to try to develop the experiments, I like to think of new things to bring, so I like the development part of the project. I end up enjoying this stage more than the interventions, but, the interactions in the interventions, it’s fantastic, and I think that it is cool how every intervention is a box of surprises. (Ivete, Textile and Fashion female undergraduate student, 22 years old [Silva, 2018, p. 276])

Based on the quote above, one can infer that one of the preferred aspects of the work for the student is the creation of new ideas for didactic prototypes and the ways they are received by the public during interventions.

To include, is to be part. For me that’s it, to be part of any reality. That even if it seems not to be, it is to show that it is for everyone with any other situation that is going on in life. (Jorge, Natural Sciences Teaching program, male student, 20 years old [Silva, 2018, p. 182]).

In the case of this second participant (Jorge), we observe that the focus is not on the apparatus nor in the reaction of the public (unlike it was the case indicated in Ivete’s quote). Instead, the focus was on the accessibility of scientific knowledge to people overall that resulted from the activity. This is yet another important aspect of the activist nature of the project Science Stand: it imbues participants with a sense of social responsibility for enabling the general public to have access to various realms of science (e.g. having contact with experiments, phenomena and concepts that they have never had the opportunity to experience, besides interacting directly, in an informal and pleasant way, with university students, in a social context that excludes vast segments of the population from access to higher education). There have been a few cases, for example, of young people who have visited exhibitions in public facilities and thus learned about the public university and the opportunities for access to it, including some who actually entered university and are now volunteers in the project.
Conclusions

As one can see, the Science Stand project encompasses several different kinds of actions that are defined by 4 programs (Joaninha, Allice, Pris and Ellie) and the groups that integrate them (Dian and Emma [strand I: social issues]; Lucia, Maria and Rita [strand II: artistic and cultural approaches]; and Annas and Lira [strand III: accessible practical science experimentation]). Altogether, they engage undergraduate students from eleven programs at the EACH/USP, including Biotechnology, Natural Sciences, Environmental Management, Public Policy Management, Leisure and Tourism, Marketing, Information Systems, and Textiles and Fashion. Ultimately, the overall objective of the program Science Stand is to encourage activist science and technology by disseminating science knowledge for socio-ecological transformation in specific marginalized areas of São Paulo. With this in mind, a democratic environment was created for volunteers to work, which is respectful of the plurality of participants’ academic and personal interests.

In the Science Stand, students are engaged in communicating science in schools and universities (programs Joaninha and Allice), public spaces (Ellie program) and with children and adolescents in situations of vulnerability (program Pris). The possibility of integrating different groups – Annas, Dian, Emma, Lira, Maria and Rita – enables the dissemination of science in an interdisciplinary perspective, reflecting the broad participation of students from different educational levels. In addition, the merging of two groups may result in benefits for undergraduate students’ lives that go beyond their academic perspectives (e.g. changing habits and attitudes towards consumerism, animal rights and other environmental problems).

Another factor that guides the whole project is gender equality in science, which underscores how the protagonism of young girls in the communication of science can be stimulated. Hence, the extensive role of young girls in the project. In addition, cultural products such as movies and video clips and the playful approach that the Science Stand uses makes the contact with science fun, relevant and encourages critical thinking about the meaning of edutainment in education.

In a country like Brazil, where large segments of the population have little access to scientific practices in their everyday life outside of school, the Science Stand has brought about important changes in the city of São Paulo. As a result, participating students create activities autonomously, thus becoming mobilizing agents (activists) in the communities where they work or visit. This, in turn, impacts their own ways of seeing and acting in the world, leading them to question fixed gender roles in science, increasing their hope for less social inequality and inviting them to take responsibility for sharing their knowledge with others. That is, students are transformed from within in the process of attempting to transform society.

References


(Re)engaging Our Ethical Commitments and Becoming Activists in Our Own Backyards

Using Research to Expose, Disrupt and Transform Opp(Regre)ssive Science/STEM Teacher Education Practices

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Responses

JASTE is a non-refereed, open-access, journal. We encourage reader feedback on contributions to it. Please send your comments, suggestions, etc. about this paper to its author, Alberto Rodriquez. Thanks!

ABSTRACT

In this manuscript, I provide an example of what activism in your own backyard may look like in institutional contexts using Foucault's notions of ethics. To this end, I report findings from a two-year study conducted in my own science methods courses with two cohorts of pre-service teachers. Through a critical autoethnographic lens, I recount a synthesis of struggles and successes that illustrate what happens when one’s ethical and professional commitments to work for social justice intersect (collide) with the urgent need to address opp(egre)ssive practices in our own programs. Suggestions for how to be an activist in our own backyards and how to (re)engage our ethical commitments through a praxis of self-care are also provided.

Road Map

The guiding questions the editors of this special issue included in their call for submissions were quite compelling, and for me, the following question was particularly captivating: “What might activism and political engagement in science/education entail?” Since I was already engaged in an activist project, I wanted to explore more closely a modified and more personal version of this question. That is, “What might activism and political engagement in science/education entail in your own backyard (at your own institution)?”

Thus, in this manuscript, I draw attention to the need to (re)engage our ethical commitments and turn our activist lens inward. We, especially teacher educators and researchers, should reflect on the following questions: In what ways does our research and activist work effect transformative change in our own teacher education programs? More specifically, in what ways are we using findings from our own studies to instigate transformative change in our colleagues’ practices through our programs and our institutional policies for the benefit of pre-service teachers (and their future students)?
In order to consider these questions, herein, I use findings from a two-year study I conducted in my own science methods courses with two cohorts of pre-service teachers to expose, disrupt and transform contradictory and normative practices within my institution’s elementary teacher education program. To this end, I first explain how I invoke Foucault’s (1997) notions of ethics to guide and nourish my reflections and the direction of this manuscript. This is followed by a description of critical autoethnography as the most appropriate tool for inquiry in this context (Marx, Pennington, and Chang, 2017). As a Latino, immigrant, teacher, and researcher, engaged in equity, diversity, and social justice work in various educational contexts for over two decades, I have observed that critical autoethnography provides a powerful tool for deconstructing the struggles and successes we encounter when addressing oppressive and regressive practices (that is, practices that are simultaneously oppressive and regressive, Rodriguez, 2010). I close, as I start, with Foucault’s conceptions of ethics and provide some suggestions for how to be an activist in our own backyards and how to (re)engage our ethical commitments through a praxis of self-care.

**Theoretical Framings**

Michel Foucault’s (1997) notions of ethics and their application to the field of education are intriguing. Other more capable scholars have connected Foucault’s ideas in more detail to education (Infinito, 2003; Olssen, 2006) and specifically to science education (Bazzul, 2014; 2018). Bazzul (2018), for example, argues that education is a field of inquiry particularly suitable for the study of ethics and ethical subjectivity (“how one comes to understand themselves as an ethical being,” p. 474) because of the wide range of spaces where subjects (in various positionalities) operate. Herein, however, I take a pragmatist turn and use Foucault’s constructs of ethics and freedom to explicate the need for this study.

For Foucault, freedom essentially gives the construct of ethics its purpose, and ethics provides clarity for the enactment of freedom. As Infinito (2003) elaborates, “Foucault treated freedom and ethics as overlapping realms of action rather than distinct spheres of human being” (p. 156). Furthermore, Foucault interpreted ethics as an act of self-care—neither as a selfish nor selfless traditional and binary notion, but as a much more complex system mediated by the games of truth and power relations that imbue human interactions. These two notions provide useful entry points for us to better understand the dominant discursive practices that sustain (or could aid in disrupting) entrenched power structures:

The word "game" can lead you astray: when I say "game," I mean a set of rules by which truth is produced. It is not a game in the sense of an amusement; it is a set of procedures that lead to a certain result, which, on the basis of its principles and rules of procedure, may be considered valid or invalid, winning or losing. (Foucault, 1997, p. 297)

Thus, in activist work, we must not only access and understand the existing rules and procedures of dominant discursive practices. We also need to know how to use them to engage in the power relations that could ultimately facilitate the change we seek. For Foucault (1997), these dynamics are neither negative nor positive—they are just features of our humanity:

This is precisely a failure to see that power relations are not something that is bad in itself, that we have to break free of. I do not think that a society can exist without power relations, if by that one means the strategies by which individuals try to direct and control the conduct of others. The problem, then, is not to try to dissolve them in the utopia of completely transparent communication but to acquire the rules of law, the management techniques, and also the morality, the ethos, the practice of the self, that will allow us to play these games of power with as little domination as possible. (p. 298)

Returning then to the construct of ethics, we can appreciate that for Foucault, an individual’s freedom involves navigating through games of truth and power relations that influence—but do not determine—the ethical self. Our freedom is indeed best manifested in the practice of self-care, and in practicing self-care, we labor to care for others as well. Infinito (2003) expands on this insight, adding that Foucault implied that “by
forming ourselves as ethical beings, we activate our capacities for creation and potentially bring about an ever-evolving person (ourselves), thereby a new and different world” (p. 162).

Now, in the exploration of my own ethical commitments as an often “othered,” scholar of color in science education, I am constantly navigating through challenging and shifting terrains. I am expected to contribute to the advancement of equity and social justice by virtue of who I am and my expertise, but only as long as those contributions are deemed palatable and consumable in “well-articulated” portions by those with (or perceived to be in) power. Enacting our ethical commitments involves taking risks, and I am aware that each one of us must determine when, where, and how we choose to take risks in our own contexts. However, we should constantly reflect on the extent to which our ethical selves are compromised when we choose “to look the other way” in the presence of unjust and oppressive practices, and by default relinquish our freedom.

Tools for Inquiry and Reflection

In this pragmatist exploration of my ethical commitments as an activist for social change, I chose critical autoethnography as a tool of inquiry (Marx, Pennington, and Chang, 2017). This methodological approach is particularly well suited for the reflexive (re)telling of narratives of engagement. In previous writings (Rodriguez & Morrison, 2019; Rodriguez, 2015b), I described narratives of engagement as a more representative, balanced, and critical analysis of the challenges and successes we encounter in our efforts to advance social justice. These efforts include the responsive (and responsible) role researchers can (and should) play in bringing about transformative change. The “critical” in critical autoethnography enables multiple entry points for the subject/researcher to (re)tell lived encounters with dominant discursive practices, and consider how existing webs of oppression are sustained, resisted, and can be potentially dismantled.

I also prefer to adopt critical ethnography as a tool for inquiry because it unapologetically expects (requires) that the teller reveals their intentionality; whereas, ethnographic and auto/biographical work does not. In a previous critique of auto/biographical research, I described intentionality “as the consciously driven ideological, political, pedagogical, and theoretical motives behind the desire to tell a chosen story of self” (Rodriguez, 2001, p. 14). At that time, the use of auto/biographies as a research method in the social sciences was gaining as much interest as autoethnographies are gaining today. Thus, it is important to be cognizant of the differences. Marx, Pennington, and Chang (2017) also add that “although autoethnography can naturally embrace the critiques of societal injustice and positionality of identities, not all autoethnographers have explicitly and intentionally identified their autoethnographies as ‘critical ethnography’.” Although all of these methodological tools are alluring, meaningful, and impactful in their own right, Ursula Kelly’s (1997) warning resonates with me as much today as it did then when she stated:

Unproblematic or romantic notions of the power of story and/or the educationally redemptive powers of autobiography—even when applauded by those whose agenda may appear more radical—must be approached cautiously, for notions are never innocent; they always participate in larger ideological constructs. (p. 49)

For the purpose of this study, which focuses on deconstructing how my ethical commitments as an activist, teacher, and subject/researcher play out within dominant discursive practices, the use of critical autoethnography is essential. As Holman Jones (2016) explains, critical ethnography involves “linking analysis and action as they unfold together in material and ethical praxis—by creating bridges between analytic, practical, and aesthetic modes of inquiry and representation” (p. 5).

How to (Re)Engage our Ethical Commitments and Become Activists in Our Own Backyards
In an effort to instigate others to become activists in their own backyards, I organized this narrative of engagement into four temporal phases as they unfolded: research opp(regre)ssive practices, expose, disrupt, and transform. I do not wish, however, to essentialize the complexity of this work, nor give the impression that some perceived formula or steps can easily manage the emotional, physical, and laborious work required to (re)engage one’s ethical commitments. These phases are fluid, and as is explained below, we might be required to move back and forth using perseverance as our only compass.

Research Opp(regre)ssive Practices

We all know that universities embody the most intransigent kind of institutions. While the pursuit of positive change may be slow, arduous, and even precarious, it is our ethical, moral, and professional responsibility as privileged intellectuals to do so if we are to significantly advance the diversity and equity goals our universities often claim to uphold. One first step toward combating universities/teacher education programs’ reluctance to change is to research the very opp(regre)ssive practices\(^1\) in which they are engaged. To this end, I conducted a hybrid study in my own science methods courses for elementary school teachers. While this project is ongoing, I gathered a significant body of evidence through pre- and post-surveys (\(N=30\)), focus group interviews (\(N=15\)), and field-based observations. This research produced a 56-page monograph that I am now using to bring palpable evidence to my arguments and uphold the legitimacy of my voice. The monograph, I also hope, would re-direct attention away from me as the sole Latino faculty member focused on social justice issues to the actual opp(regre)ssive and contradictory practices in our program.

The results from the first year of this study were presented at the inaugural meeting of Science Educators for Equity, Diversity and Social Justice (SEEDS) [Rodriguez, 2018], and other papers fully describing the research findings so far have been submitted for publication to other journals. For more context, I offer below a brief description of the study and significant findings.

The Transdisciplinary and Critical Cross-Cultural STEM Education (TC3-STEM) Project

I have been very fortunate to teach science methods courses for aspiring high school and elementary school teachers as a graduate student, and later as a faculty member, at various universities. This was my first time, however, teaching the elementary science methods course at my current institution. Two colleagues had recently retired, so this opened up the opportunity for me to conduct a research project and teach in a mid-western cultural context again.

Eager to embark on this new venture, I began the ongoing Transdisciplinary and Critical Cross-Cultural STEM Education (TC3-STEM) Project. This study involves teaching the elementary school science methods course using a transdisciplinary pedagogical approach. This requires teaching at least two of the core curriculum areas (i.e., mathematics, science, social studies, and language arts) with the integration of either engineering and/or technology. Since the project is informed by sTc or sociotransformative constructivism (Rodriguez, 2011/1998), knowledge is conceptualized as socially constructed and mediated by sociocultural, institutional, and historical factors. This approach is also congruent with critical cross-cultural education (May & Sleetner, 2010); that is, we reject predominant and neoliberal notions of multiculturalism, which have focused excessively on discourses of “equality,” “cultural acceptance/tolerance,” “inclusion,” or “cultural recognition.” These superficial notions of multiculturalism have failed to yield systemic, long-lasting institutional and social change. The reasons for this failure are abundant and visible in the daily news, and we have been horrified by the increased incidences of hate-based violence across the country and around the world. Therefore, we prefer to use the term critical cross-cultural education because it shines light on the importance of teaching and learning about power dynamics across cultural groups and how power is at the

\(^1\) These are practices that are oppressive and regressive at the same time (Rodriguez, 2010)
core of effecting social change—social change that could be ushered in by a more scientifically literate and engaged citizenry (Rodriguez, 2011/1998).

To accomplish our goals, the TC3-STEM Project consists of a series of modules (lesson and activities) designed to engage and model for the participant pre-service teachers how to teach science using a transdisciplinary and critical cross-cultural approach. After each lesson, participants had multiple opportunities to metacognitively deconstruct the activities and discuss potential barriers/support they expected they would encounter when using these activities in their present and future teaching contexts. An important aspect of the TC3-STEM modules is that they were designed to bring attention to two of the most pressing world challenges: access to clean water (two modules) and food security (three modules). Given the current demands on teachers imposed by the Next Generation Science Standards (NGSS) [or the state-level equivalent], our modules were designed to integrate engineering and scientific practices. However, instead of viewing the NGSS as a manual for uncritically socializing school children into potential skilled labor for corporations (Rodriguez, 2015a), the TC3-STEM modules provide multiple opportunities for participants to explore how they can assist school children in enacting their own sense of agency and embracing the role all of us can (should) play in sustaining a healthy community/planet (Hodson, 2014). For example, for one of the access to clean water modules, students conducted water quality testing using commercially available water test kits, compared their results with local city water quality reports, and learned to interpret this data. Another activity in the same module consisted of carrying out water taste tests to determine if they could tell the difference between bottled, filtered, or tap water. Students were then guided through a discussion about the millions of plastic bottles that are discarded as waste, and how this growing source of pollution is impacting the planet. After constructing bar graphs to represent their results, students were expected to write full arguments to explain the data and develop a transformative plan (e.g. carry their own re-usable water bottle, use a water filter instead of bottled water, recycle, write a recycling plan with the whole family, etc.). Finally, in order to integrate engineering practices, students were challenged to construct a water filter using only natural and easily available materials. The specific engineering challenge prompted them to create a filter that can turn a cup of dark muddy water into completely colorless, transparent water, free of debris. For this activity, students first have to research how various cultures around the world have used natural materials to purify and preserve water. Pre-service teachers find this activity engaging, meaningful, and surprising, and they are often shocked to discover that their filters (made of naturally occurring materials) can actually produce transparent water.

