# “They have a lot more freedom than they know”: science education as a space for radical openness

Jill Williams
Sara Tolbert

**Abstract**
While much research has examined the impact that neoliberal reforms have had on education, very little research has examined science teachers/teaching in particular. In this article, we share findings from a longitudinal study with 9 public school science teachers in Arizona, USA. We argue that neoliberal reforms have positioned science classrooms and science teachers as high potential sites of/for resistance to neoliberalism. We identify two factors as particularly influential in shaping the way in which science teachers resist neoliberal reforms: 1) the marginalization of science within the structure of school and teacher assessments; and 2) widespread (science) teacher shortages.

Keywords neoliberalism • resistance • science education • teacher inquiry • social justice

In 2018, 75,000 Arizona teachers went on strike for 6 days in response to abysmal conditions in Arizona’s public schools. Dilapidated buildings, low pay, huge class sizes, and fiscal divestment compelled Arizona’s public K-12 educators to follow the lead of others in Kentucky, West Virginia, and Oklahoma. The teachers posed a series of demands including increasing salaries for teachers and support staff, as well as increased per pupil funding. This walkout and associated demands were in response to neoliberal state education policies that have caused serious harm to students, teachers, and community members.

Arizona is a glaring example of the effect neoliberal policies have had on public education. For the past several decades, proponents of privatization and marketization have used ‘school choice’ as a rallying call to expand the charter school system, implement open enrollment policies, and defund district schools. Nearly 16% of students enrolled in Arizona public schools in 2015-2016 attended charter schools (National Alliance for Public Charter Schools 2016). Meanwhile, since 1995, all public schools have operated under a choice-based enrollment scheme, whereby students can apply for admission to any school as long as there is available space (A.R.S. 15-816.01). As of 2019, Arizona ranks 49$^{th}$ nationally for per student expenditures and schools struggle to maintain safe facilities (Education Week, 2019). Public school teacher salaries have decreased by 10.4% since 1999, while Arizona classrooms are some of the worst ranked for overcrowding (NCES, 2017)--with many high school science classrooms in the most economically oppressed communities reporting class sizes of 40+ students (Tolbert, Gray, Rivera and Schindel,

J. Williams
Southwest Institute for Research on Women and School of Geography and Development, University of Arizona, 925 N. Tyndall, Tucson, AZ, USA 85721
Email: jillmwilliams@email.arizona.edu

S. Tolbert
Te Rāngai Ako me te Hauora College of Education, Health, & Human Development, Te Whare Wānanga o Waitaha University of Canterbury, 20 Kirkwood Ave., Ōtautahi Christchurch 8014, Aotearoa New Zealand
Email: sara.tolbert@canterbury.ac.nz

submitted). Arizona has been, in fact, "ground zero" for the dismantling of public education, fueled and financed largely by conservative lobbyists, including billions from the Koch network (Hohmann 2018).

Teacher shortages abound. In 2017-2018, well into the academic year (2017-2018), nearly 2,000 teaching vacancies remained. The State Superintendent of Public Instruction at that time implicated poor working conditions such as low pay, excessive bureaucratic measures, and restraints on teacher autonomy as key causes of these vacancies (Fischer 2017). Yet, in response, the state has tried to address the vacancies by reducing teacher qualification requirements, rather than fundamentally improve working conditions. As of spring 2017, they dismantled prior requirements for public school teaching careers including teacher education, certification, and/or experience, notwithstanding widespread evidence of the importance of quality teacher education for ensuring teachers are prepared to effectively engage students (Cochran-Smith, Feiman-Nemser, McIntyre and Demers 2008). Despite a robust body of research that shows the negative effects neoliberal policies have on students, teachers, and communities more broadly (Hursch 2007), emotional appeals to "individual choice" have proven to be consistently persuasive in shaping education policy across the state.

In this article, we share findings from a longitudinal study of how science teachers engage with social justice education in the context of stark neoliberal education reforms that have severely impacted the quality of education in schools in the state of Arizona, USA. In doing so, we aim to deepen existing understandings of resistance to neoliberal reforms, by paying particular attention to the contexts that condition teacher resistances in their varied forms. Our initial findings suggest that neoliberal reforms have ironically positioned science classrooms and science teachers as high potential sites of/for resistance. We conclude by calling for more research on the specific ways in which science teachers in particular emerge as situated actors resisting neoliberal reforms in education.

**Literature Review**

The dire conditions we have described in our introduction are not unique to Arizona or the United States, but rather a direct result of neoliberal reforms occurring in schools and classrooms across the globe. Neoliberal reforms in education intend to make public schools mirror free markets by increasing 'consumer choice' and promoting competition between schools and teachers. Neoliberal education reforms in practice, however, can be characterized as "including two seemingly contradictory impulses" impacting schools (Reeves 2018, p. 98): (1) expanding school choice, which increases competition between schools and exacerbates racial and socioeconomic inequality (Picower and Mayorga 2015); and (2) centralized oversight by the state, such as scripted, standardized curricula and standardized accountability measures that restrict teacher autonomy and stymie responsive pedagogies (Pease-Alvarez and Thompson 2014).

