Power in the Digital Age: A Critical Revision to Productive Disciplinary Engagement (PDE)

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Abstract: Engle and Conant's (2002) articulation of productive disciplinary engagement (PDE) highlights problematizing, resources, intellectual authority and accountability as important principles for designing learning environments. Yet, in the years since their writing, the field has advanced significantly in its articulation of power in relation to learning. Students' disciplinary engagement is not only dependent on how they author, share or convince others of their ideas, but also how such practices invoke issues of power. This suggests a need to revise the framework to engage specifically with what are now readily understood as racialized, classed, and gendered dimensions of learning. In this paper, we bring the issues of power to the forefront to explore the equity potential of the PDE framework. This preliminary move – which centers on the promise of positioning as a principle – is a starting point for the field in working toward a more integrated understanding of power and disciplinary learning.

Introduction

Years of research (National Council of Teachers of Mathematics [NCTM], 2014) have unveiled key features of productive mathematics learning environments that highlight the importance of instructional tasks (Smith & Stein, 1998), meaningful mathematical interactions (Cobb, Yackel, & Wood, 1992), and student authority and accountability (Engle & Conant, 2002). While for many the design of mathematically productive learning environments is the same as designing equitable environments, current research provides compelling evidence of how even well-designed learning environments may still fail to engage non-dominant students at various levels (Esmonde, 2009b; Langer-Osuna, 2011, 2016; Philip, Olivares-Pasillas, & Rocha, 2016) in classrooms with or without technology. Thus, this analysis problematizes the easy equivalence of productivity and equity by asking: What is mathematically productive about equitable engagement and what is equitable about mathematically productive engagement? In this conceptual review and through analysis of empirical examples from the literature, we seek to determine characteristics of a learning environment that promote both productive and equitable mathematical engagement for students. We begin by focusing on inequities resulting from power-laden micro-interactions that shape and are shaped by larger social structures of power. We use this to inform a reinterpretation of Productive Disciplinary Engagement (PDE) as a framework (Engle & Conant, 2002) of principles for designing effective learning environments. The benefits of PDE have been well documented in various analyses of students' disciplinary learning (e.g. Barron & Darling-Hammond, 2008; Kumpulainen, 2014; National Research Council, 2009; Schoenfeld, 2013). The PDE framework has also been adapted and appropriated to think about other types of learning environments such as knowledge forums (Zhang, Scardamalia, Reeve, & Messina, 2009), technology-rich classrooms (Rasmussen, Krange, & Ludvigsen, 2003), and online learning courses (e.g., Hickey & Rehak, 2013). We submit, however, that this framework requires elaboration to sufficiently address issues of power that arise in-situ, with or without technology, to better reflect principles of productive disciplinary engagement *and* equitable engagement. This paper therefore contributes to expanding the use of PDE to address the sociopolitical dimensions of learning (Gutierrez, 2013) necessary for thick democracy (Apple, 2006).

Broadening PDE to PEDE (productive and equitable disciplinary engagement)

First, we briefly describe the PDE framework and its four principles: problematizing, authority, accountability and resources. Then, we summarize the literature on positioning, a construct we will argue as central to articulating principles of productive *and equitable* disciplinary engagement (PEDE). We then elaborate our broadened framework of PEDE in the context of an empirical example taken from the literature (note: in the interests of space we present only one of multiple empirical examples in the full paper).

PDE framework and its four principles

Engle and Conant (2002), in their framework on productive disciplinary engagement (PDE), defined student engagement as evidenced by contributions to the topic made in coordination with each other rather than

independently as assessed by their alignment of eye gaze, body positioning, and their emotional displays expressing passionate involvement. Engagement is explicitly linked with disciplinary practices: "there is some contact between what students are doing and the issues and practices of a discipline's discourse" (p. 402). In mathematics, for instance, students are expected to reason and justify their thinking as they solve mathematical tasks, build on each other's ideas, and revise their explanations in light of new information or critiques (Common Core State Standards Initiative, 2010). As such, it is expected that a productive engagement will not only bring about a change in the learner's knowledge, but also in her beliefs about disciplinary norms of participation (Yackel & Cobb, 1996).

The PDE framework is also accompanied by four principles, i.e., the features of a learning environment that help foster student engagement: problematizing, authority, accountability and resources. Table 1 (except the last column) explains each of these principles in more detail. Problematizing encourages exploration of mathematical content by students in personally meaningful ways. Student authority allows learners to take active roles in the construction of their knowledge, and accountability ensures that authority to share ideas comes with a justification that is open for critique. Resources, as a principle, function at a different level, as shown, in the sense that it also supports the realization of the other principles.

