Controversial issues in science: Exploring the power dynamics of applying critical pedagogies in secondary schools

Temas controvertidos en la ciencia: Explorando las dinámicas de poder en la aplicación de pedagogías críticas en educación secundaria

Nelly Alfandari[1]*, Dimitris Tsoubaris[2]**

Abstract: This article reflects on the implementation of critical pedagogies in a secondary school science classroom in England, in a project titled: "controversial topics in science". It explores the transformative potential as well as the challenges of implementing critical pedagogies in the neoliberal secondary school. The project critically engages with dominant science education and proposes a situated and emancipatory approach to teaching science. Drawing on Theatre of the Oppressed as methodology, the research explores changes in the power dynamics amongst participants, their relationship with learning and the institution. This article suggests that this work is part of a paradigm shift towards critical pedagogies and, as such, provides an insight to the potential of expanding relevant approaches throughout the science curriculum beyond the classroom.

Keywords: Critical pedagogies, critical science education, secondary school, power dynamics, Theatre of the Oppressed

Resumen: Este artículo reflexiona sobre la implementación de pedagogías críticas en un aula de ciencias de la secundaria en Inglaterra, en un proyecto titulado: "temas controvertidos en la ciencia". Explora el potencial transformador, así como los retos de la aplicación de las mismas en un sistema educativo de talante cada vez más neoliberal. El proyecto se compromete críticamente con la educación científica dominante y propone un enfoque situado y emancipador de la enseñanza de las ciencias. Utilizando el Teatro del Oprimido como metodología, la investigación explora los cambios en las dinámicas de poder entre los y las participantes, su relación con el aprendizaje y la institución. Los resultados del análisis sugieren que aplicar pedagogías críticas en las escuelas puede contribuir a un cambio de paradigma en educación secundaria.

Palabras clave: Pedagogías críticas, educación científica crítica, educación secundaria pública, dinámicas de poder, Teatro del Oprimido

Introduction

The neoliberal education system measures a good education by high test scores as well as by the conduct and attitude of those who attend it, students and staff alike. This presents a performative

[1] *N Alfandari (German, first author, doctoral candidate in education/ secondary teacher, London South Bank University, email: alfandan@lsbu.ac.uk, Orcid: https://orcid.org/0000-0003-0174-9841)
[2] **D Tsoubaris (Greek, second author, PhD candidate in Science and Sustainability education, National and Kapodistrian University of Athens, email: dtsoubaris@ecd.uoa.gr, Orcid: https://orcid.org/0000-0002-2513-940X)

focus on results as well as behaviour, opposed to content or processes of learning and teaching[3]. Within neoliberalism, 'performativity' is a category or way which measures and rates how a person comports themselves within their associated role and productivity. As Ball suggests: "Performativity is a technology that relates effort, values, purposes and self-understanding directly to measures and comparisons of output"[4]. Within schools, this leads to a culture of micromanagement of classroom processes, geared towards performative outputs in line with the institutional discourse, often oriented towards corporate values[5].

In contrast, critical pedagogies see "the program content of education" as "the organized, systematized, and developed 're-presentation' to individuals of the things about which they want to know more"[6]. Such an approach engages with the students' realities and is led by their process of exploring power structures and institutional processes. Transferred to a critical engagement with science education, this approach implies that learners acknowledge the different ways in which scientific and technological change affects societies and environments, as well as the fact that it is inextricably linked to power relationships. Furthermore, it supports them to develop their own views and value systems about science and technology and to prepare for and take meaningful actions[7]. In contrast, science education marked by neoliberalism, teaches detached, unquestionable pieces of information, which students compete to reproduce in a repetitive manner, complying with an idealised approach of the products and processes of science[8]. As such critical science education challenges the role of science and how knowledge is produced within it and has the potential to transform students' relationship to it.

This research is coming out of an informal partnership between a researcher exploring critical pedagogies as inclusive education practises in the context of soaring exclusion rates in education, and a science teacher, implementing a critical science project in his lessons in secondary schools. Coming from different backgrounds, the science teacher from critical science education, the researcher from teaching in alternative exclusion units and working with Theatre of the Oppressed, both agreed on the potential of working with critical pedagogies in the secondary school classroom. Their partnership came out of the Radical Education Forum[9], a network of educators, self-educating on and organising through critical and popular pedagogies within, against and beyond the neoliberal education landscape. The shared experience framed

[3] Stephen Ball, «Neoliberal education? Confronting the slouching beast», *Policy Futures in Education* 14, n. º 8 (2016): 1046–1059.
[4] Ball, «Neoliberal education? Confronting the slouching beast», 1053.
[5] Stephen Ball, «Show me the money! Neoliberalism at work in education», *FORUM: For Promoting 3–19 Comprehensive Education*, n.º 54 (2012): 23–28.
[6] Paulo Freire, *Pedagogy of the Oppressed*. Translated by MB Ramos. (New York: Continuum, 2007), 93.
[7] Derek Hodson, «Time for action: science education for an alternative future», *International Journal of Science Education* 25, n. º 6 (2003): 645–670.
[8] Larry Bencze, Erin Sperling and Lyn Carter, «Students' Research-Informed Socio-scientific Activism: Re/Visions for a Sustainable Future», *Research in Science Education* 42, n º1 (2012): 129–148.
[9] «Next meeting: Radical Education Forum hosted by Pupil Power» in the blog Radical Education Forum, accessed the 23rd of July, 2021, https://radicaleducationforum.tumblr.com .

their dialogic reflections throughout the research. They were interested in exploring how critical pedagogies applied within science education shift the process of knowledge production and the agency of students within it as learners as well as critical actors, and the implication this has for the subject of science within the neoliberal education system.

Throughout the critical science project, which took place in the summer term of 2018, the teacher's and researcher's different roles complemented each other. The teacher, embedded in the school community, had established a relationship of trust with the students, on the basis of which the collaboration with them was built. Yet he also existed within a part of the school system the critical pedagogical framework challenged. Engaging from the position of her external role, the researcher was able to stage an intervention in the classroom, drawing on Theatre of the Oppressed[10] tools, through which students and teacher could explore their relationships to each other, to the learning and the institution[11].

This article is looking at the shifts of these relationships throughout the critical science project and explores the transformative potential of the work as a pedagogical intervention in the classroom. Specifically, it explores critical pedagogies' potentials within science education at a time where prognoses of climate change are being contested, and the development of visions towards climate justice are often driven by younger generations.