In the USA, neoliberal ideologies have led to privatizing schooling (i.e., including tax breaks, vouchers, and other incentives that move funds out of public education and into private schools and corporations); fostering competition over collaboration (via school choice initiative, charter schools, etc); deprofessionalizing teaching by reducing teacher certification requirements; and instituting high-stakes accountability measures to measure school/teacher 'performance' and structure school and teacher funding (e.g., standardized tests, uniform teacher performance evaluations) (Au 2016). While purportedly adopted to

"improve" the quality of schools and education, neoliberal reforms have exacerbated educational inequalities (Brathwait 2017) and negatively impacted teacher satisfaction and motivation (Pease-Alvarez & Thompson 2014). In general, poor schools have become poorer and rich schools have become richer (both in terms of educational outcomes and total income) (Hill and Kumar 2009). These reforms have not only exacerbated economic but also racial inequalities (Picower and Mayorga 2015). Ujju Aggarwal (2018, p. 75) explains that "neoliberal restructuring in education works (through, for example, the reinvigoration and expanded use of mechanisms such as charter schools and voucher programs) to structure the dispossession and increased segregation of low-income communities of color". For example, the introduction of quasi-markets into public education systems around the world has manifested such that white middle to upper class parents are able to mobilize 'school choice' in ways that are unavailable to low-income communities of color, thereby (re)producing inequities rather than reducing them (Whitty, Power and Halpin 1998).

In addition to exacerbating inequities, teachers report decreased autonomy and a 'culture of fear' in situations where neoliberal reforms have been adopted (e.g., Carpenter, Weber and Schugurensky 2012). Crocco and Costingan (2007) discuss how neoliberal policies that use rigid measures to assess educational outcomes, result in a "narrowing of curriculum" (Jerald 2006) that limits teacher autonomy and undermines their ability to forge meaningful relationships with students, while also contributing to high rates of teacher attrition. In the UK context, Ball and Olmedo (2013) report that teachers in neoliberalized contexts repeatedly report demoralisation, depression, frustration, and stress. As they write, "neoliberalism is experienced and perceived in the classroom and in the soul" (p. 90).

Teachers are directly involved in the enactment of educational policies and, therefore, can have a significant amount of control over the degree to which policies are put into practice and the form they take (Pease-Alvarez and Thompson 2014). In turn, alongside research that has examined the impact neoliberal reforms have had on teachers, schools, and students, researchers have also examined the ways in which teachers respond to and resist neoliberal educational reforms. For example, Wayne Au (2016) recounted how teachers at Garfield High School in Seattle, Washington, with the support of students and parents, launched a successful campaign to opt out of the required state standardized test, resulting in the test being made optional the following year. Au described this as a "watershed moment for the national movement against high-stakes standardized testing" (p. 318). In other contexts, researchers have examined teacher resignations as an act of resistance in response to neoliberal reforms (Dunn 2018). In her analysis of public resignation letters published by teachers in the US, Dunn (2018, p. 3) shows how the public displaying of letters served as a way for teachers to exercise "their personal and professional agency in the form of resistance to dominant narratives about what public education is and should be and what current neoliberal reforms are doing to teachers and students". Within this context, teachers enacted agency by both quitting their jobs, but also by making public the reasons why they were resigning so as to spark conversation and compel educational reforms.

While educational systems overall have been impacted by neoliberal reforms, science education in particular has been both valorized and marginalized via the adoption of neoliberal reforms and the discourses that drive them. Quality science education (or

science, technology, engineering, and math, i.e., STEM, more broadly) is consistently framed as crucial to ensuring economic competitiveness. For example, in the United States, national science standards (i.e., the Next Generation Science Standards (NGSS)), are specifically designed to "provide a globally competitive STEM education for US students" due to the key role STEM plays at ensuring economic development and competitiveness (Hoeg and Bencze 2017). Within this framework, science education is important not for the role it plays in producing environmentally or socially just and healthy societies, but because of the economic value it holds. This tendency is not unique to one national context, but reverberates throughout the world and via institutionalized efforts to assess and evaluate science learning globally. Global neoliberalism has been entrenched in science education, argues Lyn Carter (2015, p. 844), as "competition is engendered through the ever-proliferating standards that facilitate the high-stakes testing regimes" that are used to evaluate the performance of students in over 55 countries against each other. These tests serve as the basis for countries throughout the world to frame science education as a 'national problem' that requires addressing in order to ensure global economic competitiveness and national security (Carter 2015).

Paradoxically, in the United States the standardized testing policies and practices resulting from neoliberal education reforms have systematically devalued science education by using English language arts (ELA) and mathematics focused tests as the measures by which students, schools, and teachers are evaluated (Crocco and Costigan 2007). This marginalization of science takes place at many different scales and has resulted in the defunding of science classrooms and reductions in instructional time in science. While much research in education has examined the ways in which teachers resist neoliberal reforms from the banal to the dramatic, very little is known about science teachers in particular and the ways in which they experience and resist the neoliberalization of education (Carter 2014). In this study, we examined how science teachers negotiated their marginality within the neoliberal education system to challenge it in both big and small ways. The findings of this study indicate that neoliberal reforms have, in many ways, constituted science classrooms as unique contexts for resistance. In this paper, we share the surprising ways in which science teachers found agency in their marginalization.

**Methods**

It is in the context of defunding and marketization that we began a collaborative research project with public school science teachers in early 2018. Drawing on research and theorizing that shows that any authentic equity-oriented approach to science education must engage sociopolitical issues, e.g., power, environmental justice, inequality, etc. (Tolbert and Bazzul 2017), this project aimed to better understand (and mitigate) the challenges public school teachers face as they work to teach against the grain in science.