Table 1: Principles of productive and equitable disciplinary engagement (PEDE) framework

Resources (time, tools, artifacts, technology, co-constructed concepts & ideas, etc.)			
Problematizing	**Authority**	**Accountability**	**5th principle: *Social Repositioning***
"individual or collective action encouraging disciplinary uncertainties to be taken up by students."	Giving students active role to act on the disciplinary uncertainties and resolve them. Four kinds of intellectual authority:	A norm where students are held responsible to justify their contributions in light of other's ideas and responses.	Monitor and address students' positioning of each other, w.r.t. math competence and socially-constructed identities.
Uncertainties can be about: Unknown path (how to begin or proceed) ⇩ Uncertain arguments (how to justify) ⇩ Questionable conclusions (how and what to conclude) ⇩ Competing claims (how to reason alternatives)	Learners "authorized" to share what they really think ⇩ Become recognized as "authors" of those ideas ⇩ Become "contributors" to the ideas of others ⇩ Gradually develop into local "authorities" about something	Inside-out accountability: Learners account for the sense-making of their ideas to Oneself ⇩ Safer peers ⇩ Challenging peers ⇩ Internal authorities ⇩ External authorities	Teachers reposition low-status students using multi-ability and multi-framing treatment: Pay explicit attention to the emerging racial and cultural discourses ⇩ Attend to them rather than ignore them ⇩ Utilize them to draw connections between the disciplinary concepts and cultural meanings embedded within them

Research elaborating the PDE framework

Further investigations are continuing to provide explanations and extend definitions of the PDE principles in order to (re)conceptualize them for different types of learning environments and for classrooms with diverse student population. For instance, Venturini and Amade-Escot (2009) highlight that co-constructed micro-ideas by students and teacher during classroom conversations are powerful resources for fostering deeper engagement. Studies also highlight the role of material artefacts, cultural tools, and technology as resources in supporting disciplinary problematizing by diverse students (Furberg & Arneseth, 2009; Krange, 2007). Two technology-rich learning environments were studied by Rasmussen, Krange, and Ludvigsen (2003). They found that the process of achieving joint understanding of tasks and problematizing the use of resources through negotiating authority relations were the main challenges in collaborative work within both the learning environments.

In contrast, several investigations also highlight the issues of equity that arise in spite of the learning environment being well-structured and productive. For example, Philip, Olivares-Pasillas, and Rocha (2016) provided evidence that certain forms of problematizing and resources, like student-generated ideas linking their racial or gendered experiences with mathematical concepts and challenging dominant ways of understanding certain academic concepts are fraught with challenges. Minoritized student contributions may get ignored, contested or positioned as less preferable by peers and teachers, leading to unproductive political controversies and student disengagement. Similarly, Langer-Osuna (2016) found that unbalanced authority structures arise if the intellectual contributions and critiques of non-dominant students are undervalued/subdued by social authority of other students (like popularity of high-status students). We therefore argue for an understanding of the sociocultural *and* sociopolitical environment and argue the importance of theorizing processes and principles that address both. To this end, we offer the principle of positioning and discuss its theoretical and empirical base in the next section.

Positioning

We see positioning as a discursive process whereby people dynamically create narratives about others and themselves mediated by their own subjective histories in the social world around them (Davies & Harré, 1990). How children position themselves and others, and get positioned with respect to academic competence and socially-constructed identities has been found to be linked to children's classroom engagement (e.g., Kim & Viesca, 2016; Leiva, 2011; Martin-Beltran, 2013; Wood, 2013). Esmonde (2009a) determined positioning as one of the key four processes that has implications for students' opportunity to participate and learn. Students positioning on the basis of physical characteristics, abilities, and teacher perceptions also influence the kinds of roles (e.g., explainer vs. listener) and work practices (e.g. individualistic vs. collaborative vs. instructive) students assume or are given during collaborative work (e.g., Esmonde, 2009b; Sawyer, Frey & Brown, 2013; Wood, 2013). Further, studies show girls, racially minoritized students, and emerging multilingual students are often positioned out of ongoing disciplinary discussions by peers and teachers (Bang, Warren, Rosebery, & Medin, 2012; Martin, 2000; Moschkovich, 1999; Philip, Olivares-Pasillas, & Rocha, 2016). Further, students irrespective of race or gender may get positioned as slow, incompetent, or learning-disabled based on their prior performances (Ben-yehuda, Lavy, Linchevski, & Sfard, 2015; Lambert, 2015), or as disruptive if their behaviors do not align with what is considered appropriate in the dominant culture (Langer-Osuna, 2016; Wortham, 2004).

The aforementioned studies demonstrate how micro-interactional acts of positioning structure learning. We thus locate the importance of *positioning* for engagement and propose a consequential fifth principle to the current PDE framework: *(Re-)Positioning. We assert that with explicit attention to the mechanisms of positioning we* shift PDE toward PEDE toward direct engagement with power.