Context

Patterns of exclusions

In England, there has been a sharp increase in school exclusions over the past years, with numbers of permanent exclusions going up by almost 40% between 2012 and 2017[12]. Meanwhile, policy discourse has been data driven, setting clear markers towards student attainment via: "a standardisation of knowledge… and audit", making "the continuous production of data available for scrutiny"[13]. According to government figures, a high percentage of those students excluded are from low-income families, marginalised communities and/or with 'special educational needs'[14]. This shows that students from marginalised communities are more

[10] Augusto Boal, *Theatre of the* Oppressed, 15. ª ed. (New York: Theatre Communications, 1985).
[11] Nelly Alfandari, «Changing the Terms of Engagement-Reflecting on the Use of Image Theatre in Research with Secondary School Students», en *Educational Research:(Re) Connecting Communities. Proceedings of ECER 2020,* ed. por Judit Onsès-Segarra and Fernando Hernández-Hernández, NW 29, Research on Arts Education, (Barcelona: University of Barcelona - Dipòsit Digital, 2021).
[12] DfE «Permanent and fixed-period exclusions in England: 2018 to 2019», in the official UK government website, accessed the 23rd of July, 2021, https://www.gov.uk/government/statistics/permanent-and-fixed-period-exclusions-in-england-2018-to-2019 .
[13] Pat Thomson, Christine Hall, Ken Jones, «Maggie's day: a small-scale analysis of English education policy», *Journal of Education Policy* 25, n. º 5 (2010): 644.
[14] DfE «Permanent and fixed-period exclusions in England: 2018 to 2019», in the official UK government website, 95.

likely to be excluded from mainstream education. According to Youdell[15] "the identity of the excluded group is fundamental to their exclusion", which "suggests that these are social processes"**.** Yet, neoliberal education policies, such as the 2016 *UK White Paper*, praise the importance of character traits such as "knowing... how to bounce back if faced with failure"[16], assigning the blame for failure on the students' individual behaviours and capabilities to be part of the school and learning culture. One of the main reasons for school exclusions is "persistent disruptive behaviour"[17]. This suggests that students from marginalised backgrounds and/or who are diverse learners are disengaged in lessons or show nonconforming behaviour. There are various reasons for this disengagement which reach beyond the classroom, as well as beyond the school. Yet, as also explored by the Timpson Review[18], an independent review for the Department of Education, the English education system is progressively failing and marginalising a specific part of its student population.

In recent years, initially as part of the global Black Lives Matter movement in 2020, as well as engaging with the spiralling precarisation due to the Covid19 pandemic, various groups have formed in the UK to campaign against school exclusion with a strong anti-racist stance (e.g., *No more Exclusions*, *Coalition of Anti-racist Educators (CARE)* or the *Black Educators Alliance (BEA)*, etc.). At the same time climate justice movements such as Fridays for Future or Extinction Rebellion gained support and momentum amongst young people, and climate strikes were especially popular amongst school students. In response, in the autumn 2020 the conservative government released a policy guideline, which amongst others prohibits the teaching of material critical to capitalism and engaging with or "promoting divisive or victim narratives"[19], implicitly targeting anti-racism groups as well as climate justice organisations.

Dominant Science Education

The neoliberal policies explored above affect Science Education (SE) directly, which is the main reason that SE has become detached from social worlds and communities and the socioecological issues of our time[20]. For the purpose of this article, we name this type of mainstream school science as dominant SE.

The problematic state of dominant SE has been an issue of debate for many years. As early as the 1990s, many notable SE scholars such as Glen Aikenhead, William Cobern, Victoria

[15] Deborah Youdell, *Impossible bodies, impossible selves: Exclusions and student subjectivities*. Vol. 3, (Luxemburg: Springer Science & Business Media, 2016), 13.
[16] DfE, «Educational excellence everywhere» 2016, in the official UK government website, accessed the 23rd of July, 2021, https://www.gov.uk/government/publications/educational-excellence-everywhere, p.94.
[17] DfE, «Permanent and fixed-period exclusions in England: 2018 to 2019», table 4.
[18] Berni Graham, Clarissa White, Amy Edwards, Sylvia Potter, and Cathy Street, *School exclusion: a literature review on the continued disproportionate exclusion of certain children* (England: Department for Education, 2019).
[19] DfE, «Plan your relationships, sex and health curriculum» 2020, in the official UK government website, accessed the 23rd of July, 2021, https://www.gov.uk/guidance/plan-your-relationships-sex-and-health-curriculum.
[20] Alonso Yanez, Kurt Thumlert, Suzanne de Castell, Jennifer Jenson, «Pathways to sustainable futures: A "production pedagogy" model for STEM education», *Futures,* n. º 108 (2019): 27–36.

Costa and Derek Hodson have criticised relevant policies and practises for functioning in a context that privileges Western, middle-class viewpoints while simultaneously undermining alternative worldviews[21].

A main feature of dominant SE is that it presents science as linked to absolute truths, without being influenced by power relations and privileges. Evidence to suggest this is that mainstream SE textbooks avoid making references to how problematic relationships between corporations and scientific research institutions lead to the manipulation of science[22]. Examples of such relations can be drawn from the numerous instances of how companies have paid scientists to undermine scientific conclusions which discredit certain technological products, for instance relating to the petroleum, tobacco and nuclear energy industry[23]. Similarly, school science often omits making references to the way that gender, race and class privileges promote inequalities within the field of professional science. An example of this is the downplay of Rosalind Franklin's contribution in the discovery of DNA[24], also reflected in science textbooks.

Another characteristic of SE in neoliberalism is that SE learning is limited to the acquisition of decontextualized technical skills and fragmented scientific knowledge[25]. This process evolves in tandem with the effort of major educational institutions to glorify fields of science and technology, in order to attract students to STEM (science, technology, engineering and mathematics) careers[26]. Such careers involve a specific technical focus and lack a more holistic scientific approach. An example of a way STEM careers are promoted in school systems is a set of posters[27] created by the Royal Society of Chemistry (RSC).

By adopting the motto "Not all chemists wear white collars", RSC advertises careers of technical specialisation (e.g., a car engineer). Rather than engaging with complexities of life, this is offering a simplified version of science. This projection contradicts the standard of a scientist as an intellectual with critical disciplinary knowledge as it assumes that the students it is trying to attract are not capable of thinking critically.

Finally, from a pupil's perspective, school science often feels like an ongoing individualised assessment and evaluation. Success depends on the learners' abilities to absorb large amounts of rapidly delivered and decontextualized laws and theories. These are often

---

[21] Erminia Pedretti, Joanne Nazir, «Currents in STSE education: Mapping a complex field, 40 years on», *Science Education* 95, n.º 4 (2011): 614.
[22] Bencze, Sperling and Carter, «Students' Research-Informed Socio-scientific Activism: Re/Visions for a Sustainable Future», 129–148.
[23] Naomi Oreskes, Eric Conway*, Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming* (US: Bloomsbury Press, 2010).
[24] Monique Frize, Peter R. D. Frize, Nadine Faulkner, *The bold and the brave: A history of women in science and engineering* (Canada: University of Ottawa Press, 2009).
[25] Yanez, Thumlert, de Castell and Jenson, «Pathways to sustainable futures: A "production pedagogy" model for STEM education», 27–36.
[26] Bencze, Sperling and Carter, «Students' Research-Informed Socio-scientific Activism: Re/Visions for a Sustainable Future», 129–148.
[27] «Not all chemists wear white coats», in the official website of the Royal Society of Chemistry, accessed on the 23rd of July, 2021, https://edu.rsc.org/download?ac=14544.

rapidly transmitted to them through positivist and authoritarian pedagogical approaches that make use of cookbook laboratory exercises always leading to predetermined conclusions[28]. The above explored mentality can be described as a consumerist ethic[29], as pupils compete to gain personal access to the best products of SE, such as courses and qualifications, in order to compete in the frame of the STEM division of labour.