In terms of the TC3-STEM research design, we involved two cohorts of science methods students. As mentioned earlier, we conducted pre- and post-surveys (with a total 30 participants), as well as focus group interviews with a total of 15 students. Similar to many teacher education programs in the US, 98% of the participating pre-service teachers were Anglo, middle-class females, with very limited experiences with cultural diversity. Field-based observations during the students’ practicum were also conducted. This practicum was a component of both the science and mathematics methods courses, and it consisted of 27 hours of field work at a local school (i.e., three hours a week for nine weeks).

The Wilcoxon Signed Rank Test for paired samples was used to analyze the Likert scales component of the surveys (Bridge & Sawilowsky, 1999; Klotz, 1963), and a constant comparison approach was used to analyze the participants’ short answers from the surveys and the focus group interviews (Strauss & Corbin, 1998). Broadly speaking, our research questions sought to investigate the impact of the TC3-STEM Project on pre-service teachers’ perceptions of their preparedness to teach science using a transdisciplinary and cross-cultural STEM approach. Findings exhibited statistically significant growth for both cohorts, and—in fact—most students commented that they wished they had been provided with more opportunities to learn about STEM integration across other curriculum areas throughout their teacher preparation. Again, detailed results of this study will be shared in other publications. For the purpose of this manuscript, however, I wish to highlight that while these positive results were cause for celebration, the barriers we encountered during the pre-service teachers’ field-based practicum—and the (lack of) response from our teacher education
During field observations, informal conversations during class, and focus group interviews, we found that most participants in the first cohort were not allowed to teach science during their practicum. In other words, pre-service teachers are expected to teach three science lessons during the last three visits of their nine-visit school practicum, in addition to other shorter science and mathematics methods-related assignments. Partner schools receive a letter from the mathematics and science methods professors at the beginning of term describing our assignments and expectations, and once again requesting the principal’s and supervising teachers’ support. However, our interviews revealed that the vast majority of students in the first cohort did not see their supervising teachers teach science and social studies, neither were they allowed to teach all three of the expected science lessons. In fact, most participants were allowed to teach only one science lesson. The participants were told that science and social studies were taught for shorter periods at other times of the academic year, and that all teachers needed to adhere to a strict schedule that favored mathematics and language literacy instruction in order to prepare students for mandated assessments. Unfortunately, this phenomenon is not new and not unique to my institution. That is, denying school children access to science and social studies instruction to make more room for mathematics and language arts’ “drill and practice” in response to mandated assessments is a widespread practice across the US (which began soon after President Bush’s 2001 No Child Left Behind Education Act). The National Science Teachers Association (NSTA) has even finally taken a stand against this pervasive practice and produced a statement calling for equal time and attention to science instruction (NSTA, 2018). What makes this issue even more contradictory in our case is that pre-service teachers in our program are expected to take more science content courses than commonly expected by other teacher education programs because our institution is a strong STEM university. Adding to this spiral of contradictions is the call for the NGSS to prepare teachers to effectively integrate science and engineering practices across all grades.

Given this context, for year two of the project, I modified the post-survey for the second cohort of science methods students in order to better assess the extent of the problem and to discern whether this was just an unusual circumstance. In addition, I more purposely provided students with strategies for advocating for themselves, ensuring that they be provided with multiple opportunities to see their supervising teachers teach science, and being able to teach science during their school practicum to meet course requirements. I also began to inquire whether other science methods instructors (including graduate students and lecturers) had encountered similar situations in this and/or other partner schools. The anecdotal evidence gathered through these inquiries was confirmed by the second cohort of participants’ responses.

In short, out of the 16 pre-service teachers participating in the second cohort of the study, 47% never saw their supervising teacher teach science even once. Five students saw their teachers teach science once or twice, and four of them saw their teachers teach science three or four times. This situation was worse for social studies. Almost 53% never saw their supervising teachers teach social studies even once, and only 5 out of 16 students saw their supervising teacher teach this subject twice. For those who saw their supervising teachers teach science, we asked how long they spent teaching a science lesson. Five students gave responses such as “the lessons were not very long, maybe 20-25 minutes.”

It was evident then that the progress I was making in my science methods course by focusing on transdisciplinary and critical-cross cultural STEM education was being truncated by the very field-based experience that was meant to provide our pre-service teachers with opportunities to enact what they were learning in actual school contexts. Given the well-documented challenges commonly associated with assisting pre-service teachers—who are members of the dominant culture—in deeply integrating issues of equity, diversity, and social justice into their science curriculum and pedagogy (Rodriguez, 2011/1998, 2015b; Rodriguez & Kitchen, 2005; Underwood, & Mensah, 2018), and given the continuing pressure from the NGSS and state standards to prepare teachers with the knowledge and skills to integrate engineering practices, as well as address the needs of all learners, the barriers our pre-service teachers were encountering in their school
placements were extremely disheartening. In the next section, I explain how I sought to use the findings from this study to broadly expose these barriers and bring about change.

Expose

For this phase, I compiled the findings from the first two years of the TC3-STEM Project into a 56-page monograph, and I sent a copy of this document to all the members of the Elementary Teacher Education Committee, as well as to all members of the college administration and field practice coordinators (a total of 36 individuals). Since our college was preparing for accreditation review, I took the opportunity to tie some of my recommendations to relevant accreditation standards as follows:

1. According to the Council for the Accreditation of Educator Preparation (CAEP, 2018):

   **Standard 2: Clinical Experiences - Rationale**: High-quality clinical experiences are early, ongoing and take place in a variety of school- and community-based settings. These experiences integrate applications of theory from pedagogical courses or modules in P-12 or community settings and are aligned with the school-based curriculum (e.g., Next Generation Science Standards, college- and career-ready standards, Common Core State Standards). They offer multiple opportunities for candidates to develop, practice, demonstrate, and reflect upon clinical and academic components of preparation, as well as opportunities to develop, practice, and demonstrate evidence-based, pedagogical practices that improve student learning and development, as described in Standard 1 (emphasis mine).

   **Standard 4.4 – Program Impact**: Required component: The provider demonstrates, using measures that result in valid and reliable data, that program completers perceive their preparation as relevant to the responsibilities they confront on the job, and that the preparation was effective. (emphasis mine).

Considering these standards and the findings from this study; the challenges participants faced regarding observing and/or teaching core curriculum areas such as science and social studies; the limited exposure to cross-cultural and STEM integration in participants’ school placements; and the continuing low grades assigned to [partner] schools due to the low performance and treatment of students of color and of students with other special needs, the [College of Education] administration and faculty should reflect and take collective action regarding the following question: What is our moral, ethical and professional responsibility to ensure that our pre-service teachers are afforded all the necessary opportunities to meet the professional standards for which our teacher education program has been accredited? (TC3-STEM Project report, p. 38).

Out of the 36 individuals who received this report, only one has directly responded to it so far (and it has been five months to date). It is important to note that I am not criticizing these individuals for not directly responding to the issues raised in the monograph. I did not interview each person and explore their specific positionalities, perceived constraints, and working contexts. This autoethnography is not about them. It is indeed about me and how I chose to engage my own ethical commitments and responsibility to advocate for our pre-service teachers (and the thousands of school children they will influence throughout their careers). In my view, if we are truly committed to equity, diversity, and social justice, and expect our research work to influence and help advance the work of other professionals in teacher education, should we not then seek to enact those very commitments in our own backyards whenever we recognize oppressive practices?

In any case, the deafening silent response I received after sharing the monograph in my college is worth briefly deconstructing here because silence can also be a powerful tool in the politics of domestication. This

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In our state, schools are graded on two scores. One in response to federal accountability measures aimed at assessing the schools’ efforts to meet the needs of all students (e.g. ELLs, students of color, low income students, and students with disabilities), and the other to assess improvement in students’ academic achievement. This partner school received a federal grade of D and a state grade of C in 2018.

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The negative process of acculturation involves overt and covert practices designed to ensure compliance to existing explicit (or implicit) norms in order to preserve the status quo (Rodriguez, 2005, 2009). The politics of domestication are particularly challenging for scholars of color who, as mentioned earlier, are often hired with the expectation of contributing to advancing an institutions’ equity and diversity goals, only to then be silenced or ignored when we act on those expectations. In addition, the politics of domestication may also explain the pervasive low impact of teacher education research on the actual barriers and contradictions pre- and in-service teachers encounter in their school working contexts. For example, as mentioned earlier, the NSTA (2018) recently (and finally) released an official statement regarding the need to provide science instruction equal attention as other elementary school curriculum subjects. Although this statement is welcome, it comes decades too late, and six years after the National Research Council Conceptual Framework for the NGSS (2013) acknowledged this concern:

Over the past decade, accountability pressures—generated by the focus on student achievement as measured by high-stakes assessments—have heightened the curricular emphasis on mathematics and English/language arts and lowered attention to (and investment in) science, art, and social studies—especially at the elementary school level. In another California study—this one involving elementary school teachers in nine San Francisco Bay area counties—participants indicated that science is the subject area in which they felt the most need of professional development [21]. They also reported that they taught science less than one hour per week on average across the elementary school grades—with science instruction being more prevalent in the upper elementary grades than in the K-2 grade band (p. 282, emphasis mine).

Nevertheless, the NGSS’ fast-moving, standards-reform train, propelled by one of its strongest supporters—the NSTA—pushes on while the contradictory nature of teacher education programs and teachers’ actual working contexts, like the ones reported in this autoethnography, carries on.

In light of the silent response I received, what could possibly be my next option? How do I still leverage the research I conducted to disrupt the status quo and continue to advocate for pre-service teachers?

### Disrupt

Naively, I must confess, I was expecting that the research monograph I shared in my college would instigate some conversations about improving our program, or at the very least, encourage college administrators to initiate a phone conversation (or a visit) with school partners to improve our memorandum of understanding regarding field-based experiences for our students. This is what I imagined the disrupt phase of being an activist in our own backyard would (should) have looked like. Since it was clear that this was not going to happen, I opted to take a more direct approach as one of the science methods instructors of record. I opposed the placement of pre-service teachers taking my course in the same school where our students were being denied opportunities to fulfill my course assignments and where our teacher education program was being prevented from fulfilling its obligations according to our own accreditation standards (as listed above). Citing ethical, moral, and professional conflicts with this “business as usual” approach, I requested that our student teachers be placed in a different school and that college administrators send a friendly reminder to the school principal and partner teachers regarding our memorandum of understanding for field-based experiences.

Needless to say, this direct approach created a “disturbance” in the normal order of things, and I was invited to a meeting with college administrators. To this meeting, I brought printed copies of the aforementioned TC3-STEM research monograph, with highlighted findings from the research project. This strategy reinforces the need to have completed the research and expose phases discussed above in order to be better positioned to advocate for students during this phase, as well as be better prepared for the next step—the transform phase.

### Transform

After a cordial and promising meeting with college administrators, we reached an understanding. Pre-service teachers attending my science methods course in the next semester will be placed at a different school. While there was no guarantee that these students would be able to see their supervising teachers teach science, as well as be allowed to teach science (as required by the course), at least, this effort provided me with an opportunity to continue the TC3-STEM Project at a different partner school. With regard to contacting the principals at partner schools to revisit our memorandum of understanding and accreditation requirements, all the administrators were apprehensive to take this action. I understood their concern. They did not wish to appear to be “dictating” what partner schools should do; however, I pointed out, once again, that we had an ethical, moral, and professional responsibility not to look the other way either. This lack of inaction continues to fuel the dissonance between our efforts to prepare effective and culturally responsive teachers and the working realities of teachers today. That is, teachers’ working reality is often driven by the pressure to comply to mandated assessments and by contradictory and oppressive practices (e.g., the NGSS’ push to integrate science and engineering practices while science is not being taught—or rarely taught—in most elementary school grades). We could assist in interrupting this wasteful and negative socialization cycle by at least ensuring that our pre-service teachers have multiple opportunities to practice teaching what they are learning in our teacher education programs—and in my case, practice using more culturally and socially relevant STEM pedagogical approaches as modelled in the methods course. In response, it was agreed that I—as the instructor of record—should have a cordial conversation with the school principal to re-visit our course expectations and stress the importance of their support. The college administrators also agreed to keep addressing the issues I raised during teacher education reforms efforts that we were just starting in the college, prompted by our newly hired dean. They also agreed to include the TC3-STEM research monograph as part of the resource materials being gathered for the reform committee members to review.

These outcomes were helpful, but an important aspect of this phase of activist work is never to take anything for granted. We need to be ready to persevere, monitor and even shift to any of the previously mentioned phases in order to ensure that our efforts are heard, are meaningful and instigate transformative action. Again, perseverance is the primary device in an activist’s tool kit.

Conclusion

In this text, I have used critical autoethnography as a tool to explicate the barriers and successes I encountered in my efforts to address oppressive practices in my own teacher education program. Hoping to enhance clarity, I divided this study into four phases that were not meant to essentialize the complexity and physical and emotional demands involved in social justice work. Instead, these phases might provide useful examples of how we can be activists in our own backyards when we choose to (re)engage our ethical commitments. Essentially, this pragmatist account might encourage others to reflect and consider that after all, if our published (or on-going) activist work is meant to provide insights and promote social justice goals, should not those same goals, insights, and research findings be used to effect change at our own institutions—in our own backyards?

In these troubling times of “post-truths,” continuing social violence, and violence against our planet, more than ever, we—teacher educators/researchers—must double our efforts to make our research work matter. We need to collaboratively work to improve the professional opportunities of future teachers so that they are able to see, as well as practice, effective, culturally inclusive, and social-justice oriented teaching during their professional programs. We must also remain alert and wary of yet another fickle education reform effort (e.g., the Next Generation Science Standards) and of deceptive slogans (e.g., “Science for all,” “No child left behind,” “Race to the top,” etc.) [Rodriguez, 2011/1998, 2015a] that mainly serve the interests of shortsighted politicians or the deep treasure chests of major publishing companies (Owen, 2019).
I close with one final recommendation. Even though, we may not be able to achieve all objectives in our activist efforts—whether in our own backyards or elsewhere—it is essential that we keep in mind that the significance of our work cannot be measured by simplistic and binary codes, such as success vs. failure. Going back to Foucault (1997) and the practice of self-care, by exercising our freedom to act and (re)engaging our ethical commitments, we begin a labor of caring, not only for others, or for the advancement of our profession, but for our own personal growth as human beings.

References


Rodriguez, A. J. (under review). Exposing the concentric and contradictory circles of opp(regre)ssive practices that prevent the advancement of teacher education. Submitted for review to the *Journal of Teacher Education*.


Testing the Waters
Using Environmental Justice to Motivate Environmental Science Students

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Responses
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The Next Generation Science Standards (NGSS) promised to motivate students through the practice of science (Achieve Inc., 2013). The NGSS reflect the STEM movement, which aims to build a strong workforce that will usher in prosperity and promise a more secure nation. Over the 11 years that I have been teaching a high school environmental science course, I have developed a more problem-based pedagogy based on environmental issues, such as water pollution, pipeline construction, and climate change, which have proven to be politically charged scientific issues. Unfortunately, a focus on STEM may exclude sociopolitical aspects of science that could encourage students to develop a sense of civic responsibility (Zeidler, 2014).

With a focus on relevance and authenticity, I aim to create lessons that have importance to students now, not just for potential careers or college majors. As any effective teacher would, I hope that all of my students are engaged in learning. I consider the four forms of engagement outlined by Sinatra, Heddy, and Lombardi (2015). The first three forms (behavioral, emotional, and cognitive) depend on the structure of the learning environment, and therefore on lesson design. However, agentic engagement is a fourth type of engagement that demonstrates agency exerted by students, who may actively contribute to their own instruction (Bandura, 2001; Reeve, 2012; Reeve & Tseng, 2011). In considering the agency of my students, I seek to prepare them for immediate empowerment, not future employment. I considered the potential to prepare and even mobilize my environmental science students for action as engaged citizens in a contentious and confusing society. It is worth noting that data collection began at the beginning of the 2016 school year, coinciding with the 2016 Presidential election.

In an ongoing inquiry, I explore the potential for environmental justice to motivate high school environmental science students. In four sections of high school Environmental Science, I measured student dispositions before and after introducing the students to environmental justice (inspired by Martin Luther King, Jr. and fueled by inequity and oppression). I relied on socioscientific issues (SSIs), which Sadler, Chambers, and Zeidler (2004) describe as “social dilemmas with conceptual ties to science” (p. 387).

Using socioscientific issues to teach science, let alone motivate students, is notoriously challenging because of the teachers’ approach to science itself. Science continues to be taught as a politically neutral body of knowledge to be transmitted without values (Hart, 2003). Having learned science this way, science educators continue to teach this way. The resulting hierarchy of knowledge marginalizes those without it (Barton, 2002) and sustains a myth that scientific knowledge is not biased (Laughter & Adams, 2012). The need to challenge this system in an effort to include students in all aspects of the scientific endeavor fuels my work, with an understanding that science teachers’ tendency to sidestep the potentially controversial implications and applications of science effectively alienates and disempowers students (Gayford, 2002).
With the help of my students, I am energized by questioning, and potentially dismantling the hegemony of this form of science and science education (Hodson, 2003).