Re-positioning as the fifth principle

The core idea behind repositioning is that teachers pay explicit attention to the issues of power and positioning arising in the classroom interactions, and *reposition* students perceived as low-status in order to provide and maintain their access to mathematical discourse and participation (See Table 1, last column). For this, we build on (a) Cohen & Lotan's (1997, 2004) multi-ability treatment with its specific focus on students' behaviors, emotions, and expressions, and (b) Hand, Penuel, & Gutierrez's (2013) multi-framing treatment to emphasize teacher moves. We consider the principle of repositioning as a *dance of teacher authority* where teacher dynamically moves in and out of different teaching frames to support all students' needs, to recognize student mathematical discourses as intricately linked to their racial and cultural identities, and publicly emphasize that connecting emotionally or culturally to the topic is a sign of engagement. However, we acknowledge that with the addition of repositioning as a possible principle, there also comes a necessary revision to the original four principles—what are considered as valuable resources, what it means to problematize, become intellectual authority, and be accountable. As such, problematizing is about encouraging disciplinary uncertainties to be taken up by learners *as linked to political, cultural and social realities*. Learners are authorized to share what they really think about the disciplinary concepts, and *also about political, cultural and social issues in relation with those concepts*. Learners are responsible to justify their contributions that are open for critique vis-à-vis *politically, culturally, and socially lived experiences of people*. Culturally-relevant resources are used in conjunction with their *political, cultural, and social meanings that are embedded within them* to advance disciplinary learning. We will describe these extensions further in the context of an example below. Furthermore, it is also important to ensure that repositioning does not come at the expense of disciplinary rigorousness. We have conceptualized connections between Repositioning and the other principles of PDE in Table 2. The best way to recommend our proposal is to demonstrate it using an example as we do below.

Table 2: Illustrating affordances and limitations of PDE for equity and how repositioning addresses those limitations.

PDE Principles	Affordances for Equity	Limitations for Equity	Connections with 'Repositioning'
Problematizing	Allows for personally and culturally meaningful exploration of content.	Challenging 'dominant ways of knowing' may lead to racialized controversies.	Repositioning supports uptake of sociopolitical uncertainties (racial, gendered, dominant ways of knowing) using disciplinary concepts and practices.
Authority	Students are given active role in the construction of their own knowledge.	Utilitarian/ dominant beliefs may hinder uptake of controversial/ political issues. Framework addresses intellectual authority but not social authority.	Repositioning allows students to discuss controversial racial, gendered and cultural issues using disciplinary concepts and practices. Repositioning curbs undue social or intellectual authority.
Accountability	Accountability ensures that authority to share ideas comes with a justification that is open for critique.	Authority to share and justify one's ideas is easier than maintaining accountability to critique and revise ideas.	Repositioning ensures disciplinary accountability and accountability to others as students explore sociopolitical uncertainties and controversies.
Resources	Culturally relevant resources has potential to tap into students' interest.	Students may fail to connect disciplinary concepts with the racial/ cultural meanings embedded within such resources.	Repositioning allows co-constructed micro-ideas on sociopolitical uncertainties and social controversies generated by students to be used as resources for disciplinary exploration

Example from the literature

After conducting an extensive review of the mathematics and science education literature, we carefully chose a few rich empirical examples to illustrate how PDE principles might get renegotiated in-the-moment as a result of emergent power dynamics, leading to sabotaged work of engaged students and committed teachers. We present here one especially rich example of several examples we chose and re-analyzed. This example (Philip, Olivares-Pasillas, & Rocha, 2016) that we present below was originally analyzed by the authors to draw attention to the racial contestations that occurred in the classroom as a result of the racial context that the activity was embedded in. We repurpose their data to analyze student engagement, with the content and with each other (i.e., peers and teacher), to highlight mechanisms that afforded productive disciplinary engagement but *limited* student equitable participation.

Philip, Olivares-Pasillas, & Rocha (2016) investigated interactions of students involved in the data visualization activity in an urban high school computer science classroom, which was designed to be culturally relevant for the youth of color. The students were given graphics representing geographical rental patterns of two movies in the Los Angeles area: a popular, mainstream movie "The curious case of Benjamin Button" and a niche, independent, Black movie "Not easily broken". Using this example, we first identify how it exemplifies productive disciplinary engagement (which was not the original article's focus, but is important for the current investigation) despite particular students being adversely positioned during classroom interactions. We then show how the use of PEDE would necessarily illuminate for the designers and analyst (researcher, teacher) issues of power that must be mitigated in order for this to also reflect equitable disciplinary engagement.

