Unpacking 'Culture' in Cultural Studies of Science Education: Cultural Difference Versus Cultural Production

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Abstract:

In this article, we explore three anthropological approaches to science education research: funds of knowledge, third space/hybridity and practice theory. Definitions, historical origins, uses and constraints of each approach are included along with reviews of exemplary studies in each tradition. We show that funds of knowledge research draws on an earlier research tradition, cultural difference theory and rests on an assumption that groups build culture in response to fixed and static socio-political conditions. Practice theory is more flexible in that it allows researchers to study how groups create local meanings, which may conform to, resist or even transform those larger conditions through cultural production. We then illustrate the approaches by analysing the same case (that of a Mexican-American boy) using both cultural difference theory and practice theory, to illustrate the strengths and limitations of each approach.

Keywords: funds of knowledge | third space | practice theory | science education | culture | situated learning | equity

Article:

Culture is, as Eisenhart (2001b) put it, an 'idea to think with' (16), one, which has been conceptualised, in a variety of ways by science educators. Historically, science education research has rested on psychological notions of learning and only in the past 25 years or so have anthropological perspectives surfaced with any traction. Primarily, these perspectives are borne out of a desire to reconceptualise science learning environments, to question taken-for-granted assumptions embedded in how the work of science education gets done and to bring to light processes of inequity and possibilities for challenging the status quo. One problem, however, is that science educators may not question or understand the nuances or historical roots of the concepts of culture they take up in their work. In this article, we explore three anthropologically

grounded approaches to the study of science education, each with its own strengths and limitations: (1) funds of knowledge and its ideological forebear, cultural difference theory; (2) third space/hybridity; and (3) practice theory. We trace these approaches to their anthropological roots, unearth the understanding of culture in which each is grounded and explore what each approach reveals and constrains. To illustrate the strengths and weaknesses of various anthropological approaches, we end the article by analysing the school science experiences of a Mexican-American boy named Julio, using both cultural difference theory and practice theory.

Three anthropological approaches to science education

Funds of knowledge

In recent years, some science educators have used one conceptual model of culture, the shared knowledge and practices of a bounded group of people, to inform the 'funds of knowledge' approach, looking at ways to incorporate what students bring from their homes and communities into the science classroom. These efforts scaffold students' science learning by guiding them to realise that they already possess scientific knowledge and skills, and that their families and communities use science on a daily basis, whether or not they label it as such. The premise, according to Hammond (2001), is that 'linking school science to community activities is a way to enable all students to see science as accessible and relevant to their lives' (986).

The funds of knowledge approach was originally framed as a way of incorporating household knowledge and skills of students in Mexican communities in Arizona as a way of 'capitalizing on household and other community resources' to 'organize classroom instruction that far exceeds in quality the rote-like instruction these children commonly encounter in schools' (Moll et al. 1992, 132). In this study, anthropologists teamed with classroom teachers to conduct ethnographic research into the community and family funds of knowledge available to local students. As a result of this project, the authors 'learned that it is feasible and useful to have teachers visit households for research purposes', and that such visits could become 'the catalyst for forming research teams among the students to study topics of interest to them, or importance to the teachers, or for achieving curricular goals' (139). Funds of knowledge approaches were also grounded in concern for equity and often involved science. One researcher, herself an anthropologist involved in a project where Mien parents grew gardens and built a traditional garden house on school grounds, argued that 'science is so concrete that its potential as a hook is greater than that of most other discourses' (Hammond 2001, 997).

Basu and Calabrese Barton (2007) explained the funds of knowledge approach this way:

Funds of knowledge refer to the historical and cultural knowledge of a community, … [and also] experiences and knowledge that may be more particular to a given family within the context of a community. … Funds of knowledge therefore include knowledge, action, and disposition or habitus with a recognition of how each of these domains are culturally constructed and refined. (468)

Or, more briefly, ‘the cultural knowledge an individual possesses as well as how and why they act upon that knowledge’ (485). Upadhyay described the benefits of a funds of knowledge approach for science learning, and its connection to equity:

This greatly improves ethnic minority students’ opportunities to learn and enjoy science and truly affords a social justice experience for these students by allowing immigrant students, like Hmongs, an opportunity to bring their cultural ideas into science classroom discourses. (2010, 58)

Researchers have been able to document positive outcomes associated with classrooms and programmes incorporating funds of knowledge approach. One teacher's efforts led to increased participation in school-based science activities by students and community (Upadhyay 2009). Students in an after-school science programme, which helped them draw on their funds of knowledge, were found to have ‘pursued self-motivated science explorations outside the context of the classroom or used science in an ongoing way to improve, expand, or enhance an exploration or activity to which they were already deeply committed’ (Basu and Calabrese Barton 2007, 469). Teachers in New Zealand who taught science classes with a high proportion of Māori students used Māori cultural knowledge of mountains during a landforms unit (Cowie, Jones, and Ortel-Cass, 2011). Cowie and colleagues found that both teachers and students benefited from the legitimate inclusion of Māori cultural knowledge in the science classroom; legitimising Māori students’ funds of knowledge provided them an impetus to develop science-related identities in school science and provided teachers with deeper understanding of their students. Another programme helped Mexican-American parents of pre-schoolers identify science concepts and knowledge embedded in common household activities; the parents were in turn able to explain those concepts to their children (Riojas-Cortez et al. 2008). Science teachers in high-performing schools in Uganda were able to draw on students’ everyday knowledge ‘as a pedagogic resource or means to induct learners into science knowledge’; teachers in low-performing schools were more likely to focus on students’ everyday knowledge *instead of* promoting science knowledge (Sikoyo and Jacklin 2009, 720). An ongoing professional development programme that taught teachers to incorporate students’ funds of knowledge (among other techniques) yielded significantly higher student growth compared with similar schools whose teachers did not receive the training (Johnson and Fargo 2010). The funds of knowledge approach in this case consisted of the classic approach: ‘conducting home visits to better understand how to bring real world experiences from different cultures into the classroom’ (45). This last finding was particularly striking because schools were assigned to the treatment and comparison groups at random.

The funds of knowledge approach points to manageable, satisfying and effective actions that teachers can take to improve the science educations of their students. Further, it does so while framing students in non-deficit-based ways. Rather than blaming students for their failures in the science classroom, the funds of knowledge approach locates the failure in a mismatch between students and classroom, and points to concrete steps teachers can take to rectify that mismatch. It

invites teachers to see students' households as 'containing ample cultural and cognitive resources, with great, potential utility for classroom instruction' (Moll et al. 1992, 134) and thus gives teachers concrete tools to 'use diversity as a resource in the service of learning' (Nieto 2000, 183). This approach 'contrasts sharply with prevailing and accepted perceptions of working-class families as somehow disorganized socially and deficient intellectually' (Moll et al. 1992, 134), the destructive and discouraging deficit view of cultural difference. As such, it is a dignified and respectful approach to teaching, and one with great power to improve science education.