Reflective, critical practice becomes the saving grace. Jorgenson (2011) connected the interests of science teachers who participate in “green pedagogies” to their childhood experiences. These teachers felt comfortable addressing the moral, social, and political aspects of environmental issues, and evolve into “fruiting bodies of dissent” (p. 47). Ladson-Billings (1995) recognized exemplary teachers as those who are committed to teaching and learning with higher purpose. Such teachers believe that all the students are capable of academic success, view pedagogy as a dynamic, evolving art, and saw themselves as members of the community, with their work as a way to give back to the community. My own efforts to promote social justice would be incomplete without a morally transformative approach to teaching and scholarship, and the realization that such teaching practice is in its own right a form of social justice (Dantley & Tillman, 2010).

However, it is the students who are at both front and center in my practice, which fuses research and praxis. For my doctoral research, I measured changes in student dispositions with surveys, as well as conducted interviews with willing participants, who shed light on their learning experiences in the course, including changes in their motivation to learn science. I continued to design lessons with their advice in mind. My goal herein is to share their recommendations for environmental science teachers to infuse socioscientific lessons with environmental justice in an effort to encourage all students to develop their voices for environmental advocacy and sociopolitical action.

Lesson Design

I found that students valued morals in environmental decision-making. Therefore, I expanded our problem-based curriculum to help student reflect on their worldview and develop their environmental ethic. The curricular approach required instructional strategies beyond traditional science education pedagogy, yet remained student-centered and inquiry-based. I encouraged students to ask questions and use evidence to draw conclusions. SSIs served as “phenomena,” defined by the National Research Council (2012) as observable events that students can explain and make sense of by using the three dimensions of the NGSS.

I justify a socioscientific approach by rejecting the assumption that all scientists do science in the same way and are motivated by the same things. Therefore, I applied the NRC’s (2012) broad description of science practices, especially the role of critique. Through discussion, discourse, and reflective writing, students explored their positions on issues ranging from pipelines to food deserts, based on their worldviews as well as scientific evidence. Students could develop attitudes predisposing them to environmental literacy, which considers dispositions that include attention to equity and willingness to act, personal responsibility, based in concern for other people and other societies (Hollweg, Taylor, Bybee, Marcinkowski, McBeth, & Zoido, 2011). I aligned the lessons to standards that reflect our approach.

Students began the unit by investigating the three main environmental ethics (anthropocentrism, biocentrism, and ecocentrism), and exploring Dr. Martin Luther King, Jr.’s influence on the environmental movement. I shared daily videos about the Dakota Access Pipeline protests in North Dakota, which reached a fever pitch during this unit and spurred an introduction to the future unit on renewable energy resources. In fact, environmental justice encompassed each environmental issue the students encountered, supporting the outlook that environmental problems connect to greater societal ills mired in inequity and discrimination. In a culminating group project, students designed community gardens in a food desert. Students expressed pride in applying the dispositions and skills they had developed to impact the lives of others, paving the way for units on biodiversity, urbanization, water pollution, energy sources, and climate change that would leverage a justice-based approach to sustainability.
Become the Change Agent You Want Your Students to Be

Science teachers may serve as mentors for civic participation, rather than mere technicians and implementers of educational standards. Consciousness of environmental problems and concern about their impacts on people are hallmarks of environmental literacy (Hollweg, et al., 2011). I contend that teachers should act as ambassadors of eco-consciousness, and proponents of environmental justice. An environmental science classroom built on a socioscientific approach becomes more democratic through both inquiry and discourse.

This transformation starts with the teacher. Science teachers tend to avoid controversial topics because they do not know how to teach them (Gayford, 2002). Their ambivalence disengages students by perpetuating the traditional view that science is value-free. My students wanted teachers to express their opinions in the classroom to show that they care not only about the content they are teaching, but also the issues that they present. Therefore, I recommend standing up for the environment, and for the people at disproportionate risk of being harmed by environmental problems.

A socioscientific approach requires an understanding of, and sensitivity to, students’ backgrounds. Teachers must respect and incorporate students’ worldviews to demonstrate the development of opinions based on argumentation and dispositions. Our students proposed that science teachers model decision-making through argumentation. SSIs enhance these skills by highlighting interactions between environmental problems and societal troubles. As environmental justice invokes diversity and inclusivity, students may develop a unified front towards environmental stewardship that may inspire civic participation. Therefore, teachers who design lessons around SSIs facilitate authentic inquiry-based learning in an increasingly democratic sense. Teaching environmental science requires a critical lens that considers culture, politics, and ethics. Social studies and English teachers provided valuable insight into leading discussions and debates that rarely usually occur in science classrooms. Relevance of SSIs increased through interdisciplinary collaborations.

Invite Change Agents into Your Classroom

Our students admired scientists as change agents who deserve the resources to conduct their research and a voice in policy making. One student declared, “If they have extensive of knowledge of what’s going on, they can definitely help.” In their eyes, scientists monitor environmental health, as well as provide solutions. Through their contemporary vision of scientists, they connected societal problems to environmental challenges as lessons evolved into critiques of inequity, racism, discrimination, and oppression, bolstered by scientific knowledge. Environmental justice solidified their thinking when they learned how the civil rights movement of the 1960s advanced environmental protection as a human rights issue.

Teachers may act as role models reflecting both science and activism, by enacting an ecocentric stance both in and out of the classroom. Teachers may invite guest speakers into the classroom to offer students the chance to connect with environmentalists and other activists. Through TED Talks and online research, our students “met” activists who confront local environmental problems.

Students may build confidence when they realize that they can participate in change efforts. Confidence and motivation reinforce each other when students can see themselves in the work they study (Oyserman & Destin, 2010). Footage of the Dakota Access Pipeline protests inspired conversations about the extent to which students would participate; daily updates of the intensifying protests fueled class dialogues. Lessons became transformative when students can identify with, and as, stakeholders.
Position Students As Change Agents

Through environmental justice, students confronted the social impact of environmental problems. Advocates of environmental justice contend that environmental problems affect marginalized populations more than privileged groups. SSIs provoked civic engagement and other forms of “meaningful involvement” promoted by environmental justice (EPA, 2017). One resolute student described expanding STEM practices to include more pressing concerns:

If you can only teach about how it is being built, I don’t think that would be fair, because I feel like they should be able to know what’s going on in their community. If something was being built in my community, say there was a new water tower being built two streets from my house, I would want to know...how it’s being built and why.

Transcending the design of technological solutions through engineering practices, science becomes transformative when students ask why a problem exists in the first place.

Learning how to write environmental policies enhanced students’ capacity to propose solutions. After researching local environmental problems, each student wrote to a legislator to explain the science behind the problem and offer legitimate solutions. Students expressed genuine concern for their topics, which included pollution-induced asthma, access to nature, and the waste treatment plants in their neighborhoods. By exploring these phenomena, students were authentically engaged in their communities.

Empowering Science Students with Environmental Justice Itself

Eventually, the classroom environment transforms through student participation that mirrors civic engagement, as our pedagogy empowered students to become change agents themselves. One student declared our class “the most outgoing and forward class I’ve had for science so far.” Schindel’s (2012) framework for social justice science education, which includes three types of mutually reinforcing empowerment, (social, political, and academic) validates my approach.

First, social empowerment emerged through the development of a supportive and inclusive classroom in which students felt safe and confident in expressing themselves, and supported each other in doing so. Students realized that their voices could be a strong force for equity and inclusion. Second, students became politically empowered. One student declared, “Environmental science isn’t just about the plants, it’s about you know, different political standing.” Her classmates critiqued inequities surrounding environmental pollution and access to environmental resources. They sided with the Sioux in their efforts to protect their water and sacred lands, and questioned the inequities suffered by African Americans in cities like Camden, NJ, and Philadelphia. Finally, academic empowerment was evident in the development and application of knowledge and skills that support student success in all settings. Students routinely referred to concept maps they created to demonstrate the interconnectedness and interrelatedness of Earth’s spheres, as those phenomena implicated societal problems. Students integrated topics they learned in Environmental Science in their history classes. Written and oral exercises required skills developed in language arts. One student explained, “Science can be anything from political, to social, to environmental, to biology.” The overlap with political empowerment became apparent.

A contest to build a community garden emerged, demonstrating the transformation of the classroom and the mutual reinforcement of the three forms of empowerment during the culminating project. Learning experiences had proved to be truly authentic, as the learning involved complex, realistic tasks (Frey, Schmitt, & Allen, 2012). Motivated to effect positive change, students could take the reins of the lesson and curriculum, and take the learning out of the classroom to effect positive change.
Environmental Justice in the NGSS Era

Students suggested that socioscientific issues should be the focus of a classroom that implements STEM practices, because a solely STEM approach did not appeal to them. One student claimed that traditional assignments offer too much opportunity to disengage. He pictured kids opting out of learning:

I’m not going to build a bridge; I’m not going to be an engineer. I’m not even going to live near a river where there is a bridge...I’m not gonna do the lab. I don’t need to do the lab. Why should I do a lab?

By engaging students in issues that matter to them, they have the opportunity to express themselves and to participate authentically through immediate civic action rather than an eventual STEM career. That same student, once empowered, expressed concerns about, and responsibility for, his community’s water quality:

I definitely went home and filled my glass with water and looked in it, and was like, “Is there lead in there?” I think I will [test it], just for the sake of other people...I don’t want to have that problem so I definitely would test the water just to make sure that it’s safe.

His transformative attitude transcends the NGSS’ technocentric approach, which values scientific and technological solutions to global challenges like sustainability (Feinstein & Kirchgasler, 2014).

Environmental science education may be incomplete without considering social and ethical dimensions of the phenomena students study. If environmental science is concerned with the interconnectedness and interrelatedness of Earth’s systems, it behooves us to realize that the environment is no longer a natural system that humans have impacted, but rather a social construct that includes natural systems (Hodson, 2003).

Conclusion

“Testing the waters” can mean sampling local water for impurities, as one student became compelled to do. However, we may consider taking risks to motivate students by expanding the NGSS, even if that means mutating or defying it in practice. In the mean time, the students are testing the metaphorical waters of questioning everything they can, including the scientific phenomena, the oppressive forces leading to environmental damage, and the nature of school itself. This research demonstrates the transformative power of social justice education in science classrooms. Furthermore, I suggest using socioscientific issues in physics, biology, and chemistry as well, such that teachers connect practices across disciplines. A sociopolitical approach may motivate students through holistic education that is relevant, realistic, and crucial.

References


From Computational Thinking to Political Resistance
Reciprocal Lessons from Urban Latinx Middle School Students

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Responses
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Abstract
Working with Latinx adolescents and providing informal learning experiences through a voluntary after-school program aimed at developing their computational thinking and competencies, discussions around the election of Donald Trump emerged as it was important for many students. Emergent bilinguals internalized the xenophobic discourse that was amplified during the presidential election season. Thus, students feared deportation, discrimination, and other forms of violence. Many students experienced their friends and families facing deportation due to the increased Immigration and Customs Enforcement raids that occurred in 2016. The after-school program was a safe space in which we could provide a constructive and creative environment for students to comfortably explore these topics. In this paper, drawing on three pre-service teachers’ reflections, we explore how middle school urban Latinx students navigated their oppressors through computational thinking and show case a model of a critical pedagogy in an informal science education.

Introduction
Twenty-first century science and technology related skills and dispositions contribute not only to academic success, but also to ensuring a better socioeconomic future (Holdren, Lander, & Varmus, 2010). Moreover, computational thinking, an “analytic approach to problem solving, designing systems, and understanding human behaviors” (Sengupta, Kinnebrew, Basu, Biswas, & Clark, 2013, p.352), is regarded as a fundamental requirement of all STEM disciplines (Henderson, Cortina, & Wing, 2007). However, the report Running on Empty: The Failure to Teach K-12 Computer Science in the Digital Age (Wilson, Sudol, Stephenson, & Stehlik, 2010) states that student participation in computer science education is decreasing while the demand for computer science professionals is increasing dramatically. The lack of qualified computer science teachers and the lack of adequate and appropriate integration of computer science into the school curricula are two important issues discussed in Wilson and colleagues’ (2010) report and in others’ research (Barr & Stephenson, 2011; Goode, 2007, 2008; Grover & Pea, 2013; Kafai, Fields, & Burke, 2010).
As one of the science and technology related skills and dispositions often overlooked in preparing students for the 21st century workforce, computer science does not fully reflect a diverse population. Access to computer science education is very limited for non-Asian minorities, students of low socio-economic status (SES), and girls. Thus, this becomes a profound social justice issue involving privileges for certain students over others and creates segregation in computer science education that extends to the workplace (Goode, 2007; Wilson, et al., 2010). While Latinx people make up 17.6% of the U.S. population (United States Census Bureau, 2015), they are underrepresented in Science, Technology, Engineering, and Mathematics (STEM) careers. At the high school level, Advanced Placement (AP) Computer Science A participation is low overall, but drastically lower for Latinx students. For instance, of all the AP Computer Science A test takers in the U.S. in 2015, only 9.2% were Latinx, with dramatically lower pass rates for these students (39.3%) when compared to the overall pass rate (64.4%). At the university level, only 8.5% of Computer Science degrees were awarded to Latinx students in 2012 (Ericson, 2016). In industry, this lack of diversity is both reflected and exacerbated in top technology companies. Dowd, Malcolm, & Bensimon (2009) reported that Latinx are largely absent in STEM fields, including computer science. This correlates with the low number of Latinxs (10%) with a college degree and even lower number of Latinxs with a STEM degree (Gandara & Contreras, 2009). Many institutional barriers exist for low Latinx participation in Computer Science. An important and primary barrier is the is lack of qualified computer science teachers (Grover & Pea, 2013). Qualified computer science teachers need to be proficient in both computer science content knowledge as well as pedagogical content knowledge, well prepared, and able to implement relevant, engaging, and authentic computational experiences.

Context: A Reciprocal Model for Teaching and Learning Computational Competencies

A Reciprocal Model for Teaching and Learning Computational Competencies (ARMTLCC) is a three-year long project that extends existing research in the field by propositioning a model to teach Computational Competencies. A major goal of the project is to develop a model for Culturally Relevant Pedagogy (Ladson Billing, 1995) for teaching and learning computational competencies based on the principles of culturally relevant pedagogy and implement the model in an afterschool programs for middle school Latinx students in an urban school district in Southeastern United States. The reciprocal nature of the model in the ARMTLCC project is that afterschool teachers (university students preparing to become teachers) and the Latinx students learn from and teach each other. More specifically, the teachers learn to develop and implement culturally relevant computational experiences through formal seminar-type classes and field experiences in the afterschool setting (Aghasaleh et al., 2018). The extent of teacher participation in project activities is intended to help develop personal agency, while also engaging them in reflective practice that is aimed at specifically examining how they can best meet the needs of urban Latinx students.

Figure 1 provides a graphical representation of the many connections and constructs involved in the project focused on culturally relevant computational thinking, including the a network of agents that shape the activities: the researchers and the funding agency supporting the project; the Latinx middle school students who participated in the focal afterschool program; the pre-service teachers who learned about computational thinking and culturally relevant pedagogy to develop and implement rich and engaging computer science activities; the community partners whose organization started and sustained the afterschool program where the work took place; the families who supported their students as they worked in the program and celebrated their work every semester; and the school administration who supported the program through the provision of space and time. The central project efforts include both the afterschool leadership program and the accompanying methods course for the pre-service teachers (yellow boxes), which are described further below. The curricular and instructional elements of these two contexts relied on several foundational constructs (pink ovals), including the NGSS Science and Engineering Practices, Social Justice Education, Freirian Problem Posing, and Feminist Standpoint Epistemology. These constructs.
guided much of the curricular work in the two contexts, particularly as the pre-service teachers experienced and then developed computer science activities (purple ovals) implemented in the afterschool program.

Figure 1. ARMTLCC Conceptual and Executive Model

Computer Science Teaching Methods Course

The teaching methods course in this study was developed through the collaboration of the researchers with a computer scientist and with a focus on several guiding constructs, including computer science, computational thinking (Grover & Pea, 2013; NGSS Lead States, 2013), and culturally relevant pedagogy (Ladson-Billings, 2008). Computational thinking served as the major scientific focus, as it is one of eight scientific practices emphasized in the Next Generation Science Standards (NGSS) and state adaptations of those standards (GA DOE, 2016). These practices represent the fundamental activities that scientists and those learning about science engage in for the purposes of exploring and constructing understanding around different phenomena (Ford, 2008; Osborne, 2014). A seminal description of computational thinking describes it involving “solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science” (Wing, 2006). This particular practice has received much less attention in both education research and practitioner literature (Kite et al., 2018), remaining less well conceptualized and operationalized for K12 teachers, let alone students. As the pre-service teachers were recruited across several academic disciplines, including Language & Literacy and English Speakers of Other Languages (ESOL), developing a basic understanding of computational thinking was warranted. Thus, the
course included lectures and instructional activities focused on computer science concepts, such as encryption and searching & sorting algorithms, along with working in coding platforms relevant to the project work (e.g., Scratch (Resnick, Maloney, Monroy-Hernández, Rusk, Eastmond, Brennan, Millner, Rosenbaum, Silver, Silverman, & Kafai, 2009) and Arduino (Arduino.cc, 2015)) and review of computer science education documents, such as the Computer Science Teachers Association (CSTA) standards (CST Force, 2011). These activities aimed to develop an understanding of basic concepts and proficiency with certain technical skills so that the pre-service teachers could design and implement computational thinking activities with students in the afterschool program. Although the ambiguity around computational thinking presented challenges in designing the course, it also allowed for more flexibility to combine efforts around this construct while also grounding the work in perspectives drawn from literature broadly concerning culturally relevant pedagogy.

