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COMMENT

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Including teachers in the social justice equation of project-based learning: A response to Lee & Grapin

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In the article, "The role of phenomena and problems in science and STEM education," Lee and Grapin (2022) argue that the future of project-based learning presents social justice problems as driving questions. For example, a PBL driving question in teacher materials might be related to how social justice can be used to understand COVID-19 or climate change. We agree with Lee & Grapin but expand their framing. Through supporting *teacher-driven adaptations*, we enable teachers to make decisions about their own teaching, transposing current top-down narratives of expertise (Cochran-Smith & Keefe, 2022). Given the multidimensional nature of social justice, teacher-driven adaptations enable response to the multiple levels and contexts that demand science and social justice action (Gewirtz, 2006). We assert that tailoring of social justice issues to local contexts is necessary to ensure authenticity, which is core to all PBL curriculum (Polman et al., 2018). We advocate for increased teacher agency in such adaptations, as teachers are well-positioned and most familiar with their community, classroom dynamics, and the needs and concerns of their individual students (Torres Olave & Dillon, 2022). In Lee & Grapin's PBL of the future, culminating projects focus on social justice issues; however, if questions in curriculum lack relevancy in local context, students may struggle to develop social justice knowledge, which is participatory. Our expanded vision for a PBL of the future will produce meaningful integration of social justice that is immediate and active rather than theoretical.

For teachers to learn and enact social justice in science, they first need to be supported to combat the marginalization of their own knowledge and the restriction of their agency. Thus, teachers (who are working-class and lack the status granted to professionals) can model resistance to the injustice rooted in institutions such as school systems, and teach authentic social justice connections to science (Verma & Apple, 2020). It is our position that this transformation will not happen in PBL through merely rewriting curriculum. Instead, we need to embrace structures that support teachers in recognizing where social injustice occurs in science related contexts and then elevate local social justice action as an asset (Mensah, 2022). Social justice involves the transformation and redistribution of power. It transposes top-down structures of agency, resource distribution, and knowledge (Makori, 2021). Science units and professional learning programs must focus on examining how injustices are manifested in social structures. Then they can proceed to study how to transform those structures that disproportionately distribute power among different groups of people (ibid, 2021). We need to begin by recognizing the marginalization of teacher knowledge as a form of social injustice (Apple, 2021). Then we can design curriculum that positions teachers as possessing unique knowledge. This redesign of instruction and decision-making will thereby advance the realization of social justice (Kelly, 2006).

We envision teacher-driven adaptations in PBL as the means to provide access to understanding that there are multiple dimensions of social justice (e.g., anti-racism, compensation, representation) (Berry et al., 2021; Ender, 2021; Griffin, 2021), and attending to the ways that justice might be enacted at institutional, local community, and relational scales (Gewirtz, 2006). With teachers' knowledge of local community, contexts can be selected for students to make sense of the complexity and messiness of social justice (North, 2008). For example, high-status solutions for climate change forwarded in public media and generalized curriculum, such as electric vehicles and solar panels, are out of reach financially for people who are living in poverty. Providing a critical counter-story (Solorzano & Yosso, 2001) can connect poverty and climate activism, especially via local phenomena. Students from low SES communities can learn how many of their everyday practices are already mitigating climate change, such as living in a smaller home or apartment building, taking public transportation, and fewer (or no) plane trips. At the same time, students could learn the disproportionate impact of climate change on poor and working class communities.

By centering on the teacher's knowledge of local injustice, instead of on a distant experts' knowledge (or an expert who is not credible, see Ridgeway & Yerrick, 2018), the science also becomes localized. Teachers can then construct bridges between local phenomena and manifestations of these same issues on the international stage (e.g., see Makori, 2021; Mensah, 2011), while attending to the multiple dimensions and scales of social justice (see Table 1). For example, teachers and their students may be inspired to learn about climate change and energy use, and investigate where produce at their big box grocery store comes from. As part of this investigation, they could consult local food activists to help understand the challenges of Black and Brown food activist communities (Holland & Correal, 2013). With the help of local activists, students would be enabled to develop concomitant solutions that support local movements and minoritized farmers, and reduce carbon emissions from global transport. Similarly, teachers might recognize minoritized students in the classroom who grow and sell produce with their family (Misfeldt, 2019; Schermann et al., 2006). These students' lived experience is a protest against injustices of market hegemony, thus shifting who has voice and what is considered knowledge. Through such teacher-driven adaptations, teachers can develop classroom foci and structures to elevate those students' expertise. Key in

TABLE 1 Multi-dimensional aspects of social justice in traditional PBL vs. PBL with teacher-driven adaptations across scales: Whose knowledge is valued? Who has agency to act and make decisions?

Scale	Traditional PBL curriculum with social justice related DQ	PBL curriculum that promotes teacher-driven adaptations	Example of social justice activism in science
Institutional	• Outside expert's knowledge is valued • Outside expert makes decisions about learning social justice	• Teachers' knowledge is *also* valued • Teacher has agency to make decisions about classroom learning design within PBL structure	• Administrators (e.g., state leaders, district leaders, principals, disciplinary coaches) and curriculum designers co-developing structures that seek teacher knowledge and expertise; bottom-up rather than top-down • Creating curriculum that centers social justice phenomenon and activism
Local place	• Local context absent: outside expert's knowledge does not extend to local places • Outside expert makes decisions about learning social justice	• Teachers', families', and students' knowledge of place is valued • Teachers and students empowered to decide to learn about local phenomena and contribute to community activism	• Teachers identifying local injustice and elevating local transformative action as an asset and local social justice activism as a resource
Interactional	• Outside expert's knowledge about relational practices is valued (e.g., prewritten rubrics). • Outside expert makes decisions about practicing relational social justice (e.g., teacher tools.)	• Teacher supports students to use their own knowledge to employ criticality and reflection in social justice communication • Teacher supports students to act in specific ways that transpose relational power	• Teachers and students locating and elevating expertise about science phenomena and social justice knowledge that minoritized students bring to classroom

these examples is the reliance on teachers' own knowledge, their awareness of their students and the community (Bruckermann et al., 2021), the potential to access knowledge of external experts, and existing resources of community activism.