Funds of knowledge and the cultural difference tradition

The funds of knowledge approach rests on a particular definition of culture: culture as 'patterns in a way of life characteristic of a bounded social group and passed down from one generation to the next', patterns which reflect a group's 'successful adaptation to relatively stable environmental (economic, social, and political) conditions' (Eisenhart 2001a, 210). Students' household funds of knowledge are derived from these adaptations. For instance, the students studied by Moll et al. (1992) had funds of knowledge that drew on the skills their parents used to earn money and care for children. In this, it draws on cultural difference theory, a body of educational research, which got its start in the 1950s. A fundamental assumption of cultural difference theory is that the culture of schools reflects the culture of the dominant class; what Delpit (1988) calls 'the culture of power'. Thus, for some students, the culture they experience at home is congruent with what they find in school; for others, however, success in school entails navigating a second culture consisting of less-familiar ways of organising time, space and language use. Within this logic, 'without special efforts to teach "culturally different" students the unfamiliar school culture, these students will, from the first day and through no fault of their own, have difficulty understanding what is expected of them in school' (Eisenhart 2001a, 210).

Cultural difference theory, as we argue above when describing the funds of knowledge approach, has been successful in framing the difficulties of poor children and non-White children in schools, without resorting to deficit-based explanations. It lets us understand some students' failures to thrive without blaming either the children or their teachers and schools; instead we can place the blame on miscommunication and cultural mismatches. This, in turn, has led to concrete changes in curriculum and instruction.

At the same time, there are limitations to understanding equity in science education with the cultural difference lens. First, it is grounded in the assumption that cultural forms are reactions to existing economic, political and social situations. Groups develop shared ways of using time, space and artefacts, and shared understandings in response to their conditions. The conditions to which these groups react are assumed to be fixed and static, affecting groups in unilateral ways. Such formulations assume enduring social structures without troubling their meaning and status. This fails to allow for the possibility that science itself could be changed and thus limits our thinking about transformative possibilities. The underlying theory of action of the cultural

difference approach is to incorporate students' funds of knowledge into a science classroom as a bridge to science.

Viewed uncritically, one might assume that achieving cultural congruence in a science learning setting would leave no other obstacles to science equity. However, given what we know about the inequities in resource distribution among public schools in the USA, this is a cruel and inadequate assumption. It directs attention away from opportunity gaps in science; from the institutional processes which permit schools serving the most educationally needy students to be staffed with the least experienced teachers and given the fewest and oldest material resources (Education Trust, 2008, 2009; Kozol 2005; Lee and Orfield 2007; Shah 2011). It also fails to account for the processes by which certain kinds of people are anointed as science people, as belonging in science and with the right to use science, while other people are systematically produced as not belonging in science (Carlone and Johnson 2007; Johnson et al. 2011). And, it fails to account for the ways science as a discipline reproduces itself through culture, and the realities that a purely localised form of science (to which a culturally congruent science can fall prey) can be easily discredited because of its disconnect from larger networks of power (Carlone et al. 2009; Nespor1994). In short, the funds of knowledge approach is vulnerable to what Bourdieu calls the 'interactionist' error: 'reducing relations of power to relations of communication' (1999, 167). This formulation cannot account for how power gets reproduced or contested by long-term macro scale of political decisions about funding, meso-level institutional educational policies and shorter-term micro scale of myriad human interactions.

Third space

Researchers in the funds of knowledge tradition have responded to these limitations by studying the ways students use their funds of knowledge not just as a bridge to prototypical science but to bring new forms of science into existence. A third space or hybrid space is created when classroom members bring together elements of school culture and home culture to create something new. The concept of third space allows researchers to get at what people do with the funds of knowledge that students bring into the classroom; how teachers can make use of those funds and how teachers and students may be using them to spin-off from school science, making their own meanings. Third space work has focused on documenting that a third space exists between the 'official curriculum' and students' funds-of-knowledge-based 'counterscript' (Gutierrez, Baquedano-Lopez, and Tejeda 1999), and that this third space is pedagogically promising for educational equity, particularly in science. Calabrese Barton and Tan (2009), for instance, were able to show that when a teacher deliberately created opportunities where students were likely to construct third spaces, it led to greater student participation and better grades. Glasson et al. (2010), on the other hand, showed that science teachers in Malawi typically failed to take up rural elders' extensive knowledge of sustainability practices (including evidence-based reasons for using traditional rather than western growing practices) which could have served as a resource for a hybrid science, instead teaching science in a way which was 'largely irrelevant to most Malawian villagers' (Glasson et al. 2010, 138).

Third space/hybrid space researchers have also focused on developing the concept and related methods. Moje et al. (2004), for instance, enriched both the theoretical role of third space, describing it as ‘a bridge, a navigational space, or a space for critical understandings of the relationship between science and students’ “everyday worlds”’ (54) and its aims to expand what is valued in science classrooms; to ‘integrate, rather than divide, everyday and academic knowledges’ and ‘reshape how and why young people approach the content texts of their classrooms’ (54). They also directed other researchers towards promising arenas to look for students’ funds of knowledge: not just at family resources, but also as community and peer resources as well as popular culture resources. In doing this, they expanded the definition of culture beyond just ‘patterns in a way of life characteristic of a bounded social group and passed down from one generation to the next’ (Eisenhart 2001a, 210) to something which is no longer necessarily inter-generationally conveyed, nor shared only among identifiable groups.

Gutierrez (2008) further broadened the cultural assumptions underlying her use of third space, grounding it in social interaction. The creation of a collective third space, she argues, arises when ‘students link the past and present to an imagined future and reorganize everyday concepts acquired through *social* interaction in *joint* activities into scientific or school-based concepts [our italics]’ (158). In this formulation, activity in the third space is, in the words Ladson-Billings uses to describe culturally relevant pedagogy, ‘specifically committed to collective, not merely individual, empowerment’ (1995, 160). In third space, students and teachers can ‘create opportunities to *collectively* generate new forms of joint activity to solve the double binds students encounter’ (Gutierrez, 2008, 160). This use of third space is not only more overtly political than other uses, but it reflects the recent attempts among anthropologists to deal with the fact that ‘conventional assumptions of culture as coherent and coterminous with social background, language use, region, religion, or ethnicity have become impossible to sustain’ (Eisenhart 2001a, 213).