To more fully develop the pre-service teachers’ cultural awareness, the course focused on several topic areas of critical scholarship, including race, gender, sexuality, class, ableism, and age (Blanchett, 2006; Fausto-Sterling, 2000; Gonzalez, 2006; hooks, 2000; McIntosh, 1998; Nieto, 2012; Noguera, 2006; Tatum, 2003; Vargas, 2011). These foci intertwined throughout the course material, providing opportunities for the pre-service teachers to develop deeper understanding of how different aspects of culture impacted the ways students learn in and out of classrooms and how those considerations could shape learning interactions focused on computational thinking. This additional emphasis was warranted as cultural connections, when made explicit in delivering instruction, have been shown to enhance the learning experience for students, creating stronger affective connections to the content being taught (Calabrese-Barton & Tan, 2010; Swanson, Bianchini, & Sook Lee, 2014). The pedagogical approaches employed during the course included a combination of assigned scholarly readings followed by reflective writing and class discussions to explore cultural perspectives. Further, these perspectives were then emphasized as certain instructional strategies were modeled and as pre-service teachers designed their own activities to implement in the afterschool program. These activities also provided opportunities for the pre-service teachers to explore aspects of their own cultural identities and perspectives while connecting those to their identities as teachers.

Informal Education: Latinx Youth Leadership Academy

The racialized, xenophobic, and nationalist attacks by Donald Trump during the presidential campaign and after being elected president and the subsequent emboldening and emergence of the so-called alt-right, in effect a collection of white supremacists, neo-Nazis, Klu Klux Klan members, and other fringe and far right groups, have taken a toll and continue to take a toll on groups and individuals deemed racial and ethnic minorities in the United States. Of particular concern is the vitriol surrounding general, political, and policy discussions associated with Dreamers/DACA (Deferred Action for Childhood Arrivals), sanctuary cities, undocumented immigrants, and illegal immigration. For example, during the heat of the presidential campaign, anti-immigrant and nationalist sentiments were stoked by calling for a wall to be built along the southern border separating the United States and Mexico, calling Mexicans rapists, drug smugglers, and criminals, and calling for a “total and complete” ban on Muslims entering the United States. We have seen first-hand the impact and the hurt that these anti-immigrant and ultra-nationalist rhetoric, first, and later, policies have had on the Latinx youth we serve. Seemingly overnight (after one of the debates), the middle school-aged Latinx youth we serve were so overwhelmed by the antagonistic tone of Donald Trump’s campaign rhetoric aimed at them, their families, and their friends that they began to show a certain form of conscientization (Freire, 1996), or a critical awareness of the quickly changing social reality of their world. This was evidenced in the various Discourses (Van Dijk, 2008; Wodak, 2008) the youth had during the time they spent with us (Aghasaleh, Enderle, Puvirajah, Boehnlein, Rickard, Bornstein, & Hendrix, 2018).
Our work with Latinx youth focuses on providing informal learning experiences through a voluntary after-school program aimed at developing their computational thinking and competencies. The design of the after-school program drew from the body of literature on informal learning, most notably from the work of Dierking, Falk, Rennie, Anderson, and Ellenbogen (2003) and from Verma, Puvirajah, and Webb’s (2015) work on authentic learning. Additionally, within the limitations of the program, we used a Freirian and Foucauldian perspective to rationalize the need for informal learning experiences.

Why informal learning experiences?

In order for us to examine informal learning experiences, it is important for us to also understand formal schooling experiences of students, particularly in the United States. It is undeniable that there is great variability in the educative experience of students. That is, the type of experience that schools provide to students varies from one school to the next, and largely depends on the socio-economic conditions of the neighborhoods that schools serve. Schools in poorer neighborhoods with families having low socioeconomic status tend be under-resourced in terms of having adequately qualified teachers, the number of teachers and support personnel, supply of classroom and library resources, and appropriate learning and teaching spaces. We view these as conditions that mimic and at times amplify the oppressive conditions faced outside the confines of the school by students of low socio-economic status. Taking a Foucauldian (1977) perspective, we say that power and in tandem oppression are ubiquitous in all worldly interactions individuals have, including interactions that occur in the school. However, oftentimes the distribution and enactment of power (oppression) within the enclosure of the school is unequal in that authoritarian school personnel control and turn students into docile bodies (Foucault, 1977). According to Foucault enclosures like schools, factories, prisons, and such are required for controlling and disciplining individuals so that they become docile bodies. Similarly, Rossatto, Rivas, Heiman, and Esparza (2015) say that students “are violated in schools by oppressive systems that practice authoritarian abuse, place needless academic restrictions on them, labels, tracks, and promotes a cultural infringement on others that fail to fit into their educational, and personal, ideologies” (p. 6). Similar to the idea of docile bodies, Rossatto et al. say that schools aim to domesticate students to the dominant cultural practices of the institution and the larger society. As such, the effects of these oppressive and hegemonic practices are intensified when they are directed toward those not belonging to the dominant culture. Verma, Puvirajah, and Douglass (2018) say that “life conditions primarily arising from poverty and low socioeconomic status, and ontological factors such as race and ethnicity contribute to these oppressive and hegemonic acts enacted toward the students” (p. 2). For example, during our professional visits to schools as part of our job as educators and researchers, we frequently see stark disparities in the students’ experience between White majority schools and Black and Latinx (minority) majority schools. Unlike White majority schools, in a number of minority majority schools we have visited, students enter the school through a doorframe metal detector guarded by a district assigned police officer, are constantly subjected to uniform or dress code inspection by teachers and principals, are reproached for gathering in groups, are required to walk on the right side of the hallway, need to be escorted in groups for restroom breaks, have staggered lunch times for lack of adequate space and to guard against large gatherings, are limited to core and state mandated courses, and do not have a rich and varied selection of extra-curricular clubs or activities. Additionally, instructional practices in minority majority schools, focus on teacher centered practices that emphasize rote learning and studying for the standardized test. These and other school experiences are essentially subjecting students to disproportional and asymmetrical acts of power by the school institution. We can say that such institutionalized oppressive practices “that focus on control, management, and compliance strip students of their identity and agency and have a deeply demoralizing effect” (Verma, Puvirajah, & Douglass, p. 4).

Paulo Freire (1996) described these oppressive conditions at schools as banking. For Freire, formal schooling is like a bank. The school as an institution deposits the curriculum into the students. All
interactions that occur between the institution (the school) and the student become curriculum and what the student learns. As per the concept of banking, these interactions are called transactions, and for Freire all transactions of formal schooling are oppressive because students’ brains (as an object, as a vessel) are used for collecting, accumulating, and regurgitating the oppressor’s knowledge. The oppressor has power in determining what is put in the vessel and what is avoided; the teacher/the institution becomes the arbiter of knowledge. Thus, in situations like this, the recipient of knowledge, the student is treated as an object and by extension much like other objects has no consciousness. The knowledge received has no real connection to students’ lived experiences. Students receive knowledge passively and are seldom given discursive opportunities to collaborate and construct knowledge as a collective (Lemke, 1990); this is similar to Foucault’s idea of docile bodies discussed earlier. Because banking prevents awareness (consciousness), growth of true intellect is limited.

**Informal Learning Experiences**

For Freire, true intellect is cultivated only when students are conscious or become aware of their social conditions. Freire calls this conscientization. Through conscientization, the oppressed gain capacity by way of critical thinking to first become aware and then interrogate their oppressive conditions (Blackburn, 2000). This according Freire leads to emancipation or liberation. We feel that informal learning experiences, where students participate in learning under their own terms allows for the mitigation of oppressive conditions found in the formal schooling experience. According to Dierking, Falk, Rennie, Anderson, and Ellenbogen (2003), informal learning provides students with choice to take part in learning experiences that are meaningful to them, lets students take part in learning experiences on a voluntary basis, and lets students decide on the extent of their participation. They say that informal learning is “…self-motivated, voluntary, and guided by the learner’s needs and interests” (p. 109). Thus, informal learning experiences move away from the oppressive conditions of the formal classroom to more liberating experiences where there is more congruency in the distribution of power among participants (Puvirajah, Verma, & Webb, 2012).

While not ideal in terms of student emancipation and liberation, our designed model of informal learning ascribes to several tenets of Freire’s educative approach for “transform(ing) an oppressive reality into a liberating one” (Blackburn, p. 4.). Much like Freire, our model of informal learning was designed with student conscientization as driving factor. We wanted our Latinx students to move away from the banking concept of education to become aware of their oppressive social reality and taking appropriate actions to become emancipated. In this informal learning model, we emphasized reciprocal learning through which participants (Latinx students, pre-service teachers) learned from and taught each other. This follows Freire’s assertion that both the teacher and the student create and foster a more symmetrical relationship where they can learn from each other as collaborators. As such, both the teacher and the student become subjects of knowledge creation. However, an essential aspect of this knowledge creation and conscientization is problem-posing. Our Latinx students, as will be seen later, participated in problem-posing within the informal learning context. In problem-posing education, students are no longer objects; they become subjects of the educative process where they use their minds (as a subject, as a place where conscious thought occurs) to interact and engage with the world around them and incorporate their lived experiences to create knowledge that is meaningful and authentic. In fact, in problem-posing education, all involved, all participants, become subjects. The teacher’s once oppressive role is diminished, and the students’ once passive role of knowledge receivers is elevated to knowledge creators. In essence, it becomes difficult to distinguish the teacher from the student in a problem-posing educative setting (Verma, Puvirajah, & Webb, 2015). Additionally, according to Freire, problem-posing education is highly discursive in that students do not need banked information, and that they already possess expertise and knowledge that through collective dialogue could be created, recreated, and refined for action in the world.
Using the outcomes of their research on an informal learning context, Verma, Puvirajah, and Webb (2015) developed a model to describe what would constitute authentic learning both within informal and formal learning environments. They describe authentic learning to be made of three acts of authentication. They define “acts of authentication as practices that legitimize an individual or a group’s participation in an activity as recognized by the participants of the activity and/or by the learned observer” (p. 270). These acts are participation in talk, participation in productive disciplinary engagement, and participation in communities of practice. Verma et al. argue that the interface between talk and productive disciplinary engagement can only occur through participation in a community of practice.

Theoretical Framework: Feminist Standpoint Epistemology

Feminist standpoint epistemology has three principals. First, knowledge is socially situated: Haraway (1988) rejected objectivity and believed that there is no “god trick of seeing everything from nowhere (p. 581).” She introduced “situated knowledge” as a response to the positivist call for objectivity that reduced everything to value-free data for the purposes of control. Second, the Other is likely socially situated to ask questions than it is for the Self. Third, research, particularly that focused on power relations, should begin with the lives of the marginalized. Feminist standpoint epistemology has informed research methodology in the social and natural sciences, philosophy of science, and political activism in the past few decades. It has been one of the most significant contributions that emerged from second-wave feminist thinking. Feminist standpoint theories place relations between political and social power and knowledge center-stage. Feminist scholars —such as Dorothy Smith, Nancy Hartsock, Hilary Rose, Sandra Harding, Patricia Hill Collins, Alison Jaggar and Donna Haraway— have advocated taking women's lived experiences as knowledge.

According to Harding (2004) a standpoint is an achieved collective identity or consciousness which is not merely a perspective due to one’s identity (e.g., being a woman), rather a perspective is occupied as one’s socio-historical positionality. A standpoint is earned through the experience of collective political struggle that requires both science and politics (Hartsock, 1998).

Sandra Harding wrote,

Only through such struggles can we begin to see beneath the appearances created by an unjust social order to the reality of how this social order is in fact constructed and maintained. This need for struggle emphasizes the fact that a feminist standpoint is not something that anyone can have simply by claiming it. It is an achievement. A standpoint differs in this respect from a perspective, which anyone can have simply by ‘opening one’s eyes’. (1991, p. 127)

Feminist standpoint epistemology addresses an important question that “whose knowledge is the most worth?” (Harding, 1991). Interestingly enough curriculum scholars have been asking a similar question for a long time; i.e., “what knowledge is of most worth?” (Spencer, 1884).

Feminist standpoint epistemology informs our science teaching by validating multiplicity of positions that could generate knowledge. This gives voice to students to bring in their lived experiences, thought, feelings, and wonders to the science classroom. For instance, their projects on Donald Trump, rape and sexual violence, and Black Lives Matter become as scientific as their projects on global warming, robotics, and engineering.

In what follows, three pre-service teachers (Valeria, Matt, and Mike) reflect on their experience of working with urban Latinx middle school students learning (computer) programming with Scratch, a kid friendly picture/visual based gateway computer programming language. These reflections highlight how two typically distinct educational constructs (computational competency & culturally relevant pedagogy) are synthesized in teachers’ thinking and practice. Matt was preparing for being a middle school English teacher. Valeria was preparing to be an English Speakers of Other Languages teacher capable of working
across elementary and secondary classrooms. Mike was preparing to be a high school Physics teacher. The variation in these teachers’ disciplinary areas added a richness to their collective efforts as they worked with the students and developed curricular activities to implement. Situated in a Southeastern state in the heat of the 2016 presidential election and its aftermath, many students chose to focus on the rise of Donald Trump as a sociopolitical phenomenon as a topic for their CS projects.

Young Computer Scientists Develop Programs

On the first day, we asked students about the issues they see growing up in their neighborhood. The students came up with different topics such as the 2016 presidential election, Black Lives Matter, rape, litter, etc. Their first lesson in Scratch was a simple monologue. The students were to create a monologue about their topic using *Sprite*, a collection digital objects used in Scratch that work as active characters that can move. Then we advanced to a dialog between two Sprites. After these lessons, we asked the students to create a pseudocode for their overall project about their topic. As used in program development, pseudocode is made up of statements written to show the sequential steps required to solve a specific problem or achieve a particular goal. These statements can then be translated into computer programming code. Pseudocode is like drawing a map through a problem. Within our context, it could even be thought of as a storyboard. Once their pseudocode was implemented into Scratch, the students added interactive dialog (input/output), loops and if/else statements along with other computer science elements based on the lessons taught by the teachers.

Freirian Problem Posing Is Culturally Relevant (Matt)

Throughout my time working in this program, I had multiple experiences that informed my understanding of the process of teaching computer science, as well as my personal perspective on teaching in general. One of the major concepts I learned to use was Freirian problem posing (1968) curriculum. Problem posing curriculum involves the students having an overarching problem or question that they attempt to solve throughout the curriculum. By using problem posing curriculum, the students have a framework they can use to relate all of the concepts they cover throughout the lesson/unit to their original problem. This accomplishes two things: it gives students a concrete application for the curriculum; i.e., addresses the question ‘when are we ever going to use this information?’; and it gives the students an anchor to become personally invested in what they learn.

What I found interesting about the curriculum used in this program was the kind of problems used in the application of problem posing curriculum. In my experience, there is often a bias involved in what kinds of problems are focused on in particular subject areas. For instance, science classes focus on practical/engineering problems; literature classes focus on ethical/moral issues; social studies classes focus on ‘political’ issues. While these types of problems might neatly fit their respective content area, focusing on the obvious topics can limit student creativity and give them a false impression of how narrow those content areas are. The curriculum we developed for this project subverted this convention by having the students use computer science to tackle whatever problem they chose.

In order to give students freedom to work with any problem, we had them brainstorm their own topics. The students would get together in groups and bounce ideas off each other about different problems they had/saw in the world. These problems ranged from personal issues to global ones. This idea fit in well with the concept of culturally relevant pedagogy (Ladson-Billings, 1995) because it allowed the students to reflect on their culture (and the culture of their peers) and incorporate that culture into their learning. What surprised me the most about this experience was the extent to which the students took national and global issues and made them more personal. When asking students why they picked their
topics, the reasons they gave for their choice were often personal and emotional. The biggest example of this was the groups that wanted to focus on Donald Trump. We as instructors wanted them to focus more on ‘issues’ instead of people, so we recommended that students should focus on some of the issues Trump represented instead of the person himself. However, when we asked many of the students why they picked Trump, their reasons would often be personal, such as “he’s a bully”, “he doesn’t like women”, or ‘he’s racist”. While those reasons could be abstracted to broader issues (combative politics, patriarchy, and racism), the students all chose to internalize those character flaws in Trump himself instead of think of them as broad issues. Another assumption I mistakenly (potentially prejudicially) made was that most of the students at the afterschool program would choose topics related to their shared Latin American culture. An example of this preconception came from the teachers who ran the afterschool program, most of whom were Latinx. Upon hearing how our program would use problem posing for the students’ projects, they thought that many of them would pick soccer-related issues. However, when the students were brainstorming their topics, soccer rarely (if ever) came up, and none of the students selected it for their topic. Upon reflection, I recognized that despite their shared Latin American culture being the students’ reason for being at the after-school program, the students were also a part of many different cultures, some of which they may feel are more important to them personally than their Latin American heritage. After seeing the students brainstorm and select their topics, I was even more grateful that we had them select their own topics instead of having them focus on instructor-selected problems that would have little to no relevance to their day to day lives.