Our overarching conceptual and methodological framework is grounded in inquiry as stance, practitioner research, (Cochran-Smith and Lytle 2009) and feminist/critical pedagogy (Darder 2011). We met monthly over the course of two academic years to share resources for teaching politicized science education, e.g., for doing community engaged/activist/science projects (Tolbert, Snook, Knox and Udoinwang 2016) and for resisting opp(reg)ressive school and/or state policies (Rodriguez 2010). We sent out invitations to local district schools, science department heads, and teachers and

administrators we knew. Interested participants were invited to apply to be a part of the action research study. As part of their application, they were asked to describe why they were interested in social justice and science education. We subsequently invited all who applied, which were 9 participants, to join our group. They included 3 upper elementary teachers, 4 middle school teachers, and 2 high school teachers. Two are men and seven are women. Eight are White and one is Mexican American. All worked in the same large public school district except for three (two middle school teachers and one elementary school teachers), who worked in a public charter school within the geographical boundaries of the district (see Table 1).

Table 1. Participants

| Pseudonym | Gender/Ethnicity | Level | Subject(s) |
|---|---|---|---|
| Amy | Female, White | 7th/8th | Science |
| Andrea | Female, White | 6th-8th | Science and urban gardening |
| Charlotte | Female, White | 9th | Environmental Science |
| Claire | Female, White | 4th/5th | All |
| Edward | Male, White | 8th | All |
| Elliot | Male, White | 10th-12th | Geology/Chemistry /Sustainability |
| Kaye | Female, White | 5th | All |
| Simon | Male, White | 6th/7th | Science and math |
| Susanna | Female, Mexican American | 4th/5th | English Language Development, Science |

At group meetings teachers shared their experiences and knowledge related to inequity and science education. We worked collectively to determine possibilities for action. These meetings consisted of discussions regarding their varied motivations for wanting to teach science in a sociopolitical way, experiences enacting this approach, how aspects of their social and political identities intersected with this work, the challenges they faced, and how they negotiated or might negotiate these challenges. We also invited guest speakers and facilitators periodically, such as scientists, activists, and educational researchers whose work could be used to inform sociopolitical-oriented lesson development. In late summer 2018, the teachers self-identified working groups based on the grade-level they were teaching and their topical interests in order to work together to develop lessons to implement during the 2018-19 academic year. They identified lesson topics not normally included in canonical science education (see Buxton 2006), but rather those that were relevant to the students and communities in which they were teaching. These topics included food access and nutrition, the spatiality of the urban heat island effect as it relates to socioeconomic status, and water harvesting for community needs. Through this process, teachers collectively generated perspectives, including "interpretive frameworks and theories of practice" useful in their own problem-posing contexts but that can be applied to other local contexts as well (Cochran Smith and Lytle 2009, p. 188).

This methodological approach makes explicit and centers the very ways in which university researchers and teacher-researchers work collectively to understand the world and produce knowledge. Drawing on the theoretical insights of feminist scholars, we see personal experience and collaborative reflection as legitimate forms of evidence—not simply opinions or anecdotes—that inform what we know about the world. In addition to the analysis that took place within group meetings and discussions, meeting transcripts were analyzed using an inductive approach in which we identified emergent themes; periodic anonymous surveys and individual follow-up interviews were also conducted to gain additional insight on themes and trends. For this particular article, we focus on a central theme that emerged from this work: *How have neoliberal policies been enacted in a way that paradoxically constitutes science classrooms and teachers as particularly vibrant sites for resistance? What is unique about the way in which science (as an institutionalized subject) and science teachers (as particularly situated socio-political subjects) negotiate the larger context of the neoliberalization of education that opens up space for individual and collective action?*

## Results and Discussion

As mentioned previously, we did not set out to focus on teacher resistance to neoliberal reforms or involvement in collective action for education reform. Rather, what we intended to explore was how teachers can be supported to develop and implement sociopolitical pedagogy in science education. Our project, however, coincided with the emergence of large-scale collective organizing in the state, providing an opportunity to collectively reflect on educational policies, their negative effects, and resistances to them. In this section, we begin by discussing two contextual factors that were key to enabling the teachers we worked with to feel empowered to resist neoliberal reforms—the marginalization of science as a discipline and teacher shortages, with science teachers being in particularly high demand. We then discuss the relationship between everyday forms of resistance enacted by our research participants and the larger scale efforts to effect change in education policy that happened in the state in 2018.

### The Margin as a Space of Resistance

The widespread adoption of neoliberal policies in state school systems across the United States is tied to the adoption of a series of federal education policies beginning in the early 2000s. In 2002, the No Child Left Behind Act (NCLB) was passed, and put in place a nationwide system for holding schools 'accountable' for student learning and achievement. Within NCLB, standardized tests became a central mechanism to assess student learning and evaluate school/teacher performance. This testing framework was imposed upon school districts by tying participation in standardized tests to schools' ability to obtain federal education funding.