This realisation characterises an article by Calabrese Barton, Tan, and Rivet (2008), in which they examined the particular strategies a group of urban girls used to generate sanctioned or unsanctioned science-infused identities in science classes, without compromising their social identities. Although the article was grounded in hybridity, the authors did not make the girls’ home funds of knowledge primary in their analysis. Instead, they directed their attention on the classic data of ethnographers: the things the girls said, did, made and used in science settings. The hybrid spaces in this article were no longer hybrids of students’ family/community funds of knowledge with the school's official curriculum; rather, they were places in which the girls could engage in what anthropologists call ‘cultural production’: ‘a set of symbolic and material forms, affected but not determined by history and structure, actively appropriated or “produced” in groups to bring order and satisfaction to experiences’ (Eisenhart2001a, 212–13).

This approach has been criticised for framing hybridity as ‘something teachers are to achieve’ (Richardson Bruna 2009, 225). Richardson Bruna goes on to argue that educational researchers have often overlooked:

‘Bhabha's critical insight that hybridity is always already there, regardless of whether the teacher decides he wants to ‘create’ it. Students’ text-making activities and classroom experiences will always and necessarily be realised at the confluence of home and school literacy practices. (2009, 226)

The great use of hybrid space as a theoretical tool, according to this line of argument, is not to find out ways teachers can ‘achieve’ or ‘create’ it, but to identify:

cracks in structure that may be taken advantage of by the subordinate group, in order to transform that structure. Learning the codes of the dominant group is a skill that can be put to use to dismantle the colonizing structure kept in place by that group. (Gonsalves, Seiler, and Salter 2011, 396)

In other words, the great use of third or hybrid space is to assist in studying power and identifying space for change: ‘the ideas upon which any system of exploitation is built are necessarily contradictory and will produce gaps and spaces for resistance, transformation and liberation’ (Shumar 2010, 502). We see this particular take on hybridity research as closely connected to practice theory, the third tradition in cultural studies of science education that we discuss below.

Practice theory

Practice theory is characterised by its attention to both micro- and macro-level factors, its focus on how individuals exhibit agency within the constraints of larger-scale structure and its (anthropological) focus on patterned, rather than individual, behaviour. Practice theory in educational research is rooted in ideas about cultural production (Eisenhart and Finkel 1998; Holland and Eisenhart 1990; Levinson, Foley, and Holland 1996; Willis 1977), situated learning (Lave and Wenger 1991) and networks of power (Nespor 1994, 1997). Users of practice theory often look at the way certain subject positions are celebrated or marginalised in a particular setting (Davidson 1996; Luykx 1996) and at the figured worlds within which those identities make sense (Holland et al. 1998). Thus, practice theory attends both to larger societal structures and to the ways individuals exhibit agency in everyday practices, working together to fashion cultural meanings that may reflect, contest and/or transform meanings implied by those structures. ‘Practice theory explores how individual and group cultures are formed in practice, within and against larger societal forces and structures’, and ‘gives equal weight to macro-level structures (i.e., gender, class, race) and micro-level factors (i.e., an individual's everyday practice)’ (Buxton 2001, 389). Within this approach, culture is not a set of practices handed down across generations as a response to enduring social structures, but a shared set of meanings, continually produced in everyday practice; new meanings can be congruent with what came before but also might have potential to alter what came before.

Practice theory attends closely to local processes, but the analysis cannot stay local. The theory directs user's attention to both micro- and macro-processes; it requires that researchers connect

local practices and meanings to larger socio-historical meanings to which the local processes conform, resist and/or transform. Practice theory also attends to individual agency. Individuals can act to challenge prevailing cultural norms; however, they do so in the midst of pressure to ‘conform to the culture as currently practiced’ (Buxton 2001, 389). Within this framework, ‘individuals are not free to choose for themselves any view of the world, any way of acting in class, any definition of success, or any identity’ (Eisenhart 2001a, 215). The agency of individuals is constrained by structure, ‘the underlying principles that shape the normative patterns within social groups’ (Shanahan 2009, 45). When individual responses to prevailing cultural norms coalesce into ‘ongoing expressions of identity and purpose’ (Eisenhart 2001a, 217) shared by groups, they rise to the level of cultural productions.

Furthermore, to be indicative of cultural production, individual actions must reveal something about a group's shared meanings. Behaviour must be patterned, either in ways that align with local cultural meanings or contest them, to be of interest. Individual action must ‘be identified, not by individual statements of belief, but by patterns in the ways participants act in classrooms, label their own efforts, and describe themselves to others’ (Eisenhart 2001a, 217).

The strength of practice theory is its ability to resolve cultural puzzles, to explain surprising patterns and show how things are not as they seem. Margaret Eisenhart, whose work highlights the utility of practice theory in educational research:

uses ethnographic techniques to describe both contexts within science education and science workplaces, and individual stories experienced by players within these worlds. She then illustrates how individual histories, attitudes, and identities of participants can enable them to rewrite what appear to be pre-determined stories. (Hammond and Brandt 2004, 17)

For example, in a study of a university science lab with a disproportionate number of women undergraduates, graduate students and postdoctoral researchers, Buxton (2001) was able to show that whereas one all-male group in the lab, the ‘Cool People's Bay’, had the strongest appearance of resisting the cultural norms of science (through their reputation for ‘loud music’ and ‘wacky behaviour’), in fact that group was deeply engaged in conforming to wider cultural norms in science (particularly in their competition for resources). Another group, the ‘Chick Bay’, composed entirely of women, gave much less impression of resisting the cultural norms of science; however, they quietly undermined those norms much more than the researchers in the Cool People's Bay, by sharing scientific resources, training new lab members and tutoring struggling undergraduates:

Whereas the behaviours in the Cool People's Bay exemplified a number of obvious and overt examples of resistance to the prototypical norms of science and scientist, there was much in the Cool People's Bay that conformed to those norms as well. In contrast, norm violations in the Chick Bay occurred in such subtle ways that they went largely unnoticed by the rest of the lab.

Although much less noticeable than the boisterous behaviour of the Cool People's Bay, actions in the Chick Bay seemed more likely to lead to changes in science practice. (402)

In order to ‘examine more deeply the call for a changed science curriculum’, Carlone (2004) set out to investigate the experiences of girls in an Active Physics class. Active Physics is a thematic curriculum designed as a rigorous alternative to traditional, topic-centred physics curricula. Carlone ‘wondered whether a different kind of school science, one that promoted alternative (and broadened) meanings of what it meant to “do science” and “be a science person”, would make for a more inclusive and interesting science for girls’ (393). What she found, however, was that even the girls who ‘were successful and interested in the class (and who defined themselves as “lab” people) did not define themselves as “science people” and opted not to pursue further study in physics’ (404). Carlone was able to make use of the simultaneous focus of practice theory on local meanings and larger socio-historical processes to show that this was happening because the setting was, despite its novel curriculum, characterised by prototypical meanings of science as ‘difficult’ and scientist as someone with ‘raw ability’. She was also able to show that these local meanings, aligned with prototypical meanings, arose arbitrarily; the teacher found ways *not related to physics* to make the class more difficult (for instance, not giving students sufficient time to complete assignments).