One experience that I want to highlight is a lesson about Loops we did with the students. The intended curriculum for the lesson, like most of the lessons in the program, was to have the students explore a computational thinking concept (in this case Loops) through their topics. I had the idea that this could be accomplished by having the students create a ‘song’ in Scratch based on their topics. I had multiple reasons for this. One was that Loops are commonly used in musical composition, and the Google CS First lessons (Google CS First) on loops all incorporated music. The second reason was that everything they had done in Scratch up to that point was dialogue/narrative driven, and I felt it was important to demonstrate how versatile coding can be. My final reason was a bit more basic: many of the students liked to explore the sound features in Scratch (often at the expense of working on their intended project), so I thought that incorporating that into a project would be a good use of their already-present interest. Unfortunately, the lesson did not go as well as I had planned. Some of the students struggled to come up with a song or sounds that fit their topic, while other students who were not as interested in music were not engaged in the lesson. My teaching partner and I compensated for this by modifying the lesson for some groups to where they could include more of a narrative aspect in their project to focus it. My partner had the great idea of having some of the students record lyrics that fit their topic as a way to incorporate their topic into their projects. This experience taught me that by applying my personal ideas and preferences to a lesson, I can unintentionally make it exclusionary for my students who do not share those preferences. By reflecting on all of my experiences in this program, I now have a framework that I can use to meaningfully engage in learning with students of any background.

**Loops of Donald Trump** (Valeria)

Students in the after-school STEM program explored topics of computer science while using a program called Scratch. Scratch is a platform that allows students to create their own projects that include games, animations, and interactive stories. Students can personalize their projects using a variety of coding scripts that dictate the movement, looks, sounds, and a variety of other features involved in each project.

Programs like Scratch can be used as a tool for students to tell their stories, and also express themselves creatively. Working with Scratch, students can use a language that they are comfortable with.
This is valuable when we think of upholding the connection between the curriculum and students’ home cultures. In many cultures, family history is passed down through generations via oral storytelling. Parents and grandparents are valuable members of their communities since they keep these histories alive. Scratch was used in the classroom to give students a new way to expand upon traditional storytelling methods like essay writing or journaling.

Figure 2. Scratch Program

This semester in the program, we used Scratch to introduce students to a variety of computer science concepts. The students learned about Loops. In computer science, Loops are operations that make an action happen repeatedly. In Scratch, this repetition can be dictated by certain commands. You can have something “repeat until” one action occurs, or you can have something “repeat forever”. Students use the “control” scripts in Scratch to create their own Loops. Many actions can be placed in a Loop including motion, sound, and appearance.

Since being introduced to the Scratch platform, students were interested in experimenting with sound features. Every time students opened Scratch, a variety of sounds could be heard from the students’ computers, whether or not the project we were working on included music. Because of this, we decided to have students create their own songs related to their project topics.

A few weeks after the 2016 presidential election, students worked on their Loop projects. Students used sounds, recorded music, and voiceovers to create songs related to their topics. One group with the topic of Donald Trump, decided to title their sound Loop project “F*ck Trump”. The students in the group approached me and were apprehensive about sharing their controversial title. They said, “You’re going to be mad!” I saw the title, and I let them know that their feelings were valid and I felt similarly. Then, I urged them to explain their choice of strong language, and explore those problems that caused them to feel that way. The students gave me some reasons, “He’s tearing apart our communities; he’s a woman abuser; and he’s racist.” After writing down these reasons, the students used Scratch to record a group member speaking this list of issues into a microphone. Using coding from Scratch, the students played the dialogue on a loop including background music, and created a background using their own design.
The topic of “Donald Trump” explored in this Scratch project was increasingly relevant throughout the semester. Discussing the election of Donald Trump was important since post-election, many students felt fear. It has been reported that hate crimes increased since the election (Yan, Sgueglia, & Walker 2016). Two teachers were removed from a nearby high school (the high school many of the after-school students will attend once they graduate) for making anti-immigration comments following the election. Emergent bilinguals often internalize the xenophobic discourse that surrounds non-native English speakers. The students in the after-school program are very savvy when it comes to their knowledge about current stories in the media. They are constantly exposed to social media, which often presents the most extreme, negative, and even false societal views. This xenophobic discourse was amplified during that year’s election season. Thus, students feared deportation, discrimination, and other forms of violence. Many students experienced their friends and families facing deportation due to the increased Immigration and Customs Enforcement raids that occurred in 2016 (The Southern Poverty Law Center & The Georgia Latino Alliance for Human Rights, 2016). The after-school program was a safe space in which we could provide a constructive and creative environment for students to comfortably explore these topics. Having students explore their oppressors through the lens of computational thinking was one way that we explored critical pedagogy in the after-school program.

Students used Scratch to creatively explore problems relevant to their everyday lives. Computer Science has long been a field dominated by white men (Exploring Computer Science, 2016). However, students in the after-school STEM program bring a wide variety of funds of knowledge (Gonzalez and Amanti, 2005) to this field. Computational thinking involves viewing problems through the lens of critical thinking by looking at the many facets that relate to one issue. By encouraging students to problem pose through addressing connections, computational thinking can help students explore the world around them through a critical lens. The time has come for marginalized students, and specifically the students in this program, to be given the opportunity to explore this field.

**Pseudocodes: Computerless Computational Thinking** (Mike)

![Figure 3. Pseudocode](image-url)
Pseudocode gave students a framework for thinking computationally and systematically about how to use the tools and commands in Scratch to create their projects. Using the “gradual release of responsibility” Buehl (2005), the co-teacher and myself modeled for students how to use pseudocode to sketch their programming ideas before using Scratch. I did not feel like the lesson was going that well or that my instruction was very effective until we passed out chart paper to students and they began to write down their pseudocode. To my pleasant surprise, students understood how they were mapping out ideas to use in the project as they were very engaged with creating a chart. Students who were struggling with the direction of their project and what commands they should use in Scratch greatly benefited from pseudocode. At that point, they were able to look at their own ideas and think about structuring the project in a more holistic way outside of simply doing fun things in Scratch. The implementation of pseudocode enhanced students’ understanding of their thought process when working with Scratch, and condensed the features of Scratch to allow students to focus on just a few commands at a time. Pseudocode also helps teachers explore thinking and learning about computational thinking as the “abstraction, automation, and analysis” model, which was outlined by Lee et al. (2011, p.33). Abstraction occurred when students began to look at the bare essentials of Scratch and view it outside of a computer program; automation occurred when they went back to the computers and used technology to create the projects in a labor-saving manner; and analysis happened as students reflected on the process of taking the pseudocode and programming it in Scratch.

Pseudocode provides a method for students to approach problem solving in a way that reflects computational thinking, instead of using primarily trial and error to figure out ideas and discover commands. Exploration often consisted of trial and error after wondering how to do a command in Scratch; e.g., students would try to figure out how to add sound or different images. This was appropriate and necessary as an introduction to Scratch. As students learned more specific commands, it became necessary to move away from trial and error approach. Pseudocode allowed students to map out ideas with the Scratch skills that they had already developed. They were also able to focus on a few commands, making the interface less intimidating. Throughout the semester, teachers and researchers reviewed and reflected on the students’ pseudocode charts. We gained insight not only into how the students were thinking about Scratch, but also on their social views and thoughts about local and global issues. Here are three examples of projects that highlighted both students’ approach to creating projects in Scratch as well as their views on social issues.

One group created a project based on the issue of rape. The project was titled, “No Rapes,” and featured a dialogue that portrayed a nuanced and mature understanding of the feelings and emotions of rape and sexual assault victims. The dialogue had one Sprite discussing how victims feel ashamed and “worthless” after being raped while the other Sprite spoke about the subject in a nonchalant and almost dismissive tone. This reflects how the subject of rape and sexual assault can often be discussed by adults in our society on social media, political discussions, and news channels. Victim shaming and dismissive attitudes often appear in these adult discussions. On the other hand, these students demonstrated an understanding of rape and the project did not demonstrate any juvenile attempts at humor one might expect from middle school students. Teachers and researchers were concerned about the sensitive subject matter using such direct language. One of the students in the project strongly opposed using any other word than rape in the title, such as sexual assault. This student also originally created a list of serious topics during the problem posing activity. In addition to the subject of rape, this student listed drug abuse and prisons as other issues they would like to pursue.

Another group created an interesting project that depicted a scenario pitting United States president-elect Donald Trump against Mexican cartel leader Joaquin Guzman, better known as El Chapo. The students originally decided to focus on the election and Donald Trump, but their project morphed into Trump vs. El Chapo when the class began to use pseudocode. The presidential election and Donald
Trump were popular topics during the problem posing activity, which took place in September 2016 during the United States election season. Students expressed a strong preference for just about anyone over Donald Trump, and he was often portrayed as an arch-villain. The Trump vs El Chapo project illustrates this, as the students presented an evil Trump and an almost heroic El Chapo. I was fascinated by the students’ responses when I asked them why they feel El Chapo should be seen as a positive figure, one student claimed that El Chapo, “Does a lot for poor people.” This philanthropic view of a drug lord reminds me of the many different opinions about Pablo Escobar, a figure described anywhere from a sociopath and terrorist to some philanthropist and ethical police of the underground drug world depending on who is speaking.

A third Scratch project that illustrates this group of students’ social awareness focused on the environment and cleaning up the community. The group members were initially working in different groups whose topic concerned Donald Trump and the presidential election. As the attendance of their other group members declined, these students formed a new group. Once the three began to work together consistently, they decided on the new topic of environmental awareness by ways of cleaning up trash and keeping the parks clean. Subsequently, their engagement rose significantly. One student in particular, who was already savvy with Scratch and caught on to new concepts and commands quickly, really became passionate about the project and engaged with the program. Their family even came to view the Scratch project during the final day of presentations and they were eager to come and see their child’s work. The project really took shape after introducing pseudocode, as the students were thinking more about the process and less distracted and intimidated by Scratch and using the computer. One of the students who struggled with Scratch used pseudocode to simplify the process and focus on a few commands they were familiar with and understood well.

Each of these Scratch projects became more focused and refined after students used pseudocode to map out their ideas and program commands. Pseudocode not only helped students think about their projects in a more systematic and computational way, it also allowed the teachers and researchers to analyze the students’ thinking behind their Scratch projects and assess the way of computational thinking. Pseudocode can be applied cross-curricularly and offers an effective framework for students to take an epistemological approach to learning, and for teachers to assess how their students are thinking about concepts and ideas on a more computational and systematic level that will ultimately contribute to deeper learning.

Culturally Relevant Coding for Personal Expression

The innovation and creativity students showed through their projects helps us see the power of culturally relevant pedagogy and Freirian problem posing. Freirian problem posing enabled students give voice to the concerns and issues central in their thinking about their communities. As seen from the stories above, pseudocoding and the creation of Scratch programs provided students a different platform to express their ideas. As we continue to rethink schools as places that welcome contributions from all students, coding and pseudocoding can provide another avenue for students to express their ideas, and one that does not have to solely reside in a science class.

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References:


From Computational Thinking to Political Resistance 

by R. Aghasaleh, P. Enderle and A. Puvirajah


Didactic Modelling for Socio-Ecojustice

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Responses

JASTE is a non-refereed, open-access, journal. We encourage reader feedback on contributions to it. Please send your comments, suggestions, etc. directly to the author of this paper, Associate Professor Jesper Sjöström. Thanks!

Abstract: In northern Europe and Scandinavia, there is a tradition called Didaktik. It can be seen as both the art of teaching and as the “science for teachers”, helping us teachers answering didactic questions about WHY?, WHAT? and HOW? to teach (and support learning). Many areas of subject-specific Didaktik have in recent decades evolved from mainly practice-based methodology to quite independent research areas. This applies, for example, to the field of science-Didaktik (i.e., Science Education). Part of this field has a special interest in educational activities for socio-ecojustice. For instance, it can include complex issues used in teaching to build bridges across different curriculum subjects, among them STEM-subjects, in support of sustainability, reflexive Bildung and socio-political activism. The focus in this paper is on so-called didactic models and modelling aiming at actions for socio-ecojustice. In particular, the paper presents a model for eco-reflexive Didaktik, an example of a didactic model. Didactic modelling is the name for the processes when didactic models are used and developed, often by researchers in collaboration with practitioners. The didactic model in focus here is based on philosophical ideas and orientations, such as holism, critical realism, egalitarianism, altruism, reconstructionism and critical pedagogy.

Keywords: education for sustainability, eco-reflexive education, critical scientific literacy, Vision III, powerful knowledge, Bildung, socio-political activism, Didaktik, didactic models, didactic modelling

Didaktik as the teachers’ science and its relationship to Bildung

In northern Europe and Scandinavia, there is a tradition called Didaktik. It can be seen as both the art of teaching and as the “science for teachers” (e.g. Seel, 1999; Hopmann, 2007; Kansanen, 2009). Though there are a variety of definitions, the most comprehensive is that it is “a science and theory about teaching and learning in all circumstances and in all forms” (Gundem, 2010, p. 293). According to Duit (2015, p. 325) Didaktik “stands for a multifaceted view of planning and performing instruction. It is based on the German concept of Bildung”. The latter is the German and international term for an educational-philosophical key idea in German-speaking countries and Scandinavia (e.g. Sjöström, Frerichs, Zuin & Eilks, 2017). It is especially in the humanistic Didaktik-tradition that the notion of Bildung is central (see e.g. Fischler, 2011; Jank, 2014; Vásquez-Levy, 2002). See Westbury, Hopmann and Riquarts (2000) for some translated original contributions from the history of Didaktik and Bildung. Both the concepts will be described further below.

The German Bildung-scholar Wolfgang Klafki framed his Bildung concept with epoch-typical key issues, such as the global challenges (e.g. Arnold, 2012; Sjöström & Eilks, 2018). He identified two main orientations in his understanding of Bildung: material and formal Bildung, respectively. Furthermore, he also argued for a position mixing these two views and called it categorical Bildung (Sjöström & Eilks, accepted). More recently, Kemp (2005, in English 2010) applied the thinking of Klafki to ideas about our late modern society. Moreover, he discussed different views of the “world citizen”. Kemp described education – just like Klafki did – as being embedded in a certain time, society and culture.
In recent decades, many areas of subject-specific Didaktik have evolved from mainly practice-based methodology to quite independent research areas (Sjöström, 2018a). This applies, for instance, to the field of science-Didaktik (i.e., Science Education). Part of this field has a special interest in educational activities for socio-ecojustice. For example it can include complex controversial issues used in teaching to build bridges across different curriculum subjects – among them STEM-subjects – in support of sustainability, reflexive Bildung and socio-political activism (Sjöström & Rydberg, 2018).

In teaching practice, so-called Didaktik-models (in the following called didactic models) can be used both as tools for analysis and for planning of teaching (e.g. Arnold, 2012; Jank & Meyer, 2018). The main aim of didactic models is to help us teachers in our didactic choices (e.g. Wickman, Hamza & Lundegård, 2018; Sjöström, 2019). Models can be used, for example, in the design, action and analysis of teaching, but also for critical meta-reflection about teaching traditions, prevalent practices or didactical dilemmas. There are three main types of didactic models, although many models – as the one in focus in this paper – are mixtures of these:

- Relevance models, which help us answer the didactic WHY-question (it is about intentions, aims and objectives)
- Content models, which help us answer the didactic WHAT-question (it is about topics of instruction)
- Models for improved practice, which help us answer the didactic HOW-question (it is about methods of instruction and media used in instruction)

The Didaktik tradition focuses predominantly on the WHY- and WHAT-questions, while the Anglo-American teaching tradition focuses more directly on the HOW-question (e.g. Kansanen, 1999; Duit, 2015). Klafki developed didactic models for Bildung-oriented Didaktik (e.g. Vásquez-Levy, 2002). For the science subjects Professor Ingo Eilks from the University of Bremen, Germany, together with coworkers has formulated and empirically evaluated a didactic model for socio-critical and Bildung-oriented science teaching (e.g. Marks, Stuckey, Belova & Eilks, 2014). I, with Eilks in particular, have further elaborated on the Bildung-concept in relation to the science subjects (e.g. Sjöström, 2013; Sjöström et al., 2017; Sjöström & Talanquer, 2018).