Events evidencing productive disciplinary engagement

The given activity was open-ended, group-worthy, and culturally relevant. Students immediately became passionately involved in the discussion and had authority to share their ideas while using the given resources (data visualization graphs). For instance, a couple of students recognized the neighborhoods in the given graphs where the first mainstream movie did not do well saying "Because they Black" and "ghetto" (we will refer back to this moment in the next section). William, an African-American student, noticed that in those same neighborhoods, however, the other Black movie did better. He explained that since it is a Black movie, more African-Americans watched it. The teacher publicly recognized William's hypothesis and labelled him as the author of the idea. At the same time, the teacher also held him accountable for his explanation by offering an alternative explanation of how movies get marketed differently irrespective of race. William, however, felt

strongly about his black solidarity hypothesis and stuck with it. For our purposes, we notice that William problematized the data visualization from a racial point of view, which was more meaningful to him. Later in the discussion, the teacher and other students pursued the teacher's marketing explanation more rigorously. At this time, another black female student, Jessica contributed to William's idea by utilizing the given graphs on other states like Atlanta and Boston to critically justify his argument about black solidarity over marketing.

To summarize, we noticed students' productive disciplinary engagement through the enactment of PDE principles, namely, problematizing, authority, accountability, and resources. In the next set of episodes, we will highlight those classroom interactions which we cannot possibly explain by just using the PDE framework.

Events leading towards inequitable disciplinary engagement

Philip, Olivares-Pasillas, & Rocha (2016) highlighted in the article how students' implicit positioning of African-Americans (and thus of William and Jessica) as "ghetto", arguably a term loaded with negative connotations for Black population, initiated events of "microaggression" in the classroom. Students kept mocking and ridiculing William throughout the lesson using racial slurs. However, William and Jessica continued to support their hypothesis using evidence-based argumentation even when they continued getting mocked by the other students and their argument disregarded by the teacher. The discussion that started on a productive note soon turned into a commotion. It ended with William asking to move on to the next assignment in frustration. William and Jessica remained silent and disengaged for the rest of the session.

Additionally, we note that by pressing for his marketing argument over William's black solidarity argument, the teacher unwantedly subdued an important act of problematizing, and positioned William's argument as inconsequential. Teacher's exclusive focus on the content and predetermined explanations, ostensibly, overpowered the student needs to understand the racial context and its implications for their disciplinary argumentation.

How repositioning might foster productive equitable disciplinary engagement?

We use the revised PEDE framework to argue that if students' acts of racial positioning were monitored and addressed by the teacher, the important resources in the form of ideas that were being co-constructed in the moment by the students, rather than going unnoticed, could be utilized towards building a productive and equitable learning community.

Utilizing co-constructed political ideas as resources through multi-framing treatment

The racialized context that was arising in the classroom was also in fact allowing students to co-construct important ideas. We highlight two instances where student-generated ideas could be explored (and racial slurs curbed) with the support of the teacher to explicitly reposition the Black students and their contributions as meaningful. First, by shifting to a *coaching frame*, rather than giving students authority to negotiate or construct racial meanings by themselves, the teacher could curb students' initial negative positioning of African American students as "ghetto". Second, by shifting to a *cultural frame*, the teacher could redirect students' attention to the racial/ cultural relevance for understanding movie popularity rankings, therefore offering a more connected explanation of the black solidarity and marketing hypotheses. Furthermore, by utilizing student-constructed ideas as resources, the teacher could have also helped other non-black students gain racial understanding and appreciation about what it means to be black. Authors refer to this as fostering "data literacy about race".

Repositioning students using multi-ability treatment

William productively drew on his cultural knowledge to make sense of the data; William's expertise illustrated, in authors' words, his "racial literacy about data". The teacher could publicly recognize William's expertise in the class. This could reposition William as an expert, while highlighting to the students other perspectives necessary to competently explore and analyze data. Similarly, by publicly and explicitly recognizing how Jessica employed the data creatively to present evidence in support of the black solidarity argument, she could be repositioned as an expert on employing disciplinary practices of evidence-based argumentation and contributing to other's ideas. This could present to students other models of successful data exploration, and also help divert their demeaning racial language towards practices aligned with the discipline.

Conclusion

In this paper, we suggested expanding the PDE framework to PEDE (Productive and Equitable Disciplinary Engagement) by positing positioning as one way to press the framework in its engagement with issues of power. Re-positioning describes ways in which researchers can analyze and teachers can address students' racial/ gendered/ cultural positioning of each other, which often times create imbalances in student participation and

uptake of opportunities. We submit that such a focus forces a more specific articulation of the possibilities and promises of public education (and in particular, mathematics education) as a social and political good that advances democracy. However, we still need more work to demystify social processes embedded within these principles and clarify how they negotiate hierarchies of relational power and positioning. During our presentation, we will also discuss implications of our work for teacher preparation and professional development programs, and for learning environments with or without technology.

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