In an example of the power of practice theory to understand the relationship between individual agency, societal structures, cultural production and cultural reproduction, Tonso (2006) showed how educational reforms at an engineering college failed to result in cultural change. Tonso engaged in participant observation between 1992 and 1996 at an engineering school that embraced a novel strategy for engineering education (requiring that students take not only traditional lecture-and-test engineering classes, but also design classes in which students worked in teams to solve real-world problems). She investigated the available, recognised engineering student identities, eventually collecting 126 different terms and focusing in on the 36 most common. In particular, she looked at the ‘nerd’ identity, especially the ‘super-engineer nerd’, students who ‘excel at combining real-world practical knowledge with technical and scientific principles’ (290) – the exact student who should shine in one of the design teams which were the central element of the school's reform strategy. She then went on to show that women students, even those who perfectly exemplified the characteristics of super-engineer nerds, were not recognised as promising engineers because of the gendered way that identities were understood at this school. She also showed that despite the school's commitment to producing hands-on engineers, students performing the nerd identity were not as valued as students performing another identity, the ‘over-achiever’, students ‘whose test scores and grades ostensibly indicated being capable of doing engineering work at the highest levels’ (302) regardless of how they actually performed in design teams. These two dynamics ensured that the school culture remained static; those students whose performances did not fit the higher-status ‘over-achiever’ identity became marginalised or left the community *even when they were competent engineers.* ‘Ultimately, in spite of enormous student agency constructing subjectivities as

engineers and performing themselves as engineers, and at times doing so in resistance to campus culture, little cultural change seemed likely to result from their creative performances' (301).

As these examples indicate, practice theory yields insights quite different from those of a funds of knowledge approach or the most common use of third space. Whereas funds of knowledge studies can provide teachers with guidance for how to draw on students' outside-the-classroom lives in order to make science meaningful and show them that they already have science knowledge and skills, practice theory facilitates the linking of in-class cultural norms to larger socio-historic patterns. Whereas third space studies tend to draw attention to particular moments in classrooms in which students and teachers blend official curriculum and student knowledge and interests to create a momentary hybrid science, practice theory focuses attention on*patterns* of production of new local meanings. Funds of knowledge approaches offer much more immediate guidance to teachers and science teacher educators; practice theory helps researchers and teachers understand how prototypical science meanings get endlessly recreated even in settings (like an Active Physics classroom or a reform-based engineering programme) where one might expect those meanings to be subverted, as well as insight into how science might gradually change (like a group of female graduate students establishing a norm of collaboration in their research bay). The kind of larger-scale insights offered by practice theory can be difficult to put into immediate practice; however, these insights are crucial for understanding how the whole system works, if one's interest is to dismantle that system.

Comparing cultural difference theory and practice theory: the case of Julio

To illustrate the strengths and limitations of cultural difference theory and practice theory lenses, we present a summarised case about Julio from Carlone's previous co-authored work (Rockford and Carlone 2011). Drawn from Carlone's larger research study (NSF #REC 0546078), Rockford and Carlone analysed this case using a cultural difference lens. Here, we summarise the case and that analysis, illustrating what understandings that lens enabled and constrained. Then, we re-examine Julio's case from a practice theory lens and its strengths and limitations. In doing so, we uncover taken-for-granted assumptions about culture that undergird both cultural difference and practice theory perspectives often overlooked in cultural studies of science education:

Julio is a shy student whose family emigrated from Mexico when he was in the first grade. He lived with his mom, his teenage sister and his sister's baby daughter. His family struggled financially, and he often took care of his baby niece after school. His fourth-grade teacher described him as having 'life resource skills' that others did not have: 'Drop him off ten miles from home, and he would safely find a route, get food along the way, make a friend, and find his way back home. The rest of the class would sit down and cry 'til somebody came and helped them'.

In 4th grade, Julio was playful, generally not afraid to take risks, not afraid to be wrong, observant, collaborative, and a problem solver. He struggled in other academic areas, but often

shone in science, solving problems with electric circuits faster than others without calling attention to this fact and providing help to his friends by explaining concepts in Spanish. His teacher encouraged this practice, as the class was a dual-language immersion classroom for both Spanish and English. Often, he was the leader in science small group work, especially among his Latino male friends, encouraging them to stay on task, telling them what to write in their science journals and raising questions for them to examine in small groups. His excitement about science was contagious, especially among his Latino male friends.

However, his scientific performances could have easily been dismissed if you defined ‘smart’ in traditional ways. He did not make bids for recognition by expressing a large bank of scientific facts; neither was he the kid who engaged in robust whole-group discussions; nor was he the student whose journal was chock-full of carefully written observations and drawings. He was the anti-know-it-all student, the anti-competitive student. And yet, his fourth-grade teacher (Ms. Wolfe) and the classroom norms recognised and celebrated his understated and nonmainstream performances; Ms. Wolfe and some of his peers named him as one of the three smartest science students in end-of-year interviews.

Julio's sixth- and seventh-grade science classes (taught by the same teacher, Mr. Campbell) were dominated by worksheets, bookwork, and the occasional science project or cookbook laboratory activity (where students followed step-by-step directions to ‘answer’ a question). Here, you would most likely see Julio not talking, slouched back in his seat, his head down or propped up against his fist, often doing nothing, then copying classmates’ answers. In these two years we observed Julio in science (sixth- and seventh-grades, roughly 20 observations), we never saw him volunteer any scientific answers, ask any questions, take any kind of leadership role in small groups, nor show any overt interest in any scientific topics presented in class. He often asked the teacher for the answers to worksheets, which often, the teacher provided. Over the two years of science, Julio grew more and more despondent, disinterested, and bored. His teacher said of him: ‘If Jake or Edward are ambitious, Julio is the opposite of that. I think if you challenged him, he would say he's not very smart. It drives me nuts. I always kid him because he'll ask for the answers … All he wants is the answer. He just wants to check it off and put it away, because he doesn't think he is capable of even thinking’.

Analysis #1: cultural difference lens applied to Julio's case

A cultural difference lens directs one's attention to the relative match between the culture of Julio's home and the culture of the science class. The implication is that, when cultural norms, values and practices from home matched the cultural norms, values and practices from school science, he was more successful, interested and engaged. Rockford and Carlone (2011) analysed Julio's case by highlighting Latino cultural repertoires of practice (Gutierrez and Rogoff 2003) present in his fourth-grade classroom that were missing and/or misinterpreted in his sixth- and seventh-grade science class.