The testing framework of NCLB placed particular emphasis on English language arts (ELA) and mathematics over other subjects. Very soon after the adoption of NCLB, researchers and scholars of education warned of the implications this would likely have on "non-tested" subjects, such as science. As Marx and Harris (2005, p. 469) wrote: "The pressure of NCLB accountability…has led principals and teachers to direct time and resources toward language arts and mathematics, and, due to limited hours in the school

year, to diminish time [and resources] for science". These warnings have since become a stark reality for US public schools. In the 2018 National Survey of Science and Mathematics Education (NSSME), primary school teachers reported teaching science between 17 to 23 minutes a day compared with 85 to 89 minutes per day for language arts and 55 to 63 minutes a day for mathematics (Plumley 2019). Middle school science teachers report using outdated curriculum materials (the majority using materials published before 2009, requiring teachers to go through textbooks and manually update outdated information) and having limited access to resources for teaching science, such as updated investigative and laboratory equipment (Havecost 2019). While the shifts in resource allocations (namely support staff, equipment, textbooks, supplies) have been experienced across grade levels, middle and high schools have been able to maintain instructional time for science due to graduation requirements (most states require between two to four years of science coursework) (Macdonald, Zinth and Pompelia 2019), as well as the way in which the school day is structured in public middle and high schools in the United States (i.e., separated into distinct periods focused on a particular subject area). Furthermore, secondary science teachers overall report having a greater degree of curricular and pedagogical autonomy in science than do primary school teachers (Banilower et al. 2018). Science remains marginalized, however, within the overarching structure of accountability and teacher evaluation in most US schools.

In 2015, the Every Child Succeeds Act (ECSA) was passed and replaced NCLB. The law leaves intact standardized testing requirements, but shifts accountability from the federal government to the states, giving states significantly more control over determining the standards to which students are held. As part of this shift, each state was required to submit a plan for how the state would assess learning and work towards improving educational outcomes. Standardized test scores in ELA and mathematics remain central measures by which educational outcomes and school performance is measured in Arizona. For example, states are required to lay out "The long-term goals for improved academic achievement, as measured by proficiency on ***the annual statewide reading/language arts and mathematics assessments***" (Consolidated State Plan, pg. 10, emphasis added). In Arizona, the frameworks adopted to guide school evaluations only include performance on ELA, mathematics, and Arizona English Language Learning Assessment (AZELLA) standardized tests to evaluate school performance.

While state statutes mandate that students in the state are tested in three subject areas—English language arts, mathematics, and science—in practice, it is only the results of ELA and mathematics tests that meaningfully influence teacher and school funding (Arizona State Board of Education). Furthermore, while students are expected to take the state standardized test in science in high school, there is no minimum passing score required for graduation. The content is predominantly biology and nature of science, since the test is usually administered in their second year of high school, when most students are taking or have taken biology (10$^{th}$ grade, in the U.S. context). Moreover, in the 86 page long consolidated state plan for Arizona, science is only mentioned in the sections on 21$^{st}$ Century Community learning Centers—programs that utilize federal and state funds to implement supplemental programming (usually after school) in schools that serve at least 40% low income students. This is a further illustration of the way in which science is seen as 'supplemental' to the educational system, rather than a central component. ELA and math testing, on the other hand, is embedded across multiple scales of evaluation in a way

that both privileges these educational domains, while also placing them (and the teachers who oversee them) under greater surveillance and regulation.

The marginalization of science is further reflected in the teacher evaluation framework used at the district level. These evaluation frameworks are significant not only because they are used to evaluate teacher performance overall, but also because they are used to determine fiscal incentives (i.e., teacher bonuses) that supplement the low annual wages allocated to teachers in the state. The framework used to evaluate teachers in one of the largest districts in the state, where our study takes place, is made up of four components: Danielson Framework for classroom observations (56%), academic growth (33%), student survey (10%), and teacher reflection (1%). The academic growth category is "determined by calculating the growth of state standardized scores in ELA and Math" ([District] Teacher Eval Model, Pg. 1). Since this growth model does not include science/science teachers, science teachers are assigned growth points based on "the school or district average [in ELA and math]" (Interview, 11 November 2019). On one hand this results in science teachers feeling like the work they do with their students is not adequately evaluated. On the other hand, it also results in many science teachers feeling less pressure to "teach to the test" and, therefore, enables a certain degree of pedagogical autonomy not found in other disciplines (Interview, 11 November 2019). As one teacher, Amy, described,

> When I was going to become a teacher, I was talking to my friends who were teachers and I was initially going to go into social studies because I love political science and civics. And I have a friend who was a science teacher and that was his main argument [the lack of impactful standardized testing] for like, 'look, not only do you get to do all this fun stuff all the time and you love science, but testing is not a thing. You get to do whatever you want.' And that was a big selling point for me, to not feel that pressure, even before I got into teaching.

The science teachers we worked with consistently commented feeling a degree of freedom to 'do what they want' in their classrooms due to lower levels of oversight for science teachers; marginalization created a certain degree of freedom and possibility. As one of the teachers we worked with commented, "There is a lot less scrutiny and 'digging into the data' for science teachers because we're not a tested standard….The [ELA and math] teachers I know have talked about the pressure they feel to keep scores improving year after year and frustration when the scores don't reflect their actual work" (Amy, Personal communication, 6 November 2019).

While proponents of neoliberal education reforms might argue that this freedom would lead to a lack of accountability and, in turn, a lack of educational rigor and quality, we saw that the freedom teachers had to be creative in their educational praxis was central to sustaining their motivation to remain in the field and to engage in meaningful and impactful educational practices despite overarching state attempts to limit teacher autonomy. In particular, teachers felt freedom to experiment with new educational approaches—such as integrating discussions of identity, equity, and social justice into their science lessons—*because* of their disciplinary marginality within the overarching assessment structure imposed at the state, district, and school level. This allowed teachers to center the needs and perspectives of their students as the driving force shaping lesson

plan development, rather than externally imposed state standards. As one teacher commented on the process and challenges of developing socially engaged science lessons: "We want to be really intentional about making the unit relevant and meaningful to students' lives, which is why we took a step back and started the brainstorming process again" (anonymous survey, November 2018).