Critical Science Education (CSE)

In this context, the application of critical pedagogies[30] has become a confrontational act. Revisiting it in 2016, Giroux[31] sees it as a tool to confront "a pedagogy of repression that attempts to camouflage the role that education plays in distorting history, silencing the voices of marginalised groups, and undercutting the relationship between learning and social change". He describes critical pedagogy as a powerful tool countering social injustices perpetuated by a traditional, hegemonic education system.

Freire's *Pedagogy of the Oppressed* originates from within its *specific* socio-political-historical context, and its theoretical frame based on oppressor and oppressed sees power as binary and structural[32]. Whilst we consider the power dynamics within the contemporary English inner-city classroom as more fluid, Freire's key elements of learning as a tool for change, are pertinent in the context of schooling described above. This article reflects on its application specifically in science lessons in a context of a growing climate justice awareness amongst young people. It is engaging with a wider response of a significant proportion of science educators and researchers[33] [34] [35] who have been calling for a politicised, issue-based SE. For the purpose of this paper, we will refer to this form of SE as Critical Science Education (CSE).

CSE is the educational paradigm that derives from the application of critical pedagogy[36] engaging with the preconceptions and questions that students bring to science classrooms[37]. In many ways, it has been influenced by and evolved together with feminist pedagogies as well as

[28] Randy Bell, "Perusing Pandora's Box: Exploring The What, When, And How Of Nature Of Science Instruction", Flick B and Lederman G (eds.), *Scientific Inquiry and Nature of Science*. Science & Technology Education Library, vol 25. Springer, Dordrecht 2006, 427-446.
[29] Bencze, Sperling and Carter, «Students' Research-Informed Socio-scientific Activism: Re/Visions for a Sustainable Future», 129–148.
[30] Freire, *Pedagogy of the Oppressed.*
[31] Henry Giroux, «Beyond pedagogies of repression», *Monthly Review* 67 n. º 10 (2016): 57-71, 57-58.
[32] Ibid.
[33] Ralph Levinson, «Science education and democratic participation: An uneasy congruence? », *Studies in Science Education* 46, n.º 1 (2010): 69–119.
[34] Clayton Pierce, *Education in the Age of Biocapitalism* (US: Palgrave Macmillan, 2013).
[35] Bruno Latour, *Reassembling the social: An introduction to Actor-Network-Theory* (UK: Oxford University Press, 2007).
[36] Ibid.
[37] Andrew Gilbert, *Courageous pedagogy: Enacting critical science education* (US: Information Age Publishing Inc, 2013).

multicultural and urban education[38]. The aim of CSE is to help students develop consciousness to undertake scientific investigation that will empower them in their everyday life.

CSE also comes together with similar approaches, such as Socio-scientific Issues (SSIs) and the pedagogy of Science-Technology-Society (STS) education. The movement of SSIs is based on the internationally recognised idea of teaching SE through controversial topics[39]. Its foundation is the aim of developing reasoning skills that will enable the learner to analyse everyday life issues by taking into account their social and scientific components[40]. Examples of SSIs are global warming, air pollution, etc.

The pedagogy of STS is based on the analysis of products of science and technology that influence our lives and wellbeing. Examples of such products are genetically modified rice, mobile phones, or nuclear weapons. STS covers a wide range of pedagogical currents, which have been described by Pedretti & Nazir[41].The pedagogical outline of this research project was in line with what the authors call the *Socio-Ecojustice current:* Relevant classroom activities are designed to appeal to students' sense of justice, motivate them to critically think about such products and take action to change the existing situation[42].

Ecology of the school

The challenges teachers face when attempting to apply a CSE based approach in class are very well documented[43]. Perhaps the most important factor that has been identified to constrain CSE applications in science classrooms is the exam preparation culture, which values knowledge consumption, rather than knowledge production[44]. Furthermore, the research of Hoeg et al[45] underlines the role of standardised curriculum, lack of time and resources and the focus on teaching content knowledge. Concerning the latter, Bencze & Carter[46] note that even when teachers are given a viable alternative, many prefer to continue teaching predetermined science knowledge and theory, so as to address pressures to teach to the exam content.

On the other hand, there are numerous factors that constitute a supportive school environment for CSE practises, such as relationships of trust between members of staff and the

[38] Edna Tan, Angela Calabrese, Maura Varley Gutierrez, Erin Turner, *Empowering science and mathematics education in urban schools*, (Chicago: The University of Chicago Press, 2012).
[39] Dana L. Zeidler, Bryan H. Nichols, «Socioscientific issues: Theory and practice», *Journal of Elementary Science Education 21*, n.º 2 (2009): 49–58.
[40] Patrick Ashby, Felicia M. Mensah, «Critical Chemistry Education in a Private, Suburban High School», *Research in Science Education* 50, n.º 1 (2020): 303–332.
[41] Pedretti and Nazir, «Currents in STSE education: Mapping a complex field, 40 years on», 614.
[42] Ibid, 617.
[43] Ibid, 602.
[44] Landon Beyer, Michael Apple, *The Curriculum: Problems, politics, and possibilities* (New York: State University of New York Press, 1988)
[45] Darren Hoeg, Nathalie Lemelin, Larry Bencze, «Sociopolitical development of private school children mobilising for disadvantaged others», *Cultural Studies of Science Education* 10, n.º 4 (2015): 1155–1174.
[46] Larry Bencze, Lyn Carter, «Globalizing students acting for the common good», *Journal of Research in Science Teaching* 48, n.º 6 (2011): 648–669.

senior leadership team (SLT). Milestone Academy[47], where this research took place, is a new school with a relatively small number of staff members and a good level of communication with SLT. Also, the school had just launched a teacher-based action research program, which gave staff the opportunity to experiment on alternative teaching approaches. Arguably, the above conditions would be of little value without teachers being resilient enough, despite the pressures they experience in neoliberal school systems, in order to develop necessary skills, such as time management and active learning approaches.

Finally, it should be mentioned that teachers' personal and political principles, such as the adherence to social justice and environmental sustainability is also linked to the potential of creating spaces for CSE in classrooms[48].

The research project

This article explores the implementation of CSE as an end of year project with a year 9 class at Milestone Academy. The school is a comprehensive secondary inner-city school, with a high percentage of students with "English as an Additional Language" (55% to 60%) and a considerable percentage of free school meals eligibility (20%). The project took place at the end of the school year with a year 9 (age 13–14) mixed-ability group consisting of 24 students from a diversity of ethnic backgrounds and origins. The students had been working on the first year of their GCSE science course, which is the main SE curriculum in the UK. The project lasted for ten teaching periods.

The researcher was present throughout the project and participated as a support to the teacher. At the end of the project, she facilitated a creative workshop with the students and their teacher to reflect on the project, drawing on elements of the participatory theatre method Theatre of the Oppressed[49], which is based on critical pedagogies. The following sections will first give an overview of the research workshop and methodology, the Theatre of the Oppressed, then introduce the methodology worked with in the critical science project, and outline how this was applied in the science classroom at Milestone Academy.