When didactic models are formulated, used and/or developed, this may be referred to as ‘didactic modelling’ (Sjöström, 2019). In this paper, the focus is on didactic models and modelling aiming at actions and activism for socio-ecojustice. By activism in science and technology education I mean the same as Alsop and Bencze (2014) did. In particular, the paper presents a model for eco-reflexive Didaktik, an example of a didactic model.

The rest of the paper is subdivided into the following four parts: Didactic models and modelling; Powerful knowledge, critical literacy and eco-reflexive Bildung; Science education for socio-political activism; and A didactic model for socio-ecojustice.

**Didactic models and modelling**

Two fundamental didactic models are the didactic questions (WHY?, WHAT?, HOW? etc.) and the classical didactic triangle (teacher-content-student) (see Figure 1). However, there are many more models: both comprehensive and detailed, abstract and concrete, and general and subject-specific (Sjöström, 2019). Didactic models can be used both as analysis tools and as tools in the planning of teaching (e.g. Arnold, 2012; Wickman, 2014; Jank & Meyer, 2018). Almqvist, Hamza and Olin (2017, p. 21) write (my translation): “Didactic models can look different and have different purposes. In particular, they should enable didactic analysis of any part of the teaching, such as the selection of teaching content, planning of how the content should be realized in the classroom, how the teaching should be assessed or to understand what happened during the lesson, why it happened and how the teaching could be modified”. There are also more comprehensive didactic models on, for instance, philosophical views, teaching traditions and teacher competencies.
Examples of research-based and teaching-oriented didactic models are organizing purposes (Hamza et al., 2018), didactical dilemmas regarding controversial issues teaching (Rydberg, 2018; Sjöström & Rydberg, 2018) and key elements in teaching about risk (Schenk et al., 2019). The models have the potential to change practice, but practice will also affect the models. Such interaction between theory and practice has been called didactic modelling (e.g. Ingerman & Wickman, 2015). Blomhøj and Højgaard Jensen (2007, p. 26) have another take on didactic modelling (my translation): “Didactic modelling is our term for a systematic, research-based and reflected development of an education practice”. In other words, it means that didactic knowledge is developed by teachers in collaboration, in one way or another, with Didaktik-researchers (e.g. Ingerman & Wickman, 2015; Hamza et al., 2018); moreover, it creates opportunities for teachers’ systematic development of their teaching. The starting point is always one or more didactic models that are tested and refined in teaching practice (Sjöström, 2019).

Didactic models can be traced back to Klafki’s didactic analyses in the late 1950s, with five areas of questions (Klafki, 1995; Duit, 2015; Sjöström & Eilks, accepted). Ingerman and Wickman (2015) see didactic models as a way of introducing us as teachers to a more general form of didactic analysis. We must balance different purposes of teaching with each other, thus focusing on the different functions that education should meet, that is, qualification, socialization and subjectification (Biesta, 2009). In this paper, the focus is on what can be called emancipatory subjectification. Students should not be forced to have any specific views or values – except general democratic thinking – but education always needs to expose students to and highlight well-informed alternative views, thinking and facts to give them the possibility to question mainstream and/or antidemocratic discourses. In line with these thoughts, Alexander (2018, p. 914) phrased the following: “Pedagogy worthy of the designation ‘critical’ must not only initiate into particular ethical viewpoints but also offer exposure to alternative perspectives”. Similarly, but with more focus on content matter and within the European didactic tradition, Hopmann (2007, p. 117) claims, “Didaktik and Bildung require normativeness […] they challenge the teacher to be aware of the unavoidable normativeness in every dealing with whatever subject matter.”
Powerful knowledge, critical literacy and eco-reflexive Bildung

One understanding of our world is that we live in a risk society (Beck, 1992), in which citizens, professionals and politicians must be aware of and able to manage different risks. Scientific knowledge is one of several necessary knowledge bases (Elmore & Roth, 2005). In line with this, science and technology education must be designed with the purpose of educating critical-democratic citizens (e.g. Sjöström & Eilks, 2018). Hodson (2011) has argued for a critical scientific, technological and environmental literacy – shortened to critical scientific literacy. The aim of critical scientific literacy is to have knowledge and abilities for being an autonomous, responsible-taking and action-knowledgeable citizen, working in the interest of socio-eco-justice and global sustainability. Elmose and Roth (2005, p. 21) called this Bildung, and it “involves competences for self-determination, constructive participation in society, and solidarity towards persons limited in the competence of self-determination and participation”. It is praxis-oriented, in addition to being oriented towards consciousness and critical literacy. In line with this, Mogensen and Schnack (2010, p. 60) argued that their concept of action competence is “closely linked to democratic, political education and to […] the notion of ‘Bildung’.

According to Biesta (2012a, p. 817), “the role of the individual in the process of Bildung, […] has to be understood as a reflexive process”, that is, a process were the individual establishes both a relationship and a critical stance towards the existing culture and society. In this process of emancipatory subjectification, the individuals become “autonomous – subjects of action and responsibility” (Biesta, 2012b, p. 7). This phrase “tries to capture a conception of human subjectivity that is not selfish or self-centered but always understood as being in responsible relation with other human beings and, by extension, with the natural world more generally” (Biesta, 2013, p. 739). Biesta (2012b, p. 16) regards this as “highly political, as it intervenes in and reconfigures the existing order of things”. To specify the meaning of Bildung today, we have to base it on the fact that we live in a globalised risk society with many global and ecological challenges (e.g. Straume, 2015; Taylor, 2017; Sjöström et al., 2017; Roselius & Meyer, 2018). Horlacher (2016, p. 118) has asserted that Bildung can be “seen as a tool to promote political education, and foster public spirit and identity” in our society. When it is oriented towards ecological awareness, I have previously called such an orientation eco-reflexive Bildung (Sjöström, 2018b).

Outside the Bildung-traditions, but with many similarities to Klafki’s categorical Bildung-thinking (Bladh, Stolare & Kristiansson, 2018), Young (2013) emphasised the need of every citizen to have so-called powerful knowledge. It is relevant knowledge developed within disciplinary contexts. In other words, it refers to discipline-grounded knowledge important for all. Young (2013, p. 118) contends that “Powerful knowledge opens doors: it must be available to all children […] It transcends and liberates children from their daily experience.”

In traditional science education, the focus has been on scientific concepts and models. Compared to both the “powerful knowledge”-conceptualisation by Young and the “categorical Bildung”-thinking by Klafki, a relevance focus has been missing. In addition to (a) scientific concepts and models, both (b) scientific processes – NOS (Nature of Science) – and (c) societal contexts – STSE (Science-Technology-Society-Environment) – should be emphasised in a socio-critical and eco-reflexive Bildung-oriented science education (Sjöström & Eilks, 2018). In practice, it would mean including more philosophical, ethical and socio-political perspectives in science teaching, and the focus should be on problematization, understanding uncertainties and balancing the benefits and risks of science. In addition to these three legs – concepts, NOS and STSE – Hodson (2003) also suggested socio-political activism as a fourth leg. In a paper about different ways of using the concept of Bildung in the international science education literature, I together with co-authors merged NOS- and STSE-contextualisations to one approach and called the remaining three approaches conceptual, contextual and critical (Sjöström et al., 2017, p. 182). The latter approach is connected to eco-reflexive Bildung and also a Vision III of scientific literacy. The meaning of Vision III will be presented in the next section.
Science education for socio-political activism

The dominant model for working with controversial issues in science education is referred to as socio-scientific issues (SSI) (see e.g. Pedretti & Nazir, 2011). It is typically complex and relevant social issues with a science base (see e.g. Ratcliffe & Grace, 2003; Zeidler, Sadler, Simmons, & Howes, 2005). However, it is not a uniform teaching model. Although the teaching has the same origin, there are several different orientations on such teaching (Pedretti & Nazir, 2011). Simonneaux (2014) has discussed different orientations of SSI-education using a continuum from “cold” (mainly emphasizing, for instance, monodisciplinarity, scientific learning and epistemic values) to “hot” (also emphasizing transdisciplinarity, political citizenship and philosophical values). In the middle of Simonneaux’s (2014) model, we find, for example, knowledge about science, critical thinking, and scientific citizenship. Although STSE-contextualization is emphasized, the focus is on cognition and evidence-based argumentation. This is problematized at the hot end, which also contains philosophical reflection and socio-political activism.

Simonneaux’s (2014) chapter is published in an anthology oriented towards critical, radical and activist-oriented Science and Technology education, that is, ST education at the hot end. The editors of the anthology are Bencze and Alsop (2014). They discussed four maxims for such education praxis: contemporary conditions, democratic political theory, subjectivities and agency, and morals and ethics. Some keywords describing the anthology are sustainability discourses, Science and Technology Studies (STS), citizen science education, critical pedagogy, transformative learning, SSI, reflexive inquiry and research-informed activism-projects (Bencze & Alsop, 2014).

Levinson (2017) has compared mainstream SSI (e.g. Zeidler et al., 2005) – placed in the middle of Simonneaux’s continuum – with other science-society education approaches, such as STEM (Science-Technology-Engineering-Mathematics), SAQ (Socially Acute Questions), and STEPWISE (Science & Technology Education Promoting Wellbeing for Individuals, Society & Environments). He described the education purpose of mainstream STEM, which is at the cold end of Simonneaux’s continuum, to be providing human capital. The education purpose of SSI is the development of scientific knowledge needed for socio-scientific reasoning, that of SAQ is to develop a critical discourse, and that of STEPWISE is to develop knowledge for activism and socio-ecojustice. Both SAQ and STEPWISE are at the hot end of Simonneaux’s continuum. In a similar organizer, I together with Eilks used the concepts of Vision I, II and III of scientific literacy and STEM education (Sjöström & Eilks, 2018). Vision I is at the cold end, and Vision III at the hot end (see further below).

Vision I and II relate to Roberts’ (2007) two classic visions, while we introduced a third that we called Vision III (Sjöström & Eilks, 2018). It includes critical aspects that aim at philosophical reflection and socio-political actions. Science education based on eco-reflexive Bildung and Vision III aims for both students and teachers to have a holistic, ethical and political attitude regarding STSE relationships (e.g. Sjöström, Eilks & Zuin, 2016). One consequence of this is that teaching in curriculum subjects must orient itself towards both transdisciplinary perspectives (Sjöström & Rydberg, 2018) and powerful knowledge (Young & Lambert, 2014).

As a basis for SSI discussions, the students should have access to both relevant scientific research bases and socio-political contextualisation. Nielsen (2012) has argued that students’ arguments will not only come from rational scientific reasoning, but they will always also be strongly influenced by the individual’s ideological and ethical views and own experiences, and should be allowed to be. In hot SSI teaching, we as teachers may need to handle strong emotions, a changing teacher role and complex assessment activities. As a result, we need to be aware of both the advantages and disadvantages of the various didactical options available (Rydborg, 2018).

A didactic model for socio-ecojustice

Examples of didactic models that take the global challenges into consideration are as follows: the STEPWISE theoretical framework and pedagogical approach for activist Science and Technology education by Larry Bencze (2017, e.g. p. 20 and 27) and his co-workers, the so-called SSIBL-model
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(SSI+IBSE) developed by Ralph Levinson and the PARRISE consortium (2017, p. 480), and the model/framework for socio-critical and Bildung-oriented science teaching by Eilks and his co-workers (Marks et al., 2014). Here, I will present a developed version of the latter model/framework.

The didactic model in Figure 2 – a model for eco-reflexive Didaktik – is a revised and extended version of a “Framework outlining the socio-critical and problem-oriented approach to science teaching”, initially published by Marks and Eilks (2009). It has been republished several times, for example in Marks et al. (2014) and Sjöström, Rauch and Eilks (2015). Furthermore, it has been tested (didactic modelling), in particular with chemistry teachers using different thematic themes, such as different plastics (Burmeister & Eilks, 2012; 2014), different fuels (Eilks, 2002), parabens as preservatives in personal care products (Garner, Siol & Eilks, 2014), soaps with artificial musk fragrances (Marks & Eilks, 2010), tattoos (Stuckey & Eilks, 2014), doping (Stolz, Witteck, Marks & Eilks, 2013), and “natural” cosmetics (Belova & Eilks, 2015). For many of these cases, one can talk about a chemical oppression, where people are exposed to different risk-related chemicals often without being aware of the fact (Belova et al., 2017). Then it is not enough with NOS- and STSE-contextualisations, in addition to scientific content knowledge. There is also a need for understanding the network of actors and the presence of various discourses (Sjöström & Stenborg, 2014), as well as an awareness of alternatives and possibilities for action. The didactic model in Figure 2, which has not been published before, takes this need into consideration. Furthermore, it – even more explicitly than its precursor – connects to the humanistic Didaktik-tradition and the didactic questions (WHY?, WHAT?, HOW?).

<table>
<thead>
<tr>
<th>Philosophical ideas</th>
<th>Objectives (WHY?)</th>
<th>Criteria for selecting issues and approaches (WHAT?)</th>
<th>Teaching methods (HOW?)</th>
<th>Structure of lessons and projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holism and Eco-reflexivity</td>
<td>Reflexive Bildung and Transformative learning</td>
<td>Sustainability issues</td>
<td>Integrating cognitive and affective domains (incl. dialogic processes)</td>
<td>1. Problem analysis</td>
</tr>
<tr>
<td>Critical realism</td>
<td>Problematization, Emancipation, Subjectification, Praxis</td>
<td>Relevant, controversial and complex socio-scientific issues</td>
<td>Inquiry-based learning (incl. practical work)</td>
<td>2. Clarifying the science background and context</td>
</tr>
<tr>
<td>Egalitarianism and Altruism</td>
<td>Vision III of scientific literacy</td>
<td>Authenticity</td>
<td>Relevant media (incl. authentic)</td>
<td>3. Resuming the socio-political-scientific controversy</td>
</tr>
<tr>
<td>Humanization (plural knowledge and multifaceted problematization)</td>
<td>Learning in and about science (incl. NOS and STSE)</td>
<td>Includes scientific knowledge and processes (incl. uncertainty)</td>
<td>Methods structuring scientific reasoning and controversial debating</td>
<td>4. Alternatives and examples of actions for socio-ecojustice</td>
</tr>
<tr>
<td>Reconstructionism and Critical pedagogy</td>
<td>Promotion of critical and responsible citizenship</td>
<td>Allows for open discussion (incl. different discourses)</td>
<td>Methods provoking the explicitation of individual opinions and actions</td>
<td>5. Meta-reflection (incl. analysis of knowledge emphases and possible activism)</td>
</tr>
</tbody>
</table>

Figure 2. A didactic model for eco-reflexive Didaktik. It is a developed version of a framework by Marks & Eilks (2009) outlining a socio-critical and problem-oriented approach to science teaching.

Column one concerns the philosophical ideas behind the developed model. The initial model does not have a corresponding column. Many of the ideas in the column (holism, realism, egalitarianism, altruism) are taken from Bencze and Carter (2011). For references about (eco)reflexivity see e.g. Sjöström et al. (2016) and Boström, Lidskog and Uggla (2017). For references in science education about complex socio-environmental issues, see e.g. Colucci-Gray, Camino, Barbiero and Gray (2006); for critical realism, see e.g. Levinson (2018) and Zembylas (2006); for critical pedagogy, see e.g. Santos (2009); for reconstructionism, see e.g. Sjöström (2018b); and for humanized science/chemistry education, see e.g. Sjöström and Talanquer (2014). See also Sjöström et al. (2016); Sjöström (2018b); and Sjöström and Eilks...
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(2018) for further descriptions of the theoretical frameworks used in the development of the model.

Column two relates to the objectives (the didactic WHY-question). Ideas are taken from e.g. Sjöström and Eilks (2018). Column three deals with the content (the didactic WHAT-question). Ideas are taken from e.g. Sjöström and Talanquer (2014) and Sjöström et al. (2016). Column four concerns the practice (the didactic HOW-question). Ideas are taken from e.g. Bencze (2017), and Eilks and his co-workers (e.g. Marks et al., 2014; Belova, Chang Rundgren & Eilks, 2015). For a discussion about approaches to integrate cognitive and affective domains, see e.g. Littledyke (2008).

Column five deals with the concrete structuring of lessons and projects, and it is similar to the corresponding column in the original framework by Marks and Eilks (2009). The column concerns (1) first making a problem analysis, and (2) then clarifying the science background and context. One way to get an overview of the context from a critical perspective is to construct – or at least to study an already existing – actor-network map (Bencze, 2017). An example of an existing network map, recently published in this journal, is about the actors in the chocolate industry (Nagi, 2018). The teaching is then followed by (3) resuming the socio-political-scientific controversy, (4) identifying alternatives and examples of actions for socio-ecojustice, and (5) meta-reflection, including analysis of knowledge emphases and possible activism.

Bencze (2017, p. 34) provides the following examples of actions for socio-ecojustice: join a cooperative that avoids food from factory farms, write a letter to a member of the government, produce posters with pros and cons, advertise about anti-consumerism, organize a boycott of products from companies that use child labour, bring reusable bags to grocery stores, and collect unused electronic equipment and recycle it. In teaching practice, such general examples can be discussed with the students, but also more specific cases can be highlighted. As examples, Krstovic (2017, p. 108) highlights teens that raise awareness of the impacts of bottled water and a student that developed a YouTube video about hidden actants in cosmetic products.