As bell hooks writes of the radical possibility of the margin:

> [The margin] is also the site of radical possibility, a space of resistance….As such I was not speak of a marginality one wishes to lose—to give up or surrender as part of moving into the centre—but rather as a site one stays in, clings to even because it nourishes one's capacity to resist. It offers to one the possibility of radical perspective from which to see and create, to imagine alternatives, new worlds (hooks 1989, pg. 20).

Within the context of public education in Arizona, neoliberal educational policies work to depersonalize education through the imposition of standards and norms imposed from above. However, for the science teachers we worked with, marginalization provided a space of opportunity to resist this depersonalization and center student perspectives and interests. It is precisely the marginalization of science education and science teachers within the overarching structures of accountability and evaluation that creates the space for them to resist harmful reforms and enact innovative educational approaches that are in the best interest of students.

Teacher Shortages as a Catalyst for Resistance and Collective Action

Through our engagement with teachers, we also found that teacher shortages in general and science teacher shortages in particular ironically contribute to a context in which teachers feel agency to transgress neoliberal policies as they engage with their students and in their classrooms. Discussions of teacher shortages are commonplace in the state of Arizona. According to the Arizona School Personnel Administrators Association (2017), in the 2016-17 academic year, there were 8,190 teacher openings at the beginning of the academic year. By four weeks into the school year, 2,041 positions still remained vacant. Shortages are particularly acute for math and science teachers. The US Department of Education reported numerous statewide teacher shortages in the state in key STEM subjects from the elementary through high school levels, and 30% of administrators report having the most difficulty filling science teacher positions. In 2016-17, statewide teacher shortages existed in middle school science and high school biology, chemistry, earth science, general science, physical science, and physics (Arizona Science Center, 2019). As a result, positions are frequently filled by individuals lacking science specific training; 64% of eighth grade science teachers in the state do not hold a science degree (Arizona Science Center 2019). At the same time, Arizona has the highest teacher turnover rate in the country with nearly 25% of teachers in the state leaving their schools annually—this is nearly twice the national median (Arizona Science Center 2019).

As discussions in our inquiry group shifted in spring 2018 to explore the emerging Red for Ed movement for state level educational reform and increased funding, we were

interested to hear the teachers reflect upon the ways in which teacher shortages were an enabling condition for resistance. As one upper elementary teacher commented:

> I think I've just gotten to this point where there's such a need for education reform especially in our state and we're somewhat at the advantage that there is a teacher shortage so it's kind of like, are you really going to fire me because I have Spanish books [in my classroom]? Kind of giving them like a big middle finger, like do it! Come I, oh I don't have my objectives posted?....I just have gotten to this point where it's like there's such a lack of so many things [due to the defunding of schools]....It's almost like advantageous that we are in Arizona as teachers right now because [even though there is a lot of pressure put on us by districts and at the school-level] I still kind of feel like well, I'm going to do what I think is best for kids and if you don't think that and you have a really big problem with it then we can talk. But no one's every come and talked to me. (Focus Group, Feb. 28, 2018, Claire)

A middle school teacher further discussed the space available for everyday forms of resistance that emerged within a context of job security born by teacher shortages:

> I've kind of pushed back on a lot of things and it's funny is that the moment you push back you realize you can. Umm, you know, like the [posting] objectives thing. I remember sitting in a meeting with the vice principal and I was just like well, "I don't believe that [posting the objectives is] actually beneficial, so I don't do it and I'm not going to do it..."And they go, "ok, well I might have to adjust your observation", and I'm like there's only one point [on the teacher evaluation] in [each] of these things...so go ahead and take a little point off. I'm still going to get, you know, a good rating...But actually just through that conversation they were like "we agree to disagree" and then it was a non-issue (Focus group, Feb 28, 2018, Edward)

As these quotations illustrate, teachers have exploited teacher shortages as opportunities to act boldly and resist oppressive policies. What is often (rightly) seen as a crisis of our educational system is reframed as an opportunity for action:

> I have a mantra from one of my mentors…[she says], 'when there's a line of people outside the door that are waiting to take your job, then worry about that. But until then, do what you think is best for your classroom and your students.'….It's very empowering when you realize that. (Focus Group, Feb. 28, 2018, Amy)

> Maybe [the science teacher shortage] is the reason science teaching is the perfect place for it [resistance] to happen because there's no line of [science] teachers. (Focus Group, Feb. 28, 2018, Edward)

This reality makes science teachers—especially those with years of experience and subject-specific credentials—particularly valuable and, in turn, particularly capable of

pushing back against neoliberal reforms that they deem counterproductive, harmful, or exploitative. As one of our participants commented:

> [A] huge part of my teacher identity now is that I don't feel like I have to follow the rules because there is literally no one who wants my job. No one. Not a line not even a wink of a semi qualified candidate. If I left, what? I mean maybe they'd get someone great. I mean we've talked about that, like me making space for an educator of color or another woman with a science background. Who am I to take up that classroom position? But who wants it? So I think about that a lot. And that's given me a lot of freedom to say no to things, as far as taking on extra duty or extra work. To say no to whatever new bullshit is coming out from the GATE department or the language acquisition department. That I can just say, 'no thank you. I have no desire to be a part of that.' (Interview, 11 November 2019, Amy).