Methodology: Research as a rehearsal for change

The aim of the research was to explore the critical pedagogies implemented throughout the critical science project and critical pedagogies' abilities to create more inclusive spaces for learning in the context of the soaring exclusion rates outlined above. Wanting to create a shared space for reflection with all participants, the researcher decided to draw on creative methodologies. The creative methodologies offered "alternative ground rules for

[47] In order to maintain anonymity, all names used in this article are pseudonyms
[48] Hoeg, Lemelin and Bencze, «Sociopolitical development of private school children mobilising for disadvantaged others», 1169.
[49] Boal, *Theatre of the Oppressed.*

communication"[50], by introducing creative exchanges through embodied expressions. As most participants were not experienced in theatre-based expression, this offered the opportunity for a shift in established participation habits. Participants who were most expressive in the theatre workshops, generally differed from those who came forward in interviews, as such the method supported a diversifying of voices[51]. After the critical science project, the researcher facilitated a participatory theatre workshop in order to reflect with the class and the teacher on the pedagogical process they had experienced. She worked with elements of the Theatre of the Oppressed, interested in reflecting on power dynamics within the classroom, and students' sense of agency and belonging. These workshops took place in addition to participant observations and were complemented by participatory mapping exercises and interviews with participants.

The Theatre of the Oppressed[52] offers a participatory methodology based on the principles of critical pedagogies supporting groups in exploring and reflecting on their experiences and engaging with power dynamics around and amongst them, within the creative space of the theatre. The aesthetic space shaped through theatre allows for actions which otherwise might not be possible. Gallagher explains "the drama space puts you in a different relationship both to one another as people and to the ideas that you're investigating and communicating"[53]. In this sense, participants were able to explore and express power dynamics between them, whilst actively engaging with them.

The researcher facilitated a series of image theatre exercises as research intervention with the intention to engage with these very power-dynamics and offering a space for reflection which includes the possibility to step out of these dynamics. Image theatre is one of the key methods within the Theatre of the Oppressed, in which participants critically explore their experiences through collectively created body images to "creatively, nonverbally, and dialogically express and develop their perceptions of their world, power structures, and oppressions"[54].

Gallagher[55] argues that working through the arts allows "openings for shifts in power and the reframing of the terms of engagement". Image theatre does that by working with physical expressions of embodied knowledge[56]. This enables a different engagement in the dialogue for

[50] Elizabeth Ellsworth, «Why doesn't this feel empowering? Working through the repressive myths of critical pedagogy», *Harvard Educational Review 59, n. º 3* (1989): 317.
[51] bell hooks, *Teaching to transgress. Education as a freedom of practice* (New York: NY Routledge, 1994).
[52] Ibid.
[53] Pat Thomson, Julian Sefton-Green, «A conversation with Kathleen Gallagher», in: *Researching Creative Learning* (London: Routledge, 2010), 76.
[54] Larry M. Bogad, «ACTIVISM Tactical carnival: social movements, demonstrations, and dialogical performance», en *A Boal companion: Dialogues on Theatre and Cultural Politics*, ed. J. Cohen Cruz and M. Schutzman (London and New York: Routledge, 2006), 49.
[55] Kathleen Gallagher, «The art of methodology: A collaborative science», in: *The methodological dilemma* (London: Routledge, 2008), 69.
[56] hooks, *Teaching to transgress. Education as a freedom of practice.*

(research) participants, as they are able to explore different roles through the theatre, where different rules apply[57].

Drawing on image theatre, the research was exploring the established power dynamics and associated roles within a classroom, of the "good" and the "bad" student, the "clever" or the "low ability" student, or the "cool" or the "outsider", etc.[58], and how and if they shifted throughout the critical science project. It further aimed to look at how these roles shaped the impressions participants had of themselves in the context of the everyday classroom, and as such could impact on how different students experience the learning process and affect the knowledge production and sharing in a classroom.

Seeing power as dispersed and shifting rather than fixed, the research framework was extending the binary model proposed by critical pedagogies of *oppressor* and *oppressed*[59], considering the complexity of power dynamics associated with these different roles and identities and their acquisition.

In order to explore these entangled power dynamics, the research was drawing on a critical spatial lens, "to make sense of the ways that school spaces and subjects are constituted"[60]. The aesthetic space of the theatre is produced within the realm of imagination[61], which allows for new imaginaries to develop, confronting the power dynamics at play in the everyday.

The workshop served as a final evaluation within the critical science project process. Whilst throughout the project, power dynamics in the classroom shifted, the workshop allowed for these shifts to be engaged with and explored further.

Controversial Issues in Science – Project outline and method

The structure of STEPWISE[62]

The main aim of STEPWISE is to promote research-informed socio-political actions that address Socio-Scientific issues (SSIs). It consists of three phases, which can be seen in Figure 1. During phase 1, students reflect on what they know about a product of science and technology (e.g. mobile phones). This can be done by using different resources as stimuli, such as a controversial statement, a photograph, an advertisement or a video. The objective at this stage is for students to express their own perspectives, for example by discussing what they like or

[57] Geraldine Pratt, Caleb Johnston, «Turning theatre into law, and other spaces of politics», *Cultural Geographies* 14, n. º 1 (2007): 92–113.
[58] Pat Thomson, «Working the in/visible geographies of school exclusion», in: *Spatial theories of education*, (London: Routledge, 2007), 121–140.
[59] Ibid.
[60] Deborah Youdell, Felicity Armstrong, «A politics beyond subjects: The affective choreographies and smooth spaces of schooling», *Emotion, Space and Society* 4, n.º 3 (2011):144.
[61] Augusto Boal *Rainbow of desire* (London: Routledge, 1995).
[62] "STEPWISE" is an acronym for Science & Technology Education Promoting Wellbeing for Individuals, Societies & Environments. For more information see www.stepwiser.ca.

dislike about their chosen topic, who might benefit from it and/or who might be harmed, a positive and a negative experience or thought that relates to it.

During phase 2, the teacher introduces relevant issues through a socio-scientific and environmental lens. This can be done by using strategies such as short presentations followed by Socratic discussions, for example by describing "how earth metals are vital for manufacturing mobile phones" and "how problems of mining relevant ores is linked to poor working conditions and local environmental degradation". The objective at this stage is for students to develop research skills, such as analysing information from articles and creating surveys to collect data from peers. Also, they become able to identify and describe power relationships, power alliances and privileges, which relate to their chosen SSIs.

During phase 3, students practise by designing and conducting their own research-informed action. A research-informed action consists of two parts: research and an action plan. Students begin by carrying out secondary research, e.g., using articles and the internet to learn about the life cycle of a mobile phone. This is followed by a primary research on a research question they generate, e.g., using correlational studies to learn about their peers' awareness of the issue of child labor in mining rare metals. Finally, they use their findings to develop an action plan to change the present situation in ways that they see fit, for example by making a video to disseminate using social media about the responsibilities of mobile phone companies in promoting social injustices. The framework advises that teachers scaffold as much as needed one or more cycles of lessons and activities as illustrated in Figure 1, until students are ready to carry out a student-led research-informed action project independently[63].