As described above, the precursor model of the didactic model in Figure 2 has been tested (didactic modelling) with a broad range of themes, mostly related to health and environment. However, the developed model (Figure 2) has not (yet) been worked with in practice, but models with many similarities have been tested by Bencze (2017) and his co-workers in the STEPWISE project. They conducted action research based on different STEPWISE models. Many of their findings regarding RiNA (Research-informed & Negotiated Actions) projects are summarized in a figure in the STEPWISE book (Bencze, 2017, p. 667). One of the findings is that by constructing actor-network maps, students are enlightened about problematic actants and become motivated to address problems.

The didactic model presented in this paper has Science Education in focus. However, it is mainly applicable also in Technology Education and Environmental Education. To be applicable in other curriculum subjects, it has to be modified (also didactic modelling) based on the characteristics of the specific curriculum subject. Good luck with your didactic modelling for socio-ecojustice!

References


Simonneaux, L. (2014). From promoting the techno-sciences to activism – a variety of objectives involved in the teaching of SSIs. In L. Bence & S. Alsop (Eds.), *Activist Science and Technology Education* (pp. 99-111). Dordrecht: Springer.


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Mobilizing Altruistic Civic Actions Through School Science

Going Up Against The Borg™

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Responses

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Abstract. Whether or not people in advantages contexts around the globe recognize it, it seems clear that our world is in serious peril. While small fractions of populations enjoy safety, basic comforts and many luxuries, increasingly more people are suffering from job insecurities, a range of health problems and manipulation facilitated by mass surveillance systems. Meanwhile, as few benefit, most of us are threatened by devastating climate change, environmental spoilage and species losses — all apparently undermined by systematic democratic assaults. Although network conceptions of phenomena may suggest distribution of responsibilities for such ills, much data and argument place considerable blame on few rich pro-capitalist individuals (e.g., financiers) and groups (e.g., corporations, think tanks and transnational trade organizations). Given collusion of governments in such social and ecological injustices, it appears extremely necessary that power in masses of people be rallied to critically interrogate actions of powerful entities and develop and take social actions that may lead to increases in social justice and environmental wellbeing. An important context, in light of roles of fields of science and technology in enactment of power, for promotion of such critical and action-oriented civic engagement is school science. Such roles have, indeed, been acknowledged — at least in part — for about the last half-century through ‘science-in-context’ educational domains like ‘STSE’ (Science, Technology, Society, Environment) education. Such more contextualized approaches have, however, been marginalized in most contexts. They are either given little attention or treated in somewhat ‘token’ ways (given severity of harms) by emphasizing individual — albeit reasoned — choices, which happen to be a priority of many capitalists. Marginalization of potential critical and action-oriented science education seems to have, meanwhile, dramatically increased with recent advent of ‘STEM’ (Science, Technology, Engineering and Mathematics) education initiatives — many of which prioritize teaching and learning of ‘products,’ such as laws, theories and innovations, of STEM fields and skills to develop them, at expense of educating students about problematic STSE relationships and preparation for possibly-rectifying actions. Given its hegemonic influences, as discussed here, one approach to promoting ecojustice through science education may be through encouraging and enabling youth to develop commodities that are both functional and aim to maximize wellbeing for individuals, societies and environments (WISE). Studies of one teacher’s efforts in this regard suggest considerable successes with such WISE engineering — although, as reported here, successes seem to come at expense of some educational losses that have been tied to pro-capitalist science education. Although such tempered achievements may seem frustrating, those promoting social justice and environmental wellbeing through school science may be motivated by emergent successes and possibilities for mobilizing them across networks of living, nonliving and symbolic entities.
Global Draconian Hegemony

As Greta Thunberg, a teenaged activist from Sweden, said to delegates at the annual gathering of world financial and political elite in Davos, Switzerland, in January 2019, “Our house is on fire!” Climate change is escalating at such a pace, in other words, that she said we need to treat it — not as a ‘risk,’ as she said many politicians were doing, but — like an emergency that is equivalent to imminent destruction of our home. In making such a dramatic statement, Ms. Thunberg could be echoing advice from Noam Chomsky (2017), noted linguist, philosopher, cognitive scientist, historian, political activist, and social critic, who said that — as recently stressed by the Bulletin of the Atomic Scientists (Mecklin, 2019) — humanity is facing at least two existential threats; that is, devastation from nuclear war and from climate change (the latter largely attributed to human fossil fuel combustion) (Steffen et al., 2018). They added that a ‘crisis of democracy’ was undermining efforts to overcome these threats. At the same, among numerous other harms, it is apparent that humans continue to be plagued by ongoing illnesses associated with manufactured foods (Weber, 2009), pharmaceuticals (Norman et al., 2011) and tobacco (Verma, 2009); and, industrial activities are severely compromising many eco-spaces (Leonard, 2010) — contributing to what many suggest is our current (6th, anthropogenic) mass extinction (Moore, 2016).

On the one hand, it may seem appropriate to focus blame for harms like those above on fields of science and technology and related fields, like mathematics and engineering. Based on material-semiotic ontological conceptions (e.g., Fenwick & Edwards, 2012), on the other hand, fields of science and technology (and many related entities) are linked into vast networks of reciprocal relations and, accordingly, responsibility for various ills may best be considered distributed across such systems of actants. The extent to which intentions, knowledge, etc. are equally-distributed across material-semiotic networks has, however, been questioned. Foucault (2008), for instance, suggests that some actants are able to ‘orchestrate’ many others in ways that align with powerful actants’ purposes — referring to such cooperating sets of actants as dispositifs. Among entities that could rally numerous actants to their causes, many scholars and others suggest few or none rival influences — especially in at least the last five decades — of pro-capitalist individuals (e.g., financiers) and groups (e.g., corporations) (e.g., Hardt & Negri, 2009; McMurtry, 2013; Pierce, 2013). After a period of social security and infrastructure spending and labour protections that followed devastation from the Great Depression and World War II, neoliberal forms of capitalism developed; that is, in contrast to earlier, more laissez faire (independent) forms, they encouraged alignment — like assimilation by “The Borg™” from the Star Trek™ entertainment series — of myriad living, nonliving and symbolic entities (including those associated with governments) to work for capitalist aims (Harvey, 2005; Springer, Birch & McLeavy, 2016). A key feature of neoliberalism for about the last three decades has been globalization, that is, infiltration of capitalist perspectives and practices throughout the world and, especially, facilitation of such hegemony through work of transnational entities like the World Trade Organization, International Monetary Fund, World Bank, Organisation for Economic Cooperation and Development and associated think tanks like the Atlas Foundation (Ball, 2012). This complex and extremely powerful transnational programme appears to have served interests of capitalists quite well. Piketty (2014), for instance, suggests that capitalism has been intensely concentrating wealth throughout the neoliberal period and, moreover, seems destined to continue to do so at unprecedented rates — largely at expense of many other humans and living things and nonliving environments. Oxfam (2019), an international aid agency, suggests that wealth has now concentrated to the point that 26 billionaires have about the same total wealth as the poorest 50% of the world’s population (~3.8 billion people).

Although globalizing neoliberalism has been extremely ‘successful,’ especially in terms of wealth concentration by capitalists, intense nationalist movements have become increasingly prominent in the last few years in several nations — including in Austria, Brazil, Hungary, India, Poland, Turkey and the USA. To a great extent, these appear to have been promoted by so-called right-wing populists (RWP); that is, leaders who blame ‘elites’ for many personal and social struggles experienced by large fractions of populations and promise — often in salvationary tones — better futures for masses of ‘common’ people (Laclau, 2005). While it may be somewhat early to judge such nascent movements, numerous analysts suggest that many RWP leaders’ promises — often associated with unpredictable and seemingly erratic behaviour (Kirkpatrick, 2017) — seem to be serving as ‘smoke screens’ to distract citizens from awareness of further, often much more intense, implementation of pro-capitalist policies, such as tax reductions for the rich, de-regulation of large businesses and privatization and/or elimination of former public services (Rushe et al., 2017), apparently strongly-encouraged by so-called ‘dark money’ (e.g., financiers and corporations) (Mayer, 2016). In the sense that RWP populists appear to ‘capitalize’ on crises generated, in part, by neoliberalism, they seem to declare a ‘state of exception’ (Agamben, 2005), enabling them to justify implementation of extreme capitalist policies — a process called disaster capitalism (Klein, 2007).

Rectifying Roles for School Science

Because governments — along with, to a great extent, transnational nongovernmental organizations — often facilitate contexts that appear to have contributed to private sector gains, largely at expense of wellbeing of most other living and nonliving things, it seems clear that increases in public consciousness and civic activism that prioritize social justice and environmental wellbeing are required. If such transformations in civic engagement are to occur, it is apparent that science and technology education must play prominent roles. Key agents in capitalists’ gains have been their twin influences over fields of science and technology in ways that favour private profit over general wellbeing (e.g., Klein, 2014; Krimsky, 2003; Mirowski, 2011; Moore, 2015) and over their educational counterparts to generate workers (at various skill levels) to develop and manage means of production and masses of compliant workers and enthusiastic and unquestioning consumers (Bencze & Alsop, 2014; Giroux & Giroux, 2006; Hodson, 2011; Roth & Désautels, 2002; Santos, 2009).

For about the last half century, governments in several countries have included in science curricula teaching/learning goals — known as ‘STSE’ (science, technology, society, environment) education — that acknowledge that fields of science do not work in isolation but, rather, are intertwined in relationships with fields of technology/engineering and with myriad other members of societies and with living and nonliving environments (Pedretti & Nazir, 2011). Similar such ‘science-in-context’ programmes around the world include socioscientific issues (SSI) education (Zeidler, 2014) and education around socially-acute questions (SAQs) (Legarèz & Simonneaux, 2006).

Many ‘science-in-context’ educational movements like those above may encourage and enable learners to develop and engage in social actions to address controversies and/or potential harms to living and nonliving things linked to fields of science and technology. However, many of them tend to be limited to facilitating students’ logically-reasoned decision-making leading to personal positions on a range of controversies (Hodson, 2011; Levinson, 2013; Sjöström et al., 2017). Also, while such ‘science-in-context’ educational formations have existed for decades, school science systems have tended to marginalize them; focusing, instead, on teaching/learning of ‘achievements’ — such as laws, theories and inventions/innovations — of fields of science and technology, often at expense of consideration of larger social and environmental entanglements of such fields. A governing ideology seems to be that school science is mainly about what is (e.g., our current conceptions of phenomena), rather than also about what ought to be (e.g., changes in government regulations that may improve products of science and technology) (Levinson, 2018). Indeed, this
tendency appears to be intensifying. In about the last decade, possibilities for education that acknowledges sometimes problematic relationships among fields of science and technology and societies and environments and prepares students to engage in well-planned social actions to address perceived harms like those noted above appear to be under increasingly extreme threats — largely due to rapid incorporation over that period of ‘STEM’ (science, technology, engineering & mathematics) education initiatives. Although such initiatives vary considerably, it seems that they tend to focus on teaching/learning of widely-accepted laws, theories and inventions/innovations of science and technology and techniques/methods for generating and disseminating them — largely, apparently, aiming to identify and educate relatively few professionals and technical workers in STEM fields who may assist businesses to successfully compete in a ‘neo-Sputnik’ era where, for example, companies based mostly in North America compete against those in Asia and the European Union (Pierce, 2013). As reflected in plans for the latest national science curriculum in the USA, such orientations for STEM education aim to further augment hierarchical societal systems:

The primary driver of the future economy and concomitant creation of jobs will be innovation, largely derived from advances in science and engineering. . . . 4 percent of the nation’s workforce is composed of scientists and engineers; this group disproportionately creates jobs for the other 96 percent (NRC, 2011, p. 2).

At the same time, it is apparent that many STEM education initiatives — while claiming inclusivity (e.g., more females and people of different ethnicities in STEM fields) and connectedness (e.g., among the four disciplines) — tend to exclude references to claims from fields of humanities and social sciences that may allude to problematic aspects of STEM fields (Hoeg & Bencze, 2017a,b; Gough, 2015; Zeidler, 2016), such as aforementioned compromises associated with business arrangements with fields of science and technology. In doing so, designers of STEM education initiatives tend to present reductionist conceptions of the four fields, focusing mainly on techniques and their widely-accepted products, in a process that Callon (1991) referred to as punctualization; that is, making a complex system appear much simpler than it likely is in reality. Missing elements in such reductive processes in STEM education tend to be those that would make the four fields seem problematic and, in turn, cast negative lights on their financial backers, thus causing disenchantment among workers and consumers (Bencze et al., 2018; Pierce, 2013).

In light of the above discussion, it seems clear that educational programmes are needed that would enlighten students about sometimes problematic relationships among fields of science and technology and powerful societal actants and, where they perceive harms, help them to develop expertise, confidence and motivation to develop and implement personal and social actions that may effectively address them.

Towards Altruistic Civic Engagement Through School Science

Since 2006, I have been working with graduate students, teachers and others to use action research to learn about educators’ efforts to encourage and enable learners to develop and implement personal and social actions that they believe may address personal, social and/or environmental harms associated with science and technology that concern them. This action research programme has been based on the ‘STEPWISE’ (Science & Technology Education Promoting Wellbeing for Individuals, Societies & Environment) schema for arranging lessons and student activities (Bencze, 2017a). Development of this schema was inspired by writing of Derek Hodson (2003, 2011), especially, about needs for promotion of civic actions through science education and was constructed to address teaching/learning goals in curricula for the province of Ontario, Canada, which prioritized achievement in three broad domains; that is, i) ‘products’ (e.g., laws, theories & innovations) of science and technology; ii) skills for science inquiry and technology design and communications; and, iii) relationships among fields of science and technology and societies and environments (STSE). The original version of the framework (upper right, Figure 1) organized these domains (with STSE split into ‘education’ and ‘actions’ and skills split into ‘education’ and ‘research’) into a tetrahedron to signify that students could,
‘altruistically’ (acknowledging possibilities for personal fulfilment through acts for others), use some of their literacy in the four peripheral domains to try to improve — through “STSE Actions” — wellbeing of (other) individuals, societies and/or environments (‘WISE’). This goal is meant to contrast sharply with perspectives and practices that perceive science education as a ‘selection and training camp’ for few potential knowledge producers (e.g., scientists & engineers) who may, as suggested above, help govern jobs (and, likely, habits of personal consumption, etc.) of most citizens in a world prioritizing individual competitiveness and consumerism (Bencze, 2001; Giroux & Giroux, 2006).

In our initial efforts to encourage science educators to base lessons and student activities on the tetrahedral version of STEPWISE (upper right, Figure 1), it readily became apparent that teachers found the schema quite impractical — in that, for example, it implies that teachers must engage learners in all five domains simultaneously. Consequently, I developed a more sequential schema — the latest version of which is shown at the bottom of Figure 1 — that teachers found more useful. This schema suggests that teachers provide students with ‘apprenticeship’ lessons and student activities that may eventually enable and motivate them to self-direct research-informed and negotiated action projects (“Students’ Self-led RiNA Projects”) to address harms in STSE relationships. Depending on various factors, such as students’ ages, abilities and stages of learning, ‘apprenticeships’ may consist of one or more 3-phase constructivism-informed cycles; that is:

1. **Students Reflect:** The teacher often provides students with ‘stimuli’ (e.g., commodities, like cell phones, generated with help from science and technology) that may encourage students to ‘express’ (e.g., via discussions, drawings, models) their pre-instructional attitudes, skills and knowledge (‘ASK’), etc. regarding STSE relationships (including actions people might take to address harms in them);
2. **Teacher Teaches:** The teacher *directly teaches* difficult-to-discover important ASK (e.g., about roles of transnational corporations) in STSE relationships and examples of RiNA projects conducted by others to address harms in them. Such ASK may be difficult to discover because, for example, of some students’ limited cultural and social capital and because of manipulation of information of relevant publicly-available information (e.g., via the Internet). Shortly after being taught important ASK, students are then asked to evaluate and deepen their understanding of them through some application activities, such as answering questions regarding documentaries of RiNA projects to address STSE issues;

3. **Students Practise:** To deepen and more personalize students’ expertise, confidence and motivation for them, the teacher encourages students to develop and implement small-scale RiNA projects to address harms in STSE relationships identified by students. Projects are mostly student-led, but the teacher may assist some students, in different ways, depending on students’ needs and requests.

Our research over about a decade with science educators in formal primary, secondary and tertiary (teacher education) education contexts and in after-school clubs indicate that the schema at the bottom of Figure 1 has helped many students to develop significant expertise, confidence and motivation for self-directing (mostly) varied and personally-meaningful RiNA projects — several examples of which can be found in Benece and Alsop (2014) and Benece (2017a) and in two special issues of the open-source, non-refereed, journal, JASTE, at: goo.gl/N00b3s; and, bit.ly/2JGIg7f.