Consistent with a cultural difference lens, Rockford and Carlone (2011) argued that there are common, oppressive social, cultural, economic and political conditions Latinos in the USA face, and these oppressive conditions position them as:

a racialised group subject to different types of racial discrimination. The backlash against Spanish and the 'English only movement' as well as the periodic ideological attacks—that are psychological, political, and economic in nature—on immigration provide clear evidence of this phenomenon that often manifests itself in violence. (Lynn and Parker 2006, 264)

There are specific Latino cultural repertoires of practice that can be harnessed as resources in such conditions. These are 'intergenerationally conveyed concepts, ways of talking, and belief systems that may be used and negotiated locally in communities that are often identified internally and by their neighbours in terms of ethnicity and race' (Gutierrez and Rogoff 2003, 21). For example, the Latino meaning of 'being educated' – or *educuación* – means something very different for Latinos than it does for Anglo families. In Latino culture, 'to be "educado" is to have a complex set of well-rounded understandings about the world and how to interact with others' (Rockford and Carlone 2011, 11) – somewhat akin to being well-mannered, someone who was 'raised right'. 'This is a very different than the Anglo version of "education" that usually equates with book knowledge' (Rockford and Carlone 2011, 11; drawing on work by Levinson 2001; Wortham, Murillo, and Hamann 2002). Another Latino family repertoire of practice is *familism*, where the comfort and good of the group is valued over that of the individual. This regard for the group and honouring of the kinship associated with it gets leveraged as a form of social capital (e.g., Villenas and Deyhle1999). Closely related to familism is *humildad*, where 'children are taught to respect authority figures, and not single themselves out, in fact to actively work to take focus away from themselves in favour of the group, as a sign of respect and deference' (Rockford and Carlone 2011, 12 drawing on work by Ek, 2009; Valdes, 1996).

Rockford and Carlone (2011) analysed Julio's case by first highlighting the strong connections between the culture of his fourth-grade class and Latino values of educación, familism and humildad. For example:

Julio positioned himself in ways that showed *educación*, by continually bringing others into science in ways that were deferential, held peers up as equals, and focused on group collaboration as the means to which he chose to 'do science'. Julio seemed to be unconcerned with the need to have the 'right answers', and instead positioned himself in ways where the members of his group could have experiences with scientific phenomena, almost as if taking a 'motherly' role in ways that resemble familism and kinship with his peers, especially during small group activities … These kinds of positionings are wrapped up in what it means to be 'bien educado' in Latino repertoires of practice relating to *educación*, as opposed to the dominant values of 'education', which are more knowledge- and fact-oriented. (22)

We demonstrated that the norms, values and practices in Ms Wolfe's (the teacher's) classroom recognised, drew on and celebrated practices that were consistent with Latino cultural values, thus enabling Julio's success:

[W]hat was enabled for Julio in fourth grade, with the inclusion of Latino repertoires of practice, were opportunities to collaboratively interact, take risks, observe, and utilize *educación*, *familism*, *kinship*, and *humildad* in service of scientific inquiry that benefited Julio's positioning and the pursuit of scientific understandings that do not belong to a single individual, but to the group. (38)

Concurrently, Julio's heartbreaking decline in sixth- and seventh-grades can be similarly explained by a classroom culture that was not only inconsistent with, but stood in direct opposition to, Latino repertoires of practice. In these grades, competition, low-level tasks and individual bookwork dominated classroom routines and access to discrete scientific knowledge and 'perfect' (neat, 100% accurate) work held most sway. 'Ambitious' students were those who actively sought recognition for having the right answers, which violates the principle of *humildad*. The classroom culture of sixth- and seventh-grade science makes invisible Julio's abilities to be collaborative, to bring others into the excitement of scientific ideas and to help and get help from his Latino male friends as possible resources to enhance school science. In fact, the cultural mismatch between Julio's cultural values and school science's cultural values cast these potential strengths in a negative light.

Benefits of the cultural difference lens for Julio's case: what it enables us to see and understand

The cultural difference lens, when applied to the Julio case, provides a strong explanatory, non-deficit-based account of Julio's fourth-grade success and sixth- and seventh-grade difficulties in school science. The data about Julio's preferred ways of performing himself in school science fit perfectly with Latino cultural values described in the literature, such as *educación*, *famildad*, *kinship* and *humildad*. The cultural difference lens brings to the fore values and practices that may be traditionally overlooked in research studies and actively squelched in traditional school science settings. It allows us to 'see' Julio, and his successes and failures, differently than mainstream accounts of success and failure promote. For instance, because Julio was smart in ways that are often invisible with mainstream lenses, it would be easy to explain his difficulties in sixth- and seventh-grades by honing in on deficits with his academic preparation, reading level, writing abilities, motivation and/or home support systems. Instead, we now understand that Julio's repertoires of practice, when actively leveraged and celebrated as part of the class's cultural norms and values, become valuable assets for his own success and for creating a classroom community where knowledge is socially constructed, responsibility for learning is shared and authoritative knowledge is up for debate.

One can imagine practical applications from Julio's story as told through a cultural difference lens. A science classroom, like Ms Wolfe's, that recognises, leverages and celebrates Latino cultural repertoires of practice provides access for a wider range of student identities than those traditionally celebrated by school science. Teachers could read this account and immediately incorporate practices that make their classrooms more hospitable to students like Julio, practices that promote science as a collaborative, social endeavour and that push students to question authoritative accounts of knowledge. The account provides potential prescriptions for practice that also force us to question the ways traditional school science overlooks and silences non-mainstream students and shows us how we might capitalise on their cultural values and repertoires of practices to enrich and make more equitable school science.

Limitations of the cultural difference lens for Julio's case

Although the cultural difference lens offers potential, as is the case with any lens, there are limitations. Julio's account, told through the cultural difference lens, raises the possibility that, unless a class includes Latino cultural values like *educuación, famildad, kinship* and *humildad* and/or does not actively leverage cultural resources Julio brings to the setting, then Julio, and students like him who share similar cultural values, will not be successful. This seems rather deterministic and lacks nuance. It positions Julio as a passive recipient of the structures set forth before him. We are not ready to embrace this assumption, and we do not agree that the incorporation of Latino cultural values into classrooms is necessarily a prerequisite for or is the *only* way to achieve an equitable and inclusive science education for Latino students.