In addition to enabling everyday acts of resistance, the freedom associated with job security born of teacher shortages also shaped involvement in collective action. All of the teachers in our group participated in the teacher walkouts that happened in spring 2018, except for one who was teaching at a charter school where teachers were told they would lose their jobs if they did not show up for work during the strike (and she resigned the following year). Neoliberal reforms (e.g., right-to-work laws, narrow evaluation frameworks) work to create a sense of precarity and fear among teachers and inhibit the ability to engage in labor organizing. However, the teachers we worked with illustrated that teacher shortages that have resulted from disinvestment, deprofessionalization, and marketization efforts create conditions conducive for resistence by increasing feelings of agency among teachers. As one teacher in the group commented on these feelings of agency: "[Everyone] has a reason to be afraid for their job, but the reality is *sometimes that they have a lot more freedom than they know*." This statement was made directly in response to discussions of science teacher shortages and the freedom that engenders.

Moreover, the teachers we worked with continually reflected on the way in which their feelings of empowerment and agency compounded as they engaged in acts of resistance (both small everyday resistances and participation in large scale state-wide efforts). One upper elementary teacher, Claire, commented on how her participation in the strike has made her even more emboldened:

> I'll tell you what, though, like I think the whole process has turned me into that teacher, right? [laughing] I may have been on that side before, but now it's kind of whatever little bit of fear…I had, of like, well I shouldn't do this, it's not there anymore. Like there is no reason to do anything other than what...I should do, Right? So I think that's been really nice because our [school] site was unified, our parents were organizing drives up [to the Capitol], they were standing out there with us every day, our district, our principal… it was 100% a unifying feeling, and it was very empowering to feel like, you know, you're not alone all the time. That's nice.

In this situation, agency and the sense of freedom necessary for it to be acted upon, snowballed as participation in public resistance created a sense of collective resistance and

further disrupted the sense of precarity neoliberal reforms rely upon to inhibit labor organizing (see also, Anyon 2014). As one middle school teacher further reflected on the way in which neoliberal reforms both compelled and enabled resistance across scales:

> I'm just like wondering like, there's these little pockets of resistance, but then I feel like on a really big level, teachers are being put in a role of resistance as a whole because of the political moment we're in, like because of standards being under attack and then also just looking at what the Koch brothers are trying to do in the state of Arizona.... (Andrea, November 2019).

Indeed, these contexts are driving forces behind a collective movement such as the Red for Ed movement in Arizona and its effort to transform how the public understands and supports public education. Through our work with local teachers we have seen that both small and big acts of resistance are necessary for resisting the decline of public education. Moreover, in some situations, disinvestment, marketization, and deprofessionalization has, ironically, created the very conditions that enable resistance. This is particularly relevant in relation to science teachers whose skills and willingness have been rendered particularly valuable within the larger context of disinvestment and related science teacher shortages. As teachers realize that they 'have a lot more freedom than they know' they are empowered to act and a powerful feedback loop emerges where resistance snowballs and movements build. (Elsewhere, we have described how their everyday resistance led to participation in larger resistance movements, see Williams and Tolbert 2018).

**Conclusions**

While we set out to understand how science teachers could be supported to implement sociopolitical approaches in science education, we found instead how the very marginal status of being a science teacher in a neoliberal policy context contributed to teachers' enactment of resistance. We also saw how teachers participating in the study were constituted as political subjects through their marginality, subverting state power by asserting their own individual agency in their classrooms and their collective agency as participants in a mass movement to resist neoliberal education reforms (Turner 2015). Findings from this study reveal how teachers can find in their marginality a space of hope as "radical openness" (hooks 1989), a hope that catalyzes local and global resistance to the oppressive conditions of education under neoliberal reforms.

We encourage other researchers to pay greater attention to ways in which neoliberal educational reforms differentially constitute varied disciplines, creating and foreclosing spaces of/for resistance. As this study illustrates, neoliberal reforms have constituted science classrooms and science teachers as particularly promising spaces and subjectivities of/for resistance due to the very way in which science has been marginalized within the larger structure of neoliberal education in Arizona and the United States more broadly. This is not to suggest the neoliberal educational policies are 'good' for science education. Rather, it is to draw attention to the paradoxical ways in which neoliberalism comes to be in particular contexts and the promising potential found at the margins.

**Acknowledgements**

This work was supported by funding from the Agnese Nelms Haury Program in Environment and Social Justice at the University of Arizona, faculty fellows program 2017-2019.

Special thanks to the 9 teachers we had the privilege of collaborating with for this project. It was a privilege to work and learn alongside them about how we might find the capacity to create the kinds of educational spaces we believe in even in the face of structural constraints. Thanks to our research assistant, Caitlin Meyer Krause, for diligently completing the seemingly never-ending task of transcription.

**References**

Aggarwal, U. (2018). After rights: Choice and the structure of citizenship. In Fernandes, L. (Ed.), *Feminists rethink the neoliberal state: Inequality, exclusion, and change*, (pp. 71-105). New York, NY: New York University Press.

Anyon, J. (2014). *Radical possibilities: Public policy, urban education, and a new social movement*, 2nd ed. New York, NY: Routledge.

Apple, M. (2001). Markets, standards, teaching, and teacher education. *Journal of Teacher Education, 52*(3), 182-196.