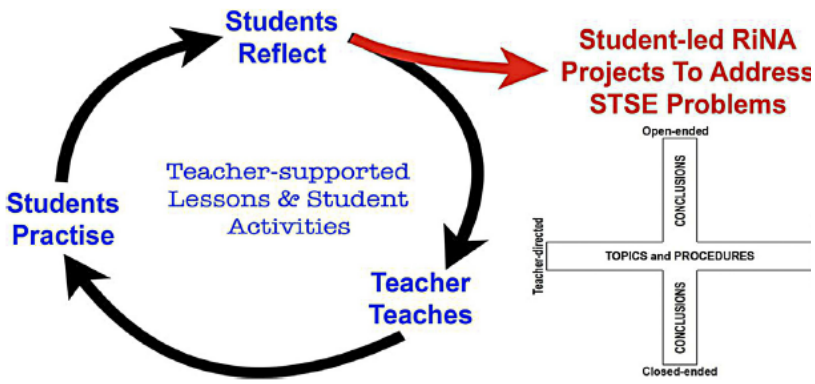

Figure 1 Diagram showing the structure of the STEPWISE pedagogical schema[64]

Project outline

[63] Bencze and Krstovic, «Science Students' Ethical Technology Designs as Solutions to Socio-scientific Problems», 201-226.

[64] «STEPWISE Pedagogical Schema for Enabling Student-led RiNA Projects» in the official website of John Lawrence Bencze, accessed on the 23rd of July, 2021, https://wordpress.oise.utoronto.ca/jlbencze/stepwise/.

During phase 1, students brainstormed scientific issues that they were interested in and explained their choices. Then, they worked in groups and prioritised a set of cards illustrating SSIs relating to the science curricula. They were provided with blank cards, on which they could include other topics of their choice. The written outcome of the group discussions that followed were mind maps which connected information about the SSIs, showing relationships between different stakeholders[65].

During phase 2, all students were shown a video that presents the social and environmental implications of the mining of rare metals in the Democratic Republic of Congo and its link to the industry of mobile phones[66], as an example of controversial issues in science. The class discussion that followed stimulated the students' thinking and shed light on how the life cycle of a product might harm or benefit social groups and the environment. They were given teacher input with examples of what students can do to change the social reality around them, such as a *YouTube* video (made by a student) that criticises a cosmetic product[67]. Finally, students brainstormed ideas of potential actions they could undertake and prioritised them to say which ones they thought would be most efficient and why.

During phase 3, students were provided with sample articles as well as access to the internet with the task of reading and analysing relevant information. A variety of resources were provided to help them scaffold their research[68]. Each group presented its findings to the class and students peer-assessed their work. This was followed by primary research which took the form of correlational studies.

Correlational studies refers to a scientific research method which monitors and compares changes in possible causes and results. It involves observations on how the variables relate to one another and analyses them utilising statistical analysis. For example, scientists could compare incidence of AIDS symptoms with natural levels of HIV virus. Unlike practising scientists, school science pupils rarely conduct correlational studies[69].

In order to introduce correlational studies, first, a class discussion took place about how this method can be suitable for researching controversial SSIs. For example, for scientists researching the negative consequences of smoking on health, an experiment would be neither feasible nor ethical. Students then came up with a research question, created questionnaires and collected data within the classroom. Regarding actions, most of the groups decided to create posters, leaflets and videos in order to educate their peers. Also, they were motivated by the idea

[65] Bencze and Krstovic, «Science Students' Ethical Technology Designs as Solutions to Socio-scientific Problems», 201-226.
[66] «Blood in the Mobile by Frank Piasecki Poulsen», in the official Youtube channel of Blood in the mobile, accessed on the 23rd of July, 2021, https://www.youtube.com/watch?v=wQhlLuBwOtE.
[67] «Sample Student RiNA Project, Cosmetics Education» in the official Youtube channel of STEPWISE Science Education, accessed on the 23rd of July, 2021, https://youtu.be/Gyco4JZn5xU.
[68] Dimitris Tsoubaris, Larry Bencze, Sheila Curtis, Majd Zouda, «Practical suggestions for promoting science student actions to overcome social and environmental harms», *School Science Review* 102, n.º 379 (2020): 64–70.
[69] Larry Bencze, «Correlational studies in school science: Breaking the science–experiment–certainty connection», *School Science Review* 78, n.º 282 (1996): 95–101.

of organising a poster presentation event[70]. During the poster presentation, the students set up their stations around the classroom and presented simultaneously as guest students and teachers were circulating around the room. Students gave out their action materials and answered questions asked by the audience.

Reflections

Shifting power relationships

Despite the attempt to embed the work within the curriculum, the critical science project was scheduled as a short-term project. Its pedagogical outline challenges the exam focused culture of the neoliberal institution which does not permit more than merely symbolic actions. Yet, at Milestone Academy it opened a space for students to genuinely express themselves in relation to socio-scientific issues affecting their lives. It involved meaningful collaborative, critical reflections on burning social issues, which produced shifts in relationships between students and teachers. The critical pedagogies challenged the learning culture of the school and did not form a part of the schools' assessment and exam focus. In the following we are going to share our reflections on how the process of critical pedagogies, as well as the final theatre workshop allowed participants to explore the set power dynamics between each other, the learning and the institution, and shift them, even if only momentarily.

Learning for change

In line with the STEPWISE framework, students chose topics of their interest from the range of controversial topics proposed. Amongst others, they chose to explore energy efficiency, nuclear weapons, climate change, smartphone use and production, or vaping. Throughout the project, they engaged with secondary literature about their topics, conducted interviews and designed posters to share their research at the classroom poster conference. Students explained that it was important to them to communicate their findings around environmental topics to others. In an interview Mustafa, a student working on energy efficiency, explained his aim was: "giving people ideas about our project and what we want to do and then explaining it further, and letting them know how we're feeling for the world".

The political relevance of their projects was important to the students, as well as sharing their learning with others. Students reported they would be "looking to influence policy making" (*Energy Efficiency group*) with their projects, or research the "socio and environmental and economic consequences of regions where nuclear bombs were dropped" (*Nuclear weapons group*). Having a sense of agency within their fields was a motivation for the students' learning,

[70] Mirjan Krstovic, «Learning About Youth Engagement in Research-Informed and Negotiated Actions on Socio-scientific Issues», en *Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments*, ed. by Larry Bencze (Luxemburg: Springer International Publishing, 2017), 93–114.

being able to explain their views to others, and wanting to engage with social justice issues. For example, early on in the preparation phase, the energy efficiency group discussed climate change and "when the world will end", which Mustafa concluded by stating: "so we have to raise awareness", which fueled the groups' work throughout. At the final poster presentation, Hassan from the climate change group, reflected that if he could take the project further, he would "ask the industrialists about what they do to protect the environment, not only in the office, also at home, and the government next".

Shifts in the knowledge production

Throughout the project students self-organised in friendship groups, in which they chose to work on topics which interested them. Working therefore was organised along friendship and interest lines, instead of their usual, identified *ability lines*. This set an atmosphere of learning by being motivated by the subject and the group, instead of by passing a test or achieving a grade. The highlight throughout the process was peer to peer interviews. Being able to draw on each other's knowledges and experiences and presenting their findings back to each other activated also the quietest of students. Students as "critical co-investigators in dialogue with the teacher"[71] is key in Freire's outline of critical pedagogies. Its intention is to equalise the hierarchy between types of knowledges valued, giving students' knowledges and interests importance in lessons, and challenging the idea of an absolute knowledge to be found only in certain books. In the critical science project, this shifted the way students engaged with the books, or secondary literature. As a group they decided what they were interested in researching, and then chose their literature on the basis of their shared interests.