One reason why this assumption is troubling is that it ignores the possibility that Latino students, or students from other non-mainstream groups, might find science inherently interesting and an endeavour worth pursuing, whether or not it incorporates their cultural values. Our studies of women of colour who persisted in science (Carlone and Johnson 2007; Johnson et al. 2011) demonstrate that some women of colour in science author themselves in ways that leverage resources from their biographies, socio-political positionalities and moral commitments that allow them to navigate science educations and careers that did not always notice, let alone celebrate, their strengths and repertoires of practice. In other words, the cultural difference lens, at least as interpreted by the Julio case, limits the possibility of agency in transforming individuals' positions. On the other hand, we recognise that it was an injustice that the women had to author themselves in these creative ways that sometimes downplayed or denied aspects of themselves.

The cultural difference lens assumes that enduring features of history, like social class, racial, ethnic or gender stratification are primary or remain static over time. This is a benefit in many ways because it forces our attention to, and does not allow us to underestimate, the power of larger societal forces and structures in shaping everyday practices. At the same time, there is not as much room, with this lens, to explain or account for alternative, transformative or creative settings where race, class and gender are not primary determinants of culture.

Another limitation of the cultural difference lens for Julio's case is that it may assume that Julio's experiences would reflect all or even most Mexican immigrant student experiences in the same settings. Our research team followed seven other students from Ms Wolfe's fourth-grade cohort across 4 years of school science (two girls whose families were Mexican immigrants, one boy whose family emigrated from Ecuador, one mixed race boy whose father was from Colombia and whose mother was from Germany, one African-American girl and two white girls). While all students' science trajectories became increasingly difficult and troubling because of the problematic teaching practices and classroom culture in Mr Campbell's sixth- and seventh-grade classrooms (Carlone et al. 2011), none of them experienced the dramatic shifts in science engagement and learning that we witnessed with Julio. His case was extreme. Furthermore, the two other Mexican-American students and the Ecuadorian American student continued to earn good grades in science and did not regularly express the overt disaffiliation Julio did. In fact, of all the case study students, the one who was most consistently even with her identity performances in school science across all 4 years was a girl whose family emigrated from Mexico a few years before Julio's family did. In other words, she performed herself similarly in every context, whether or not Latino cultural repertoires of practice were included in the classroom culture.

A closely related problem with the cultural difference explanation of Julio's experiences is that the aspects of Ms Wolfe's fourth-grade classroom culture that enabled Julio to be recognised and celebrated as a 'smart science student' were not necessarily Latino-specific or Mexican-immigrant-specific. The practices that celebrated collaboration (which aligned with *famildad* and*kinship*) shared and socially constructed scientific knowledge (which aligned with *educuación*), encouraged students to question authoritative accounts of knowledge (*educuación*) and to show empathy and encouragement to others as they struggled to express themselves in a second language (*humildad*) worked for all students, not just the Latino students (see Carlone, Haun-Frank, and Webb 2011, for evidence of the classroom culture encouraging all students' science learning and affiliation).

We see here, also, the danger of essentialising Latino culture and/or with confusing culture with ethnicity. In the original manuscript, Rockford and Carlone (2011) acknowledged this risk and tried to guard against this interpretation of their work. To do so they drew on Ek (2009), who acknowledged the fine line between essentialising the identities of Latino/as and recognising them:

as an ethnic group as bound together by a shared culture structure and a sense of a particular ethnic identity … It is important to point out that Latino/a students are agents who construct their identities within these larger macrostructural categories and labels … these categories … are meaningful to the lived experiences of Latinos/as in the United States in that these categories often affect their educational choices and opportunities. (407)

Even with these caveats, one could still critique the cultural difference lens for Julio's case as bordering on essentialism. A consideration of culture as *produced*, as is the case with practice theory, rather than *assumed a priori*, which is often the case with cultural difference lenses, minimises this risk more robustly.

Finally, issues of power are under-examined in a cultural difference lens for Julio's case. Power is acknowledged in as much as the oppressive social, political and economic circumstances that Latino/as in the USA face and in the ways schooling is not set up to recognise, leverage and celebrate Latino cultural repertoires of practice. In other words, power is constructed in a rather uni-directional, top-down way. The implied solution of Julio's situation, with a cultural difference lens, is the necessity of transforming school culture so that it is more aligned with Latino cultural values and practices. Doing so, we agree, would provide a powerful first step. However, we argue that step alone is not sufficient because of the many, multi-levelled issues of power inherent in society, schooling and science. To begin with, if we only pay attention to disrupting power locally, in a given classroom, we run the risk of advocating a school science that is *too locally situated* and disconnected from larger networks of power (Carlone et al.2009). A too-local science, for example, might leave students feeling competent and affiliated in one setting only to discover that they are under-prepared for university-level science courses (Johnson 2007). Practice theory, we argue, allows us to look at power in more multi-faceted, multi-levelled ways.

Analysis #2: practice theory lens applied to Julio's case

Practice theory is adept at helping to explain why Julio became more alienated from school science than his classmates, drawing attention to the central puzzle of Julio. When we examine Julio's case through a practice theory lens, we pay attention to the ways local practices produce group-level meanings of ‘science’ and ‘science person’ that align with and/or contest larger socio-historical meanings. Further, this lens allows accounts ‘for persons acting in cultural worlds’ (Tonso 2006, 275). With this lens, we understand that what individuals learn and know depends on how social practices enable and constrain participation – in what times and spaces, with what tools, with what goals and endpoints (Margaret Eisenhart, personal communication, November, 1998). In this view, culture is affected, but not determined, by history and structure (Eisenhart 2001a). We ask: Who was he held accountable to be? How accessible, achievable and compelling were these implied identities and practices for Julio? How were those meanings similar to and different from what we see in traditional school science, which has a history of excluding and oppressing students from non-dominant groups? This lens toggles between structure and agency, micro- and macro-levels of analysis, and group-level and individual meanings.

Thus, to examine Julio's success in fourth-grade science, we examine the regularly occurring practices, and the accompanying implied meanings of science and science person, in the classroom. We cannot examine Julio's affiliation with fourth-grade science (i.e., his agency),

without also examining the collective, patterned meanings of science and science person produced in the group (i.e., local structures). Furthermore, we understand the significance of Julio's affiliation better when we take into account historical, political, social and cultural meanings of *Latino male* participation in *US school science* (each italicised word carries with it its own powerful, enduring social, political and cultural history). In a slight shift from cultural difference perspectives, however, those socio-historical meanings are viewed as shaping and shaped by local practices and not necessarily as the enduring or primary influences on local practices and meanings.

So, in the fourth-grade (Ms. Wolfe's) classroom, scientific investigation was culturally produced as involving careful observation, question-asking and trying out one another's ideas together; it was a collaborative and generative endeavour (Carlone, Haun-Frank, and Webb 2011). Everyday practices of sharing scientific ideas with others; being patient and polite active listeners of one another's ideas; and being curious, critical thinkers implied a meaning of science that contested traditional socio-historical legacies of school science. These practices opened up spaces for participation and affiliation traditionally left closed for non-dominant students. The cultural meaning of ‘smart science student’ implied by these practices was made accessible to all students through consistent modelling, labelling and socially constructing expectations for what counts as ‘good practice’, and the teachers’ unwavering expectations that all students perform themselves as smart (Carlone, Haun-Frank, and Webb 2011).