During COVID-19, we, like Lee and Grapin, found the need to re-evaluate our PBL science units (Adah Miller et al., 2021; Krajcik et al., 2015) for rapid adjustment. We worked with teachers to develop adaptation principles based on the planned and spontaneous adaptations they designed (Adah Miller et al., in press). With this adaptation work, we saw the potential for authenticity of social justice, by doing social justice meaningful to students. Still, examples of authentic social justice learning were uncommon. The teachers needed support, as well as encouragement from one another, to hone the practices necessary to create social justice-oriented adaptations to science units. Below we describe some of the few examples from our work with teacher-driven adaptation to clarify possible social justice

instances that attend to the multidimensional nature of social justice across three scales: institutional structures, local place-based phenomena as the PBL context, and interactive practices.

1 | INSTITUTIONAL DIMENSION

In educational institutions, classroom teachers, especially those who live and teach in our nation's Black, Brown, and poor communities, are stripped of political voice (Apple, 2021) and they are expected to follow the curriculum as written. The resulting restriction of agency and marginalization of teachers' knowledge in favor of outside experts is an injustice.

1.1 | Possibilities for attending to institutional dimension in future PBL

We developed a professional learning design initially to support the online teaching of PBL science, and later to test the design in face-to-face instruction. We brought together elementary teachers and researchers to co-create adaptations of PBL features (Krajcik & Blumenfeld, 2006) and develop a core set of adaptation principles. The need to elevate teacher knowledge was authentic, so teachers responded to the need for a set of best practices for adaptation. They shared and revised practice-based definitions of equity, social justice, and engagement while reflecting on the adaptations they planned. For example, teachers discussed that some students become engaged in science by certain social justice issues and not others. Teachers in Detroit saw students invest in science during a freshwater unit because they concentrated on a local social justice issue related to freshwater: In Detroit, water costs more than in affluent suburbs. Although these teachers were not able to participate in social justice action with students, the decision to anchor science learning on this injustice was itself social justice action.

2 | LOCAL PLACE

Localized social justice issues create relevant and authentic experiences for students. We found that supporting teachers to adapt the driving question to the local context created opportunity for more connection to the social justice issues (e.g., Mensah, 2011, 2022). If the intersection of science and social justice is the goal, then PBL of the future must be designed to emphasize learning social justice through doing and embodying activism in ways that contribute to participatory social justice action in their local community.

2.1 | Possibilities for attending to the local place in future PBL

The adaptation principle, "Adapt lesson to bring in and leverage identities and intellectual resources from home" informed changes to existing units. Teachers worked together to build on existing social justice resources from students' homes. In our work, two teachers' school's neighborhood was in an airplane flight path. They described adapting the unit phenomenon

about energy transfer in natural areas to energy transfer as noise pollution. They connected science and social justice learning by following the efforts of a local activist group, which included some of the students' families, that was organizing against scheduled flyovers of military jets. The flyovers would impact the mostly poor, Black and Brown neighborhood with unsafe decibel levels. Incensed students described the issue and some students shared how their families were protesting. Students learned about the utility of science knowledge and the excitement, unity, and strength in organizing, even as the protests were largely ignored.

3 | INTERACTIVE PRACTICES

PBL creates highly interactive and interdisciplinary learning, where students collaborate to design artifacts that address the driving question (Li et al., 2021). Instead of merely learning about social justice in science, teachers aim for students to develop social consciousness (*conscientização*, Freire, 1970) or an understanding of how the social and political worlds interact in practice when *doing* science.

3.1 | Possibilities for interactive practices in future PBL

With the goal of addressing the social injustice of persistent exclusion of some students' ideas, the teachers deconstructed how expertise is produced in science classrooms. Together, reflexively, they gathered evidence that transitioning away from business-as-usual can create opportunity for social justice at the interactive level (Dominguez, 2019; Wieselmann et al., 2020). We supported teachers to apply this finding as a principle for adaptation ("Adapt lesson so the usual (traditional) structures are dismantled"). One third-grade teacher had students think about how they judge some peers' talk as *scientific*. The teacher asked if a person could express an important science idea without "big words", "sounding certain" and "using 'perfect' English" (Pérez & Johnson, 2020; Reigh & Miller, 2020). Ultimately, the class decided that tuning-out people's ideas because they do not sound scientific is wrong, that scientific talk happens whenever ideas are shared. They created a signal to mean, "Listen up, there is science talk happening!" Then the students, not the teacher, monitored discussions for science ideas, advocating for voices that had been excluded, by producing the signal, "Pay attention! Science talk!"

4 | CONCLUSION

PBL curriculum has great potential to advance social justice by promoting teacher expertise and agency through teacher-driven adaptations. If curriculum persists as top-down with expectations of fidelity, teachers will find themselves unwittingly teaching someone else's knowledge of social justice in science that does not resonate with them or their students. Rodriguez and Morrison (2019) call on researchers—and we extend this to science learning designers—to move away from understandings of social justice as an immutable body of knowledge where curriculum developers are granted omniscience. Just as social justice work involves transposing historical systems of power, the potential for students to learn about social justice in the classroom is dependent on transposition of power in educational systems, curriculum development, and classroom

implementation. Teacher-driven adaptations move PBL's future away from performativity of social justice in science and toward learning through authentic social justice activism.

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