Shift in learner subjectivities

In their culminating poster presentations, students presented their findings as experts of their learning. The teacher reflected that he noticed a shift about halfway through the project, where students started working with material, he himself had not looked into before: "I thought something is happening now, you know, because they discovered interesting facts about what they explored, some things I didn't know and I told them, you are creating science now, and I think they felt it". This description shows how students were engaging with the learning and producing new knowledges in the classroom independently from the teacher. From the teacher's perspective, this was a shift that could be felt by the students. A shift towards feeling like a researcher creating science and producing knowledges. This implies a shift in subjectivity, which the teacher verbalised to his students. This shift in the students' subjectivation also changes the power dynamics between teacher and students, as through the students' research the teacher is put in the role of the learner, as the students' findings are new to him. Drawing on Foucault and

[71] Ibid, 62.

Rancière, developing Freire's[72] understanding of emancipation further, Biesta[73] explores: "In this way emancipation can be understood as a process of subjectification, that is, of becoming a (political) subject". By being perceived or identified not as a subject of oppression, but as an equal, students can change the terms in which they are engaging in the learning context.

At the end of the project, students explained that a next step in their research would be to learn from those who they considered relevant. In their research on the impact of vaping, a group felt moving forward it would be necessary to include local shopkeepers' opinion. A group researching the impact of smartphones wanted to interview 4–5-year-old children next, "as they really grow up with smartphones and know how to use them". This implies a shift in what knowledges are brought into the classroom, and which knowledges are valued. It expands the learning space towards the students' families and local community.

Nevertheless, the students were not able to extend their research due to lack of time. It should be noted that this type of project work was a teacher's initiative, not a part of the science department's policy. Perhaps, an attempt to fully incorporate critical science project work would most likely clash with the GCSE exam preparation culture, where students' identified valuable knowledges are not included nor valued. Hence, it would mean a complicated negotiation on an institutional level, bearing in mind also the pressure exams pose.

Valorisation

The project was not graded as it was seen outside the demands of the exam. Yet, the students produced curriculum-relevant work and engaged with texts with high complexities and applied their learning. The final poster conference acted as a form of valorisation, as it allowed the students to demonstrate their knowledges, and apply it in debates with their visitors. Unlike in an exam or graded presentation, students and staff were freely roaming the room, moving from poster to poster following their interests, and the conversations were not monitored. In this sense, the valorisation was not tracked or controlled. Yet, students reported to have felt challenged and to have enjoyed sharing their research. As a form of valorisation, such a process sits outside the exam-focused school culture. Nevertheless, the school-based assessment structure was something students aspired to, as achieving good grades represents institutional valorisation. In one instant during the poster conference, the assistant head teacher praised one of the groups' work and offered to present their research on vaping at the school's assembly, a prestigious form of valorisation within the school culture, which was visible in the students' reactions. Although critical pedagogies aim to critically engage with the institutional power structures, students also showed a desire to belong to those structures and be recognised by them.

Clashing inclusion models

[72] Ibid.

[73] Geert Biesta and Timothy Leary, "Have lifelong learning and emancipation still something to say to each other?", *Studies in the Education of Adults* 44, n.º 1 (2012): 16.

Not all students at Milestone Academy were able to participate in the poster conference. A group of students in the class labelled with a special educational need (SEN), was taken out of lessons that day by the SEN department. As it was the end of the summer term, and students with special educational needs were seen to especially struggle to concentrate, it had been arranged for them to take part in an external sport event. It was an unfortunate logistical clash yet exploring it in terms of participation brings up the different pedagogical perspectives behind the two events, and the lack of coordination between the different events. The SEN department arranging the trip decided the best way to support SEN labelled students was to take them out of lessons and have them participate in a separate sport-based outdoors event. Whilst the SEN department organised the trip with the needs of the group of students in mind, they organised it *for* and not *with*[74] them, without checking in with the students' specific needs or contexts. One of the SEN students taken out of class, prepared a video to accompany his groups' poster, finding a way to be present on the day after all. The teacher reflected that "it was a shame [SEN students being taken out of class] as it doesn't allow us to see how the set up might have helped the students take ownership over their learning". In his pedagogical approach, the students' ownership of the event was key.

Shift in science-based work

Students went beyond discussing pre-given knowledge, such as the advantages and disadvantages of solar panels, which presents a shift when compared with a mainstream lesson. They engaged in deep learning, which occurs when learners have control over decisions[75]. For example, they were able to link rare earth metals to the renewable energy and mobile phone industries and evaluate the social and environmental aspects of mining. In accordance with existing research[76], students seemed to recognise the complexity of SSIs, and examined them from multiple perspectives. This is particularly important, as their chosen SSIs are also timely sustainability issues, which require multidimensional analytical skills. Reflecting on this process, we recognize the potential of an important link between SE and Education for Citizenship[77].

Also, according to feedback given by students during the process of evaluation, they felt that they improved skills such as time management and teamwork and enjoyed collecting data and making links between ideas that emerged. Furthermore, they provided evidence of examining the nature of their thinking and possibly acting to improve their learning, i.e.,

[74] Baz Kershaw, *The politics of performance: Radical theatre as cultural intervention*, Routledge, 2002.
[75] Larry Bencze and Mirjan Krstovic, «Science Students' Ethical Technology Designs as Solutions to Socio-scientific Problems», Larry Bencze (Ed.), *Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments* (London: Springer International Publishing, 2017), 201-226.
[76] Pedretti and Nazir, «Currents in STSE education: Mapping a complex field, 40 years on», 614.
[77] Zeidler and Nichols, «Socioscientific issues: Theory and practice», 54.

metacognition[78]. For example, when asked to reflect on ways to improve their research in the future, students gave meaningful answers such as 'create a timetable for different tasks', 'clarify the research question', 'summarise information collected from the internet', 'collect more survey responses', 'elaborate on the network map'. Whilst in their evaluation, students are drawing on school specific terminology, such as "time-tabling" and "time-management", skills they are referring to are showing the autonomy they were able to gain through their work.

Finally, it should be noted that during the project, students had control in designing and undertaking their own primary research. This is a more creative process when compared to mainstream science experiments, which tend to be predetermined and uncontextualized, as discussed previously in the article. Primary research can help students relate directly to their ideas and action[79] and may develop conclusions that become part of a more holistic sociopolitical consciousness[80]. However, reflecting on the process of primary research during the project, the teacher would plan more preparation activities throughout the academic year, in order to facilitate students' work on correlational studies.

Changing terms of engagement

Throughout the process of the critical pedagogies project, power dynamics in the class started to shift. At the beginning of the project the lessons were heavily teacher-led, and the lesson structure and expected student conduct was in line with the institutional demands. Over the process of the project, the teacher would gradually move towards a more assisting or technical role, and the classroom was organised as group work, each group working autonomously. In the poster conference the furniture of the classroom was moved to create a walk-through gallery-style feel, hosted by the students. After the project, the theatre workshop served as an evaluation, a shared reflection on the learning space created throughout the project. At the same time, the workshop also served for the shifted power dynamics to be further explored and engaged with, in the safety of the playful creative space[81]. One of the theatre images the class created showed where they felt most powerful in their classroom. The image manifested some of the power shifts, and playfully allowed participants to further play with changing their terms of engagement[82].