The purpose of fourth-grade science was not to arrive at pre-determined answers and fill students’ heads with science content knowledge, but to produce students as careful observers of the natural world and natural phenomena, to think critically and to ask thoughtful questions that arose out of direct experiences with the natural world and natural phenomena. Doing so required that students embrace and perform the values of empathy, generosity, scepticism and collaboration. No one person could ‘own’ the knowledge; knowledge was shared.

The teacher did not solely create these cultural practices and values; one person does not create a culture. Students had to sanction, sustain, contribute to and participate in these practices in order for the class to achieve these cultural accomplishments. In Ms Wolfe's class, although students needed her direction, modelling, scaffolding and consistent reminders, all students aligned themselves (most of the time) with the cultural practices. Incidentally, these norms did not come ‘naturally’ to all students; many had to do significant identity work to align themselves with the norms, even though the norms were more inclusive than those implied by socio-historical legacies of school science. For example, Adam, another student in the class, often tried to invoke authoritative scientific texts to display his scientific knowledge. Ms Wolfe worked hard throughout the year to get him to question authoritative sources and to diminish the power of the ‘know-it-all’ student in her classroom. Adam may have been labelled as the ‘smartest science student’ in traditional school science contexts. But, in this context, many other students explained he was not as scientific because he was ‘too technical’. This finding helps demonstrate students’ buy-in and take-up of a broader meaning of science person.

The fact that Julio's teacher and some of his classmates recognised him, with his under-stated performances, as one of the smartest science students also demonstrates students' buy-in of a broader meaning of science student than would likely be the case with a classroom that reflected socio-historical legacies of school science. Again, the cultural accomplishment of contesting legacies of school science in this way cannot be over-stated; this was a significant accomplishment.

Julio's participation, in fourth-grade, indicated his approval and buy-in of the cultural practices and values and also demonstrated his roles in sustaining the classroom's cultural practices. He was persistent, collaborative, keenly observant, curious and had a love of discovery. In fact, his love of discovery was often infectious. As just one example, one day he made a discovery that, if the tank of African dwarf frogs was dark and left undisturbed, they were more likely to come to the surface to eat. After discovering this behaviour and communicating it excitedly to the teacher, the entire class came over to observe the frogs. His discovery and keen observations consistently played a role in sustaining the meaning of scientific investigation as collaborative, open-ended and dependent upon careful observation.

In sixth- and seventh-grade science, classroom work was dominated by worksheets, bookwork and the occasional cookbook lab and research project. Authoring himself as sole arbiter and authority of knowledge as well as primary 'entertainer', Mr Campbell positioned students as obedient recipients of his knowledge and/or as good audience members for his overtures to entertain. These practices implied very narrow meanings of 'good science student' and, in this case, the teacher had a lot of power in defining the classroom norms and values. To pull this off – because we know one person cannot create culture on his own – these norms and values drew heavily on socio-historical legacies of schooling. In other words, this way of 'doing school' made sense and was sustainable because it connected neatly with long legacies of teachers as authorities, students as passive recipients of knowledge and schooling as entertainment. Students had only limited agency regarding their participation. For example, they could perform: the obedient, diligent student; the admiring, appreciative student; the vocally disruptive student; or one who quietly opts out of participation. While many of his classmates chose the former two roles, Julio chose the latter role most often – quietly refusing to work diligently on his bookwork and sitting impassively during Mr Campbell's attempts at humour and entertainment.

To understand Julio's sixth- and seventh-grade performances from a practice theory lens, we examine the subject positions (meanings of 'science person') available to him and the ways he takes up, resists and/or transforms those subject positions. Why did other students, even those who experienced Ms Wolfe's excellent, student-centred pedagogy a couple years earlier, 'buy-in' to the limited subject positions and the narrowly defined classroom norms and values, while Julio did not?

One way to understand this is to draw on Willis' (1977) classic educational ethnography, *Learning to labour: How working class boys get working class jobs*, where he

examined two groups of working-class boys in a British secondary school. One group – the ‘lads’, fully expecting to leave school at age 16 to pursue jobs requiring manual labour – openly and collectively resisted school authority, engaging in behaviours like fighting, drinking, smoking and ‘havin’ a laff’ at teachers’ expense. Unlike the ‘ear-oles’, the ‘lads’ did not buy into what Willis called the dominant educational exchange paradigm; students receive teachers’ knowledge and school's sanctioned approvals (passing grades, diplomas) in exchange for acquiescing to teachers’ control. They viewed the promise of school's rewards (a way out of their existing socio-economic status) as a false one and in not playing by the cultural rules of the schooling game they ended up in the same kinds of manual labour jobs their fathers occupied. Incidentally, the school's rewards were false; the ‘ear'oles’, who bought into the dominant educational exchange paradigm and believed in school's rewards, ended up in similar, unsatisfying working-class jobs.

Willis' work was so influential and speaks to Julio's case as viewed from a cultural production lens because his analysis considered the role of larger, societal and institutional structures in limiting, but not determining, agency. He was one of the first theorists to account for the production of culture, even though those cultural productions explained the lads’ eventual social reproduction. Tonso (2006) explains:

As such, the cultural level of day-to-day, go-to-school activities was constantly under production—where the lads were very active players, indeed—and the structural level of social class hierarchy penetrated into everyday social interactions (the cultural level) despite the school's progressive, liberal democratic ideals (at the institutional level). (276)

In Willis' account and Tonso's interpretation of it, the culture does not exist on its own; it is produced in practice, shaped by and shaping larger social and institutional structures. Further, we understand the lads’ resistance as not only a *reaction to* practices they found suspect and/or unsatisfying (as might be the case with cultural difference theory) but, also, as the *production of* new meanings of schooling – of culture. At the same time, Willis’ case of the lads demonstrates their agency in collectively creating new meanings of schooling that were more believable and rewarding (at least in the short term).

Perhaps Julio similarly rejected the dominant exchange paradigm of education to which classmates agreed. Although Julio did not express these sentiments exactly, we could initially infer that might have been the case with Julio's sixth- and seventh-grade science performances (and then follow up with additional data collection). The point is, with practice theory, we look upon Julio's different participation in fourth-, sixth-, and seventh-grade science in expansive ways; what does his resistance say about the struggle over the meaning of schooling and/or school science? Dominant meanings of schooling are not passively absorbed; they are ‘fought over continually’ (Giroux, 2006, 128). It is worth noting that Julio did not have similar opportunities as the lads to cause great ripples in local meanings of school science in Mr Campbell's classroom because he was not operating as part of a group who was resisting the

institutional and classroom cultural practices and values. Willis argued, ‘The basis for, and impetus of, this [cultural] production is the informal social group and its collective energies’ (Willis 1977, 173).