Although there appears to be much to celebrate about successes of the STEPWISE pedagogical schema (lower section, Figure 1) for encouraging and enabling learners to develop and implement RiNA projects to address harms of their concern in STSE relationships, it also seems clear that such approaches are generally not well-supported and, indeed, occur in relatively rare contexts. It was apparent, for instance, from our 3-year study of facilitated action research about one teacher’s efforts to promote self-led RiNA projects that ‘successes’ in that regard benefitted from relatively rare existence of a supportive dispositif, including alignment, in that case, among such entities as: official curriculum goals, school administrative and collegial supports, teacher beliefs in possible adverse influences of powerful people and groups on science and engineering (and related entities), sufficient material resources (Benece & Krstovic, 2017). In this light, those wanting to promote more critical analyses of STSE relationships and civic actions to address related harms, educators, administrators, teachers, and many others need to engage in *multiple* actions to help form a dispositif that may challenge pro-capitalist dispositifs and work towards increased social justice and environmental wellbeing.

**Developing and Mobilizing ‘WISE’ Commodities**

In the more than dozen years of working with the STEPWISE framework (lower half, Figure 1) in action research modes (Noffke & Somekh, 2009) with teachers of science (mainly), most of them have tended to encourage — or, been able to encourage — students to engage in *educational* forms of action to address harms (or controversies) that students perceive in STSE relationships. A good example of such an action was the educational video (goo.gl/jeAihg) that a tenth-grade student produced as a result of her research (and previous education, experiences, etc.) into the nature of cosmetics (especially ‘foundation’ make-up). That student’s RiNA project — and others like it — can be understood with reference to the schematic in Figure 2. Adapted from a similar schema published by Roth (2001) to depict reciprocal relationships between phenomena of the ‘World’ and representations (‘Signs’) of them that he suggested were involved in such translations that are common to ‘science’ (i.e., World ➔ Sign) and ‘technology’ (Sign ➔ World), this version of the schema can represent STEM fields (with engineering in the same direction as technology and with mathematics involved in both directions) and it can represent RiNA projects — with ‘research’ comparable to ‘science’ and ‘actions’ comparable to ‘technology’/‘engineering,’ and with negotiations throughout. Regarding the example provided
in Figure 2, the student had conducted secondary research (mostly via the Internet) to learn more about cosmetics and, then, a short survey (primary research) to learn more about peers’ uses, knowledge and understanding of cosmetics and, then, used available knowledge, skills and attitudes to develop the educational video — which, at the time of writing here, has been viewed over 700 times. A key feature of her work appeared to relate to the students’ ‘narrowing’ of ideological gaps between representations of cosmetics, which tend to be relatively punctualized and de-problematized, as she provided much more contextual (de-punctualized) and problematizing information to her viewers than often is the case with companies (Baudrillard, 1998; Usher, 2010). (While ideological gaps between World and Sign involve intentionality, ontological (composition of entities) and epistemological (characteristics of procedures) gaps are less so.)

With educational actions, such as the video discussed above, translations from Sign $\rightarrow$ World are only partial or speculative; that is, they may be recommendations for a different World (e.g., less cosmetic use), but they may or may not be realized — largely depending on ideological positions of those engaged (e.g., consumers) in the translations. Students (and others) may, however, choose to make more complete translations from Sign $\rightarrow$ World. This was, indeed, our aim in an action research project we called, WISE TechDesign — in which we worked to encourage and enable secondary school students to develop technology/engineering designs, as actions, that not only performed a desired function but, also, tried to maximize wellbeing of individuals, societies and environments (WISE) (Bencze & Krstovic, 2017). Focusing on engineering/technology design may be a prudent tack, given apparent hegemonic influences of STEM education initiatives. In terms of actor-network ontological conceptions (Latour, 2005), such a tack may help insert an alternative actant into an existing network and — through processes of translation (reciprocal movement of ‘inscriptions’ [e.g., conceptions of thought & action (Latour & Woolgar, 1986)] among actants — mobilize conceptions (e.g., critiques of STSE relationships and rectifying social actions) throughout the network. Promotion of engineering/technology design appears to be a prominent feature of many STEM education initiatives, often stated in terms of needs to create innovative products and services that may solve various social and environmental problems. Pleasant and Olson (2018), for instance, suggest that STEM educators “... engage learners in building a wind or water turbine connected to a generator to light a bulb. An associated driving question or driving problem might be: How can I illuminate a light bulb using water or wind power?” (p. 46). Although there have, clearly, been numerous engineering designs that have helped many

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**Figure 2: RiNA Projects Schematic.**
people — such as with hip replacement surgery (Weinstein, 2007) — and have addressed many environmental problems (e.g., to clean up oil spills [Fingas, 2015]), there also are critiques suggesting that many such ‘techno-fixes’ (Huesemann & Huesemann, 2011) too narrowly address problems — often less focused on social, political, economic and other contextual factors that may adversely affect engineering designs and uses. In his analyses of genetically-modified (GM) salmon, for instance, Pierce (2013) suggested that engineered fish can be seen, on their own, as large, plentiful and readily-available food sources to solve world hunger. Like a Trojan horse (Beneze & Carter, 2015), however, positive symbolic (semiotic) messages inherent to the salmon — such as its suggestions of bountiful nourishment and easy-availability — can distract customers from noticing possibly-problematic actants, such as government regulation policies (FDA) that funnel wealth towards companies and increased disease in GM and wild salmon from sea lice that tend to grow in seaside pens. A similar sort of masquerade appears to apply to uses of micro-balls (tiny balls of plastic mixed into numerous hygiene and beauty products) — which many activists want banned (see: goo.gl/vm8trG). In terms of actor-network theory, such subterfuge can work because entities are punctualized (Callon, 1991); that is, made to appear as single (or, at least, highly reduced) entities/actants rather than as part of larger, much more complex — and possibly-problematic — networks.

For the WISE TechDesign project, students were told they could design (as Signs) inventions (phenomena/technologies that did not exist) or innovations (modifications of existing technologies) that they intended to exist in the World — such as a cosmetic that they believe is ‘better’ than those currently available. Of course, students’ definitions of ‘better’ for whatever technology they would design would vary — depending at least on their knowledge (e.g., of cosmetics) and on ideological positions that may influence gaps between their knowledge (Signs) and inventions/innovations (World) they produce (Figure 2). This, in turn, raises crucial questions about the extent to which teachers provide students with resources — or guide them — as they design their products. On the one hand, there has been a long tradition of engaging students in inquiry-based learning (IBL) — a practice that, apparently, continues with many recent STEM education initiatives (Duschl & Bybee, 2014). Although IBL practices vary in the extent of teacher guidance, many appear to be structured to assume students will learn important ‘products’ (e.g., laws, theories & inventions/innovations) of science and technology through different kinds of investigations — some empirically-based, while others involve accessing information in public sources. Schwartz, Lederman and Crawford (2004), for instance, who have written much about IBL, suggest it 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). Such ‘guided discovery’ can be problematic, from several perspectives (Beneze & Alsop, 2009). Firstly, for example, because of limitations of intelligence, experience, cultural membership, etc., students may not ‘discover’ intended attitudes, skills and knowledge (ASK) through their observations/readings (Hodson, 1986). Thus, IBL activities can be discriminatory — reproducing existing (systems of) stratification. Secondly, in light of private sector actions to alter information available to the general public through, for example, paying ‘reputable’ scientists to conduct investigations leading to publications or to simply affix their names to company-produced publications that cast commercial products like cigarettes, pesticides, pharmaceuticals, etc. in good light (or discredit opposite claims) (Oreskes & Conway, 2010), students’ inquiries may be biased in favour of powerful actants in societies.

Given limitations like those above on many students’ abilities to gain access to valid and important ASK through their inquiries, we recommend that teachers use direct instructional methods (Teacher Teaches, Figure 1) to help ensure all students have access to them. The student who produced the video in Figure 2 was taught, for instance, about some main principles of actor-network theory, how to develop actor-network maps, dispositifs and about the Trojan horse concept often is used in consumerism (refer above). To supplement instruction about this latter concept, the teacher also engaged students in discussions about consumerism after they had viewed The Story of Stuff video (storyofstuff.org/movies/story-of-stuff). Once students have ASK like...
this, which represent kinds of Signs in the schema in Figure 2, they can then educate people using such attitudes, skills and knowledge. As well, as noted above, they can develop inventions and/or innovations that draw from such ASK. Indeed, after being taught about ANT, dispositifs and semiotics of consumerism, along with some general ideas about the nature of technology design, students in a tenth-grade class in Ontario were able to develop inventions/innovations (mostly the latter) that not only functioned but considered wellbeing of related individuals, societies and/or environments. For example, after analyses of a common cologne marketed to males, students developed an alternative cologne that they felt was more socially-just and ecologically sound — as perhaps indicated by their comments about the cologne:

The cologne itself is made from primarily pure and natural ingredients these include: Bergamot essential oil, cedar wood essential oil, lemon, cinnamon sticks, green tea leaves, and absolute vodka. Many of our ingredients, if not grown in Canada do not contain harsh chemicals so the people working in other countries to harvest cinnamon for example, would not be exposed to dangerous fumes. … [T]he production process of cork is less harmful to the environment then making a glass or plastic lid, the cork is stripped off the trunk of the tree every 9 or 10 years, this does not kill the tree. … Our product would appear more attractive to a consumer because they are able to read and identify all seven ingredients and maybe even have majority of them in their household. … A particularly salient feature of all student groups’ networks appeared to be awareness that many commodities were produced by poor people working under inadequate labour conditions in far-away places: [I]f you have a product and you are producing it in a Third World country, where you are not giving people the proper amount of pay and they are living in a low [‘destitute’] place, then that society is not doing well – and that is partly due to your product … [and] … [W]e strongly believe in fair wages, unlike other manufacturing plants around the world, and will only employ legal and adult workers. … What makes our product more attractive to a consumer than the original antiperspirants is that it hides nothing behind closed doors. … [I]t is a ‘what you see is what you get’ type of product … (Bencze & Krstovic, 2017, p. 211).

Going Up Against The Borg™

The STEPWISE pedagogical framework (lower half, Figure 1) appears to have helped many students to develop creative and relatively-influential research-informed and negotiated action (RiNA) projects — like those highlighted above — to address harms students perceive in relationships among fields of science and technology and societies and environments (STSE). Having said that, a recent case of teachers’ promotion of student-led RiNA projects suggests continuing — or, perhaps, increasing — opposition to aspects of such projects. In working with a teacher (‘Dylan’) who has been highly committed to ideals of the STEPWISE programme, including student expression of pre-instructional ideas, teacher’s teaching of de-punctualized and problematizing conceptions of STSE relationships, student-led research and socio-political actions to address harms perceived by students in STSE relationships, it became apparent that there are barriers to achievement of such goals by such committed teachers (Bencze et al., 2019). Like other teachers we have recently studied in the same school district, ‘Dylan’ used the RiNA project as a form of inquiry-based learning (IBL). As illustrated by the schema in Figure 3, students are assigned a RiNA project that would start with them choosing an STSE issue as a basis for research, negotiation and actions to address their selected issue. This approach contrasts with the pedagogical approach illustrated in the bottom of Figure 1, in which students are first engaged in ‘apprenticeship’ activities prior to being asked to self-direct RiNA projects. As well, the apprenticeship in Figure 1 places the Teacher Teacher components of the apprenticeship prior to any RiNA project work, either as part of the apprenticeship (which may involve some teacher support) or as student-led RiNA projects. In Dylan’s approach, the aspects — such as “ANT, dispositifs & World ↔ Sign relationships” — of the Teacher Teaches component were inserted at strategic points as students proceeded through their RiNA projects.
The approach in Figure 3 seems to represent a compromise to the approach recommended in Figure 1. As argued elsewhere (Bencze & Alsop, 2009) and above, as a mechanism for powerful people and groups that have — like The Borg™ — ensnared most entities worldwide in support of capitalist ends, IBL approaches can contribute to social stratification and general disempowerment (in many ways). On the one hand, the approach used by ‘Dylan’ may, for instance, give students an unrealistically positive conception of progress of science and technology — in that the teacher regularly intervened (Teacher Teaches) during students’ research, negotiations and actions and, therefore, could have made RiNA projects seem easier than they are in more independent contexts. Making science and technology processes to appear to inevitably lead to useful conceptions and products and services can be cast positive lights on capitalists, which largely influence fields of science and technology (and many other entities). On the other hand, given that — as he said, and was supported by teachers and school principals — perhaps he had little choice but to incorporate RiNA projects as forms of IBL because there were numerous expectations that IBL was a priority practice for education in their school district. Although adhering to this mandate, however, Dylan had managed to tailor his use of IBL in ways that students were not so disadvantaged by lack of access to difficult-to-discover (either via primary or secondary research) attitudes, skills and knowledge because of his strategic teaching of them throughout their projects. Most students in his class of tenth-grade science developed innovations — such as 3D-printed athletic shoes, a candle recycling device and a biodegradable potato chip bag — that had considerable
functionality; and, as well, had designs intended to increase social justice and environmental wellbeing (e.g., using locally-sourced and biodegradable materials), making considerable reference to sets of cooperating actants (e.g., involving companies, workers, transportation systems, etc.) (Bencze et al., accepted).

Summary and Ways Forward

Encouraging and enabling young people, via facilitated action research, to critically evaluate relationships among fields of science and technology and other members of societies and environments — often involving adverse influences of powerful socio-economic actors — and to develop research-informed and negotiated actions to try to rectify harms they perceive in such relationships has, largely, been an uphill battle. Although we have reported numerous successes in this regard over the dozen or so years in which STEPWISE schema have been used as frameworks for promoting such critical and action-oriented civic engagement, implementation of such practices has been largely restricted to relatively-rare contexts in which supportive collections of living, nonliving and symbolic actants (dispositifs) exist. Moreover, as reported here, it seems that even teachers committed to promotion of critical and action-oriented science and technology education must compromise some of their ideals — such as by promoting such education, albeit in perhaps helpful ways, in the context of possibly-problematic inquiry-based learning activities. In a related finding, students in a science class were able to use the dispositif concept to design and develop innovations that not only functioned but also aimed to increase social justice and environment wellbeing. But, at the same time, it was apparent — as concluded by much earlier research — students were much less able to use the dispositif concept to mobilize their ecojust innovations; that is, to engage a network of cooperating living, nonliving and symbolic actants — such as advertisements, politicians, company executives, factory workers, etc. — to form a dispositif supporting global social justice and ecological wellbeing (Bencze et al., accepted).

As argued above, limitations we have seen in promoting STEPWISE-informed perspectives and practices may be explained, at least in part, due to overwhelming influences of pro-capitalist individuals (e.g., financiers) and groups (e.g., banks, corporations, think tanks, transnational trade organizations, universities, governments, etc.) on fields of science and technology, their educational counterparts and most other entities around the globe. Going up against this Borg™-like collective seems daunting. It seems that individuals in local contexts can make some gains, but may — ultimately — be severely frustrated. Although there are, likely, various approaches enabling some successes in challenging global power structures, Evans (2012) has suggested that mobilization may be possible if ecojustice (and, perhaps, ecosocialist [Löwy, 2015]) actors systematically work to rally many and diverse living, non-living and symbolic (semiotic) actants in ways that an ecojust dispositif emerges/develops. Indeed, a small-scale version of such a counter-hegemonic dispositif seemed to emerge in the case of citizens’ efforts to eliminate (what they determined to be) toxic dust (containing many heavy metals, such as lead and cobalt) dispersal from the local port onto their neighbourhood (Bencze & Pouliot, 2017). Although the local ‘development’ dispositif (which appears to promote growth of port activities, regardless of possible environmental hazards) seemed quite powerful, reductions in dust dispersal in this context offers some hope for those wanting a more ecojust world.

In eyes of activists, individuals/groups promoting economic growth with less than desirable attention to wellbeing of many individuals, societies and/or environments, may be considered oppressors (Freire, 1970). Educating students about potentially problematic power relations involving fields of science and technology may, therefore, represent a kind of conscientization — a critical consciousness about a social milieu (Freire, 1970). At the same time, educators in democracies may not want to be guilty of oppression, in the sense of providing students with mis-translations of ‘real-world’ phenomena like those highlighted here — presenting pro-capitalist individuals/groups in an unrealistically bad light. It seems that no educator can avoid ontological gaps and, likely, ideological gaps (see Figure 2). Accordingly, as Freire (1970) recommended, to be free of
potential oppressors (including teachers), learners need to be given full control over ‘praxis’; that is, critical, reflective, practice. Levinson (2010) echoes this call in his discussion of possible citizenship roles in the context of socioscientific issues education. This recommendation is, actually, built into the STEPWISE framework — when students are encouraged to engage in student-directed and open-ended (when conclusions are not predetermined; but, rather, determined by learners in the context of experiences and their existing theory, etc.) RiNA projects (see Figures 1 & 2). Indeed, there appears to be evidence to suggest that students may become relatively free of teacher influence in their RiNA projects, after having been provided with nurturing pedagogical lessons and activities beforehand (Bencze, 2017b; Bencze & Alsop, 2014).

References


Oxfam (2017). Reward work, no wealth: To end the inequality crisis, we must build an economy for ordinary working people, not the rich and powerful. Oxford, UK: Oxfam International.