[78] Bencze and Krstovic, « Science Students' Ethical Technology Designs as Solutions to Socio-scientific Problems», p.155.
[79] Larry Bencze and Lyn Carter, "Globalizing students acting for the common good", *Journal of Research in Science Teaching* 48, n.º 6 (2011): 648–669.
[80] Hoeg, Lemelin and Bencze, «Sociopolitical development of private school children mobilising for disadvantaged others», 1155–1174.
[81] Pratt and Johnston, «Turning theatre into law, and other spaces of politics», 92–113.
[82] Gallagher, «The art of methodology: A collaborative science», 69.

Figure 2: “Image of place you feel most powerful” Research material

Whilst the teacher positioned himself in the centre of the classroom, at the heart of the U-shaped arranged student- tables, various students occupied the teacher’s designed part of the classroom, symbolised by the board and the desk. The teacher positioned himself in the centre of the “student-circle”, within participatory theatre this is seen as an affirmation of participation in the group process[83]. He is also confronting the symbolic teacher area of the classroom, having the student-body holding his back. In the meantime, Sam, a student, climbs on the teacher’s chair, looking down at the classroom. A behaviour which in any other context would be punished, in this context is an active and creative contribution. In this constellation, the teacher and Sam meet in their gaze, confronting each other from these changed positions. Omari and Lola position themselves as presenting the learning, by the side of the board.

The changes of rules of behaviour of the critical theatre workshop, made different terms of engagement possible within the aesthetic space projected onto the classroom. Participants were able to shift their symbolic roles or identities[84], which allowed also for a shift in their teacher or student perspectives on the classroom and each other. By engaging with the spatial forms of the classroom, participants shifted pre-set power dynamics[85] and were in that way able to challenge pre-established institutional roles and boundaries. By setting up the exercise, the researcher was implicated in this shift, and by acting as the facilitator, she formed a part of the exercise.

The process of the critical pedagogies project supported the relationship between teacher and students, and, whilst largely operating within the institutional framework, it allowed for a relationship of trust to develop further, which supported the interactions of the theatre workshop. Whilst the shifts in the terms of engagement throughout the theatre workshop were temporary, they accentuated the various shifts in power dynamics throughout the critical science project, and symbolised a critique, or readiness to engage and play with institutional structures and the neoliberal culture of performativities.

[83] Chris Johnston, *House of games: Making theatre from everyday life* (London: Routledge, 1998).
[84] Thomson, «Working the in/visible geographies of school exclusion», 121–140.
[85] Youdell and Armstrong, «A politics beyond subjects: The affective choreographies and smooth spaces of schooling», 144.

Conclusion

In conclusion, exploring how critical pedagogies applied within science education shift the process of knowledge production and the agency of students within it as learners as well as critical actors, and the implication this has for the subject of science within the neoliberal education system, brought up the following reflections:

Throughout the critical science project, students were keen to learn in order to make a change in the world around them, in line with Freire's outline of critical pedagogies[86]. The learning was organised according to friendship and interest lines, which produced a change in the learning atmosphere, and challenged the hierarchy between students and teacher, as well as students and institutional culture. Students were able to identify through their group project opposed to through their abilities to achieve certain grades. Instead, students engaged with the learning as experts of their own research, which shifted their relationships with visiting peers and staff at the final poster conference, as well as with their teacher, who they were able to introduce to new ideas. The work led students to aspire towards expanding the learning space and wanting to draw on knowledges from their own communities. Nevertheless, this aspiration was not in line with the institutional exam culture. Students gained valorisation of their work through applying their learning and sharing it with others. The outline of the project meant that students were able to engage with learning from a situated positionality. This is in direct contrast to the "placeless"[87] national curriculum and its exams. Yet, the recognition by the institution was still relevant for some of the students. The project saw organising the learning space *with* students not *for* students as inclusive practice, yet, operating within set institutional structures, meant it could not control the institutional organising of students' timetables.

Overall, the implementation of critical pedagogies in the neoliberal school on the one hand was fruitful within the parameters of critical pedagogies, on the other hand, the work was framed by the neoliberal institution, which was difficult to surpass. At the same time students themselves were embedded within the taxonomy of neoliberal institutions, and partly understood their success through it. In other aspects, students engaged with the learning beyond the binary frame of *oppressor* and *oppressed* as outlined through critical pedagogies and engaged through subjectivities which troubled the fixed roles. Overall, the work enabled for certain power dynamics between staff, students, institutions as well as the learning to shift, including the very power dynamics laid out by the critical pedagogical framework itself. The theatre workshop highlighted the shift in power dynamics between teacher and students throughout the project, and it showed opportunities for further shifts in forming subjectivities beyond the institutional discourse.

---

[86] Ibid.

[87] David A. Gruenewald, «The best of both worlds: A critical pedagogy of place», *Educational Researcher 32*, n.º 4 (2003): 3–12.

At a time when the government-sponsored private sector increasingly influences the fields of science and technology, it becomes more important than ever for SE to provide young people with the opportunity to critically evaluate these fields and their relationships with societies and environments as well as encourage them to undertake actions to address possible harms[88, 89]. The experience and outcome of the project shows that one way this might be possible is by teaching a science curriculum informed by SSIs and orientated toward student-led research and action projects. Calling for the necessity of a paradigm shift in education in the context of marginalisation and exclusion of inner-city youth, late activist and philosopher Grace-Lee Boggs [90] outlines a place-based education, in which students use the time they are at school, in order to engage with important social justice issues and through their learning contribute to their change. In that way, young people become active and valorised members of their communities, opposed to being seen as trouble or troubled. The level of engagement and interest students showed in the critical science project was echoing some of these ideas. The resistance of the neoliberal institution to the projects' more structural elements like knowledge valorisation and timetabling shows its challenging of the neoliberal paradigm of education. Whilst shifts in power dynamics were momentary, they provided an experience to students and teachers to "re-imagine everything"[91].

Notes:

In order to protect participants' anonymity, all names used in this article are pseudonyms

Bibliography

Printed sources

Nelly Alfandari, «Changing the Terms of Engagement-Reflecting on the Use of Image Theatre in Research with Secondary School Students», en *Educational Research:(Re) Connecting Communities. Proceedings of ECER 2020*, edited by Judit Onsès-Segarra and Fernando Hernández-Hernández, NW 29, Research on Arts Education, Barcelona: University of Barcelona - Dipòsit Digital, 2021.

Patrick Ashby, Felicia M. Mensah, «Critical Chemistry Education in a Private, Suburban High School», *Research in Science Education* 50, n.º 1 (2020): 303–332.

Stephen Ball, «Show me the money! Neoliberalism at work in education», *FORUM: For Promoting 3–19 Comprehensive Education*, n.º 54 (2012): 23–28.