Benefits of the practice theory lens for Julio's case: what it enables us to see and understand

A practice theory account, in summary, cannot examine Julio out of context from his socio-historical and political positioning, the socio-historical legacies of school science for Latino males, the cultural practices of his classroom and its implied meanings of ‘science’ and ‘science person’, and the ways he takes up, resists, transforms and/or negotiates these meanings, positionings and contexts. It is a multi-level, multi-faceted analysis that toggles between contexts and units of analysis. These are strengths of practice theory.

The practice theory lens assumes that culture is *produced* in practice. It does not assume, a priori, that students from certain ethnic, racial or geographic groups will act certain ways and embrace certain cultural practices or that their resistance, take-up and transformation of cultural meanings and practices will necessarily be distinct from those of their age-level peers from other groups. This addresses one shortcoming of the cultural difference lens; it minimises the danger of essentialising culture and treating all students from one ethnic or racial group as monolithic. Thus, with a practice theory lens, it is easier to examine within-group differences; we do not have to assume that all Mexican-American students responded in the same ways Julio did.

Practice theory provides an account of the production of culture *and* power. Everyday practices in Julio's sixth- and seventh-grade classroom produced a meaning of science and science person that were exclusive and narrow, shaped by and helping sustain larger, exclusive socio-historical legacies of school science and oppressive social structures. In examining these practices, it is easy to see school's ongoing disciplining of students (Foucault 1977) and the ways larger social structures get produced in everyday practice. Julio, through his unwillingness to play school science's games in sixth- and seventh-grades, gets framed as ‘the opposite of ambitious’ – i.e., as lazy. This meaning of Julio, as a lazy, Mexican-American boy reproduces, sustains and legitimises enduring social, historical, political and economic meanings. A practice theory lens examines the iterative production of power in everyday practice, rather than assumes that power operates in a top-down, uni-directional fashion.

Julio's sixth- and seventh-grade science stories, as told from a practice theory lens, account for limits to his agency and the ease of cultural reproduction. At the same time, the practice theory lens allows us to recognise transformative potential in Julio's story. For instance, everyday practices in Ms Wolfe's class produced Julio as smart and scientific. The fact that all students affiliated with some characteristics of the meaning of ‘smart science person’ (Carlone, Haun-Frank, and Webb 2011) implied that the class's practices produced a meaning of science accessible and believable for all students, quite a transformation from typical school science.

This is a departure from the cultural difference lens, which can rest on an implicit assumption that enduring features of history are always primary or remain the same over time. Julio's success does not have to be explained based on his ethnicity or gender. Practice theory emphasises examination of how historical persons are formed in practice, within and against larger societal forces and structures which instantiate themselves in schools. We recognise Ms Wolfe's classroom culture as a radical accomplishment because we understand the incredible power socio-historical legacies of sorting and excluding inherent in schooling and science.

Limitations of the practice theory lens for Julio's case

The practice theory lens, as applied to Julio's case here, does not focus on what Julio brings to the setting in the ways that a cultural difference theory lens (in particular, in the ways a funds-of-knowledge lens) would. The lens focuses on his negotiations with and contributions to the culture of the setting as it gets produced, but it under-represents how the resources he brings to the setting affect the ways he will react to the setting. We note here, however, that this emphasis is not incommensurate with a practice theory lens. For example, Holland et al. (1998), using a practice theory lens, highlight the ways individuals leverage different resources in creative ways to enable new forms and meanings of participation in group settings.

Furthermore, the practice theory lens demands attention to multiple contexts and units of analysis – socio-historically enduring meanings (macro-structural), group-level meanings (cultural) and individuals' take-up, resistance and/or transformations of those meanings (individual). While we view this as a strength, it also is limiting in the time it takes to collect, analyse and interpret the data. Although ethnographic studies are time-consuming, a practice theory perspective often adds another layer or two of analysis in considering the iterative meanings produced by the individual and group, which shape and are shaped by macro-level structures.

The practice theory lens does not lend itself as well as the cultural difference lens to neat, prescriptions for practice. The emphasis is on understanding the meanings produced in groups, with the understanding that the outcomes (cultural accomplishments) are continually in question (Eisenhart and Finkel 1998), and can be imaginative and unpredictable. The 'local' nature of cultural production might limit the findings' generalisability to other settings.

Conclusion

In this article, we unpack implicit meanings of culture that pervade many cultural studies of science education. Table 1summarises some of our key arguments about the strengths and limitations of different conceptions of culture for science education research. Current literature in science education (and educational research in general) is dominated by cultural difference perspectives, such as the funds of knowledge research we describe in this article, but also evident in the research about culturally relevant pedagogy. While the cultural difference lens provides strengths, we argue that science education scholars have taken up this lens uncritically, without attention to its limitations. We challenge science education researchers interested in equity and

who invoke culture as an analytic lens to lay bare the assumptions of culture underlying their work. The predominance of cultural difference lenses in science education research points to their uncritical adoption. Equity research needs to be mindful of blind spots; cultural studies in science education have not necessarily done so.

Table 1. Summary: cultural difference vs. practice theory

Lens	**Strengths: What it allows us to see**	**Limitations: What it overlooks**
Cultural difference lens	Non-deficit-based explanation of Julio's success and difficulties	Implied solutions (i.e., to correct cultural mismatches) lack nuance
	Makes visible values and practices that undergird traditional science education and that may actively work against equitable science education	Though it recognises the power of larger social structures, it assumes those structures remain static and/or are primary determinants of culture
	Immediate applications to classroom practice that force acknowledgement and leveraging of students' strengths, backgrounds, values and life experiences	Assumes power is uni-directional
		Ignores possible intra-group differences and risks essentialising groups
		Implies different solutions for different cultural groups, making applications to a multicultural classroom difficult
Practice theory lens	Enables a multi-faceted, iterative analysis; from the micro- to macro-, from the group to the individual	Limits the focus on what histories, resources and practices students bring to new settings and newly formed cultural groups
	Assumes that culture is produced in everyday practice, allowing for a more nuanced perspective of intra-group differences and minimising risks of essentialising cultural groups	Time-consuming methodological endeavour to pay attention to multiple levels of analysis

	Provides an overt examination of the ways power shapes and is shaped by everyday cultural practices	Lends itself to a more global perspective, which does not always enable neat prescriptions for classroom change
	Accounts for possibilities of transformation and helps illuminate limits to and possibilities for individual agency	

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