Arizona Consolidated State Plan. (2017). Retrieved on 17 December, 2019 from: https://www2.ed.gov/admins/lead/account/stateplan17/azconsolidatedstateplan.pdf

Arizona School Personnel Administrators Association (ASPAA). (2016). Retrieved on 17 December, 2019 from: http://www.arizonaea.org/assets/document/AZ/ASPAA_SurveyResults_TeacherShortage09-06-16.pdf

Arizona Science Center. (2019). The STEM Teacher Shortage and Arizona's Future: An Informational Brief About the Importance of Quality STEM Education. Retrieved on 17 December, 2019 from: https://www.azscience.org/media/2614/arizona-science-center-teacher-shortage-issue-brief-april2019.pdf

Arizona State Board of Education. (2019). Assessments and Menu of Assessments. Retrieved on December 17, 2019 from: https://azsbe.az.gov/assessments-and-menu-assessments

A.R.S. § 15-816.01. Retrieved 16 December, 2019 from: https://www.azleg.gov/ars/15/00816-01.htm

Au, W. (2016). Social justice and resisting neoliberal education reform in the USA. *FORUM, 58*(3), 315-324.

Ball, S., and Olmedo, A. (2013). Care of the self, resistance and subjectivitiy under

neoliberal governmentalities. *Critical Studies in Education*. *54*(1), 85-96.

Banilower, E., Smith, S., Malzahn, K., Plumley, C., Gordon, E. & Hayes, M. (2018). Report of the 2018 National Survey of Science and Mathematics Education. Retrieved from http://horizon-research.com/NSSME/2018-nssme/research-products/reports/technical-report on 21 May 2020.

Brathwait, J. (2017). Neoliberal Education Reform and the Perpetuation of Inequality. *Critical Sociology*. *43*(3), 429-448.

Butler, J. (1990). *Gender Trouble: Feminism and the subversion of identity.* Routledge: New York.

Buxton, C. A. (2006). Creating contextually authentic science in a "low-performing" urban elementary school. *Journal of Research in Science Teaching*, *43*(7), 695-721.

Carpenter, S., Weber, N., and Schugurensky, D. (2012). Views from the blackboard: neoliberal education reforms and the practice of teaching in Ontario Canada. *Globalisation, Societies, and Education. 10*(2), 145-161.

Carter L. (2014) The elephant in the room: Science education, neoliberalism and resistance. In Bencze J., Alsop S. (Eds.), *Activist science and technology education*. Dordrecht: Springer.

Carter L. (2015) Globalisation, neoliberalism and science education. In Zajda J. (Ed.), *Second international handbook on globalisation, education and policy research*. Dordrecht: Springer.

Cochran-Smith, M., Feiman-Nemser, S., McIntyre, J. & Demers, K. (2008). *Handbook of research on teacher education: Enduring questions in changing contexts*, 3rd ed. Routledge.

Cochran-Smith, M., & Lytle, S. L. (2009). *Inquiry as stance: Practitioner research for the next generation*. New York, NY: Teachers College Press.

Collins, P. H. (2002). *Black feminist thought: Knowledge, consciousness, and the politics of empowerment*. London, UK: Routledge.

Convertino, C. (2016) The paradoxes, perils, and possibilities of teacher resistance in a right-to-work state. *Workplace: A journal for academic labor,* 26, 89-99.

Crocco, M. and Costigan, A. (2007). The Narrowing of Curriculum and Pedagogy in the Age of Accountability: Urban Educators Speak Out. *Urban Education*. *42*(6), 512-535.

Darder, A. (2011). *A dissident voice: Essays on culture, pedagogy, and power*. New

York, NY and London, UK: Peter Lang Publishing.

Darling-Hammond, L. (2013). *Powerful teacher education: Lessons from exemplary programs.* San Francisco, CA: Jossey-Bass.

Dunn, A. H. (2018). Leaving a profession after it's left you: Teachers' public resignation letters as resistance amidst neoliberalism. *Teachers College Record*, *120*(9), 1-34.

Dunn, A., Farver, S., Guenther, A., & Wexler, J. (2017). Activism through attrition?: An exploration of viral resignation letters and the teachers who wrote them. *Teaching and Teacher Education*, 64, 280-290. http://dx.doi.org/10.1016/j.tate.2017.02.016.

Education Week. (2019). Map: How much money each state spends. Retrieved on 17 December, 2019 from: https://www.edweek.org/ew/collections/quality-counts-2019-state-finance/map-per-pupil-spending-state-by-state.html

Every Student Succeeds Act (ESSA). (2015). Retrieved on 17 December, 2019 from: https://www.ed.gov/essa?src=rn

Fischer, H. (2017) Arizona Teaching jobs remain vacant well into school year. *Arizona Daily Star.* Retrieved on 19 December, 2019 from: https://tucson.com/news/local/we continue-to-worsen-nearly-arizona-teaching-jobs-remain-vacant/article_1c8d665a-a4225c7b-95b9-98afe0cb0c6f.html

Freire, P. (1971). *Pedagogy of the oppressed*. New York: Herder and Herder.

Gibson-Graham, JK. (1996). *The end of capitalism (as we knew it): a feminist critique of political economy,* Minneapolis: University of Minnesota Press.

Gibson-Graham, JK. (2006). *A postcapitalist politics.* Minneapolis: University of Minnesota Press.

Glazer, J. (2018). Learning from those who no longer teach: Viewing teacher attrition through a resistance lens. *Teaching and Teacher Education*, *74*, 62-71.

Gutierrez, R. (2016). Strategies for creative insubordination in mathematics teaching. *Teaching for Excellence and Equity in Mathematics*, 7(1), 52-60.