[88] Bencze and Krstovic, «Science Students' Ethical Technology Designs as Solutions to Socio-scientific Problems», 201-226.
[89] Levinson, «Science education and democratic participation: An uneasy congruence? », 69–119.
[90] Grace Lee Boggs, *The next American revolution* (California: University of California Press, 2012).
[91] Boggs, *The next American revolution.*

Stephen Ball, «Neoliberal education? Confronting the slouching beast», *Policy Futures in Education* 14, n. º 8 (2016): 1046–1059.

Randy Bell, "Perusing Pandora's Box: Exploring The What, When, And How Of Nature Of Science Instruction", Flick B and Lederman G (eds.), *Scientific Inquiry and Nature of Science*. Science & Technology Education Library, vol 25. Springer, Dordrecht 2006, 427-446.

Larry Bencze, «Correlational studies in school science: Breaking the science–experiment–certainty connection», *School Science Review* 78, n.º 282 (1996): 95–101.

Larry Bencze (Ed.), *Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments* (London: Springer International Publishing, 2017), 201-226.

Larry Bencze, Lyn Carter, «Globalizing students acting for the common good», *Journal of Research in Science Teaching* 48, n.º 6 (2011): 648–669.

Larry Bencze, Erin Sperling and Lyn Carter, «Students' Research-Informed Socio-scientific Activism: Re/Visions for a Sustainable Future», *Research in Science Education* 42, n º1 (2012): 129–148.

Larry Bencze and Mirjan Krstovic, «Science Students' Ethical Technology Designs as Solutions to Socio-scientific Problems», Larry Bencze (Ed.), *Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments.* London: Springer International Publishing, 2017. 201-226.

Landon Beyer, Michael Apple, *The Curriculum: Problems, politics, and possibilities*. New York: State University of New York Press, 1988.

Geert Biesta and Timothy Leary, "Have lifelong learning and emancipation still something to say to each other?", *Studies in the Education of Adults* 44, n.º 1 (2012): 16.

Augusto Boal, *Theatre of the* Oppressed, 15. ª ed. New York: Theatre Communications, 1985.

Augusto Boal, *Rainbow of desire*. London: Routledge, 1995.

Larry M. Bogad, «ACTIVISM Tactical carnival: social movements, demonstrations, and dialogical performance», en *A Boal companion: Dialogues on Theatre and Cultural Politics*. Editado por J. Cohen Cruz and M. Schutzman. London and New York: Routledge, 2006.

Grace Lee Boggs, *The next American revolution.* California: University of California Press, 2012.

Elizabeth Ellsworth, «Why doesn't this feel empowering? Working through the repressive myths of critical pedagogy», *Harvard Educational Review 59, n. º 3* (1989): 297–325.

Paulo Freire, *Pedagogy of the Oppressed*. Translated by MB Ramos. New York: Continuum, 2007.

Monique Frize, Peter R. D. Frize, Nadine Faulkner, *The bold and the brave: A history of women in science and engineering*. Canada: University of Ottawa Press, 2009.

Kathleen Gallagher, «The art of methodology: A collaborative science», in: *The methodological dilemma*. London: Routledge, 2008.

Andrew Gilbert, *Courageous pedagogy: Enacting critical science education*. US: Information Age Publishing Inc, 2013.

Henry Giroux, "Beyond pedagogies of repression", *Monthly Review*, 67 (10), 2016, 57-71.

Berni Graham, Clarissa White, Amy Edwards, Sylvia Potter, and Cathy Street, *School exclusion: a literature review on the continued disproportionate exclusion of certain children*. England: Department for Education, 2019.

David A. Gruenewald, «The best of both worlds: A critical pedagogy of place», *Educational Researcher 32*, n.º 4 (2003): 3–12.

Derek Hodson, «Time for action: science education for an alternative future», *International Journal of Science Education* 25, n. º 6 (2003): 645–670.

Darren Hoeg, Nathalie Lemelin, Larry Bencze, «Sociopolitical development of private school children mobilising for disadvantaged others», *Cultural Studies of Science Education* 10, n.º 4 (2015): 1155–1174.

bell hooks, *Teaching to transgress. Education as a freedom of practice*. New York: NY Routledge, 1994.

Chris Johnston, *House of games: Making theatre from everyday life.* London: Routledge, 1998.

Baz Kershaw, *The politics of performance: Radical theatre as cultural intervention*. London: Routledge, 2002.

Mirjan Krstovic, «Learning About Youth Engagement in Research-Informed and Negotiated Actions on Socio-scientific Issues», en *Science and Technology Education Promoting Wellbeing for Individuals, Societies and Environments*, ed. by Larry Bencze. Luxemburg: Springer International Publishing, 2017. 93–114.

Bruno Latour, *Reassembling the social: An introduction to Actor-Network-Theory*. UK: Oxford University Press, 2007.

Ralph Levinson, «Science education and democratic participation: An uneasy congruence? », *Studies in Science Education* 46, n.º 1 (2010): 69–119.

Naomi Oreskes, Erik Conway*, Merchants of doubt: How a handful of scientists obscured the truth on issues from tobacco smoke to global warming*. US: Bloomsbury Press, 2010.

Erminia Pedretti, Joanne Nazir, «Currents in STSE education: Mapping a complex field, 40 years on», *Science Education* 95, n.º 4 (2011).

Clayton Pierce, *Education in the Age of Biocapitalism*. Palgrave Macmillan US, 2013.

Geralidine Pratt, Caleb Johnston, «Turning theatre into law, and other spaces of politics», *Cultural Geographies* 14, n. º 1 (2007): 92–113.

Edna Tan, Angela Calabrese, Maura Varley Gutierrez, Erin Turner, *Empowering science and mathematics education in urban schools*. Chicago: The University of Chicago Press, 2012.

Pat Thomson, «Working the in/visible geographies of school exclusion», in: *Spatial theories of education*. Edited by Kalervo N. Gulson and Colin Symes. London: Routledge, 2007. 121–140.

Pat Thomson, Christine Hall, Ken Jones, «Maggie's day: a small-scale analysis of English education policy», *Journal of Education Policy* 25, n. º 5 (2010).

Pat Thomson, Julian Sefton-Green, «A conversation with Kathleen Gallagher», in: *Researching Creative Learning*. London: Routledge, 2010.

Dimitris Tsoubaris, Larry Bencze, Sheila Curtis, Majd Zouda, «Practical suggestions for promoting science student actions to overcome social and environmental harms», *School Science Review* 102, n.º 379 (2020): 64–70.

Alonso Yanez, Kurt Thumlert, Suzanne de Castell, Jennifer Jenson, «Pathways to sustainable futures: A "production pedagogy" model for STEM education», *Futures,* n. º 108 (2019): 27–36.

Deborah Youdell, *Impossible bodies, impossible selves: Exclusions and student subjectivities*. 3. ed. Luxemburg: Springer Science & Business Media, 2016.

Deborah Youdell, Felicity Armstrong, «A politics beyond subjects: The affective choreographies and smooth spaces of schooling», *Emotion, Space and Society* 4, n.º 3 (2011):144.

Dana L. Zeidler, Bryan H. Nichols, «Socioscientific issues: Theory and practice», *Journal of Elementary Science Education 21*, n.º 2 (2009): 49–58.

Figures:

Figure 2: *Image of where I feel most powerful*, Research material, Alfandari, 2021.