Hangartner, J., and Svaton, C. (2013). From autonomy to quality management: NPM impacts on school governance in Switzerland. *Journal of Educational Administration and History*. 45(4): 354-369.

Havekost, P. C. (2019). *2018 NSSME+: Status of middle school science.* Chapel Hill, NC: Horizon Research, Inc.

Hill, D. and Kumar, R. (2009). *Global Neoliberalism and Education and its Consequences.* Routledge: New York.

Hoeg, D. and Bencze, J. (2017). Values Underpinning STEM Education in the USA: An Analysis of the Next Generation Science Standards. *Science Education Policy*. *101*(2), 278-301.

Hohmann, J. (January 30, 2018). The daily 202: Koch network laying groundwork to fundamentally transform America's education system. The Washington Post. Retrieved 16 December, 2019, from: https://www.washingtonpost.com/news/powerpost/paloma/daily-202/2018/01/30/daily-202-koch-network-laying-groundwork-to-fundamentally-transform-america-s-education-system/

Hooks, b. (1989). Choosing the Margin as a Space of Radical Openness. *Framework: A Journal of Cinema and Media. 36*, 15-23.

Hursch, D. (2007). Assessing No Child Left Behind and the rise of neoliberal education policies. *American Educational Research Journal*, 44(3), 493-518.

Jerald, C. (2006). *The hidden costs of curriculum narrowing. Issue Brief.* The Center for Comprehensive School Reform and Improvement: Washington, DC.

Macdonald, H., Zinth, J., and Pompelia, S. (2019). 50-State Comparison: High School Graduation requirements. *Education Commission of the States*. Retrieved on December 17, 2019 from: https://www.ecs.org/high-school-graduation-requirements/

Marx, R. and Harris, C. (2006). No Child Left Behind and Science Education: Opportunities, Challenges, and Risks. *The Elementary School Journal. 106*(5), 467-477.

Morales-Doyle, D. (2017). Justice-centered science pedagogy: A catalyst for academic achievement and social transformation. *Science Education*, *101*(6), 1034-1060.

National Alliance for Public Charter Schools. 2016. *A Closer Look at the Charter School Movement*. Retrieved on 17 December, 2019 from: http://www.publiccharters.org/sites/default/files/migrated/wp-content/uploads/2016/02/New-Closed-2016.pdf

National Education Association, *Estimates of School Statistics*, selected years, 1969-70 through 2016-17. Retrieved on 17 December, 2019 from: https://nces.ed.gov/programs/digest/d17/tables/dt17_211.60.asp

National Center for Education Statistics. (2017). Estimated average annual salary of

teachers in public elementary and secondary schools, by state: Selected years, 1969-70 through 2016-17. Retrieved on 17 December, 2019 from: https://nces.ed.gov/programs/digest/d17/tables/dt17_211.60.asp

Next Generation Science Standards (NGSS). Retrieved on 17 December, 2019 from: https://www.nextgenscience.org/

No Child Left Behind Act (NCLB). (2001) Retrieved on 17 December, 2019 from: https://www2.ed.gov/nclb/landing.jhtml

Pease-Alvarez, L., & Thompson, A. (2014). Teachers working together to resist and remake educational policy in contexts of standardization. *Language Policy*, *13*(2), 165-181.

Picower, B., & Mayorga, E., (Eds.) (2015). *What's race got to do with it?: How current school reform policy maintains racial and economic inequality.* New York, NY: Peter Lang Publishing. https://doi.org/10.3726/978-1-4539-1476-2

Plumley, C. L. (2019). *2018 NSSME+: Status of elementary school science.* Chapel Hill, NC: Horizon Research, Inc.

Reeves, J. (2018). Teacher identity work in neoliberal schooling spaces. *Teaching & Teacher Education*, 72, 98-106. https://doi.org/10.1016/j.tate.2018.03.002

Rodriguez, A. J. (2010). Exposing the impact of opp (reg) ressive policies on teacher development and on student learning. *Cultural Studies of Science Education*, *5*(4), 923-940.

[District] Teacher Eval Model, Pg. 1 Retrieved on December 17, 2019 from: blinded website.

Tolbert, S. & Bazzul, J. (2017). Toward the sociopolitical in science education. *Cultural Studies of Science Education*. DOI:10.1007/s11422-016-9737-5

Tolbert, S., Gray, S., Rivera, M., & Schindel, A. (revision submitted). Journal article.

Tolbert, S., Snook, N., Knox, C., & Udoinwang, I. (2016). Promoting youth empowerment and social change in/through school science. *Journal of Activist Science and Technology Education,* Special Issue (Counter)-Hegemony of STEM. Available online at http://jps.library.utoronto.ca/index.php/jaste/article/view/26827/19851

Turner, J. (2015). (En)gendering the political: Citizenship from marginal spaces. *Citizenship Studies*, *20*(2), 141-155.

Whitty, G., Power, S., and Halpin, D. (1998). *Devolution and choice in education: The school, the state, and the market.* Australian Educational Review Limited: Melbourne.

Williams, J. & Tolbert, S. (2018). Finding the freedom to resist: Connecting everyday and spectacular resistance. *Environment and Planning D: Society and Space* Online Forum on Walking out: Teaching, working, and striking on the neoliberal campus. Available online at http://societyandspace.org/2018/06/27/finding-the-freedom-to-resist-connecting-everyday-and-spectacular-resistance/

Wingard, K. C. (2019). *2018 NSSME+: Status of high school biology.* Chapel Hill, NC: Horizon Research, Inc.