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Unpacking science for all through the lens of identities-in-practice: the stories of Amelia and Ginny

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Abstract This manuscript reports on an ethnographic study of two Latina students who attended an urban middle school in a low-income community, and how they exhibit agency by purposefully authoring identities-in-practice that value nontraditional ways of knowing and resources. Drawing from both global feminism and sociocultural theory, we argue that by paying careful attention to how and why urban girls author identities-in-practice we can gain deep insight into the noncommodified forms of knowledge, relationships and activities that make up their engagement in science and that girls often employ to participate in science related communities in ways that are culturally and socially just and sustainable.

Keywords Urban education · Girls' science education · Middle school science · Identities-in-practice · Social justice

Introduction

"Science for All" has become so indelibly linked to the science education reform initiatives in the US, that assumptions about what it means or its value to the individual or to society have remained unexamined. While a glance at the most recent literature in science education reveals that this phrase takes on different meanings based on the theoretical stance it inhabits, in mainstream policy and practice circles, the meaning of "Science for All" has deviated little from what was intended when first introduced in the late 1980s. As written in *Project 2061* (AAAS 1989), science education

> should help students to develop the understandings and habits of mind they need to become compassionate human beings able to think for themselves and to face life

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> head on. It should equip them also to participate thoughtfully with fellow citizens in building and protecting a society that is open, decent and vital. America's future—its ability to be a truly just society, to sustain its economic vitality, and to remain secure in a world torn by hostilities—depends more than ever on the quality of education that the nation provides its children. (p. v)

The meaning and boundaries of "Science for All" are manifold but intersecting: Knowledge of science is both necessary and important for national security and economic vitality. Yet, the kind of economic vitality intended by such legislation refers to the vitality of the nation-state, not about individual economic advancement. Individuals have both the right and responsibility to engage science to take up the challenges of the day. Science as a way of knowing and doing can solve our problems.

National legislation in the US over the past decade has amplified these meanings. Standards documenting what students should know and be able to do in order to be scientifically literate have been written. High-stakes tests for holding students accountable for learning such knowledge have been implemented, with wide ranging economic implications that include loss of funding to schools whose students do not score well.

While a growing body of research has attended to the challenges faced in meeting science for all especially among low-income urban youth, English Language Learners (ELL) and underrepresented ethnic and racial groups, the national policy attention has been focused on how these findings translate into better achievement scores (Lee and Luykx 2006). For example, the most recent science education reform efforts have attended to the challenges of fostering "Science for All" through a concerted effort, both financially and intellectually, to focus on the design and development of the "next generation of curriculum materials," with much attention given to implementing these materials in "high needs" districts. The vast majority of these efforts are grounded in the belief that all students can learn science if they are appropriately scaffolded. Primary attention has been paid to how these materials have been shown to improve student learning as evidenced by standardized test scores in science (Schnieder et al. 2002). However, other researchers have taken other approaches to understanding the influence of new curricula, demonstrating potentially interesting advances in how students foster new discourses, identities and practices in science that merge their own social worlds with the worlds of science (Calabrese Barton et al. 2004; Moje et al. 2001).

Despite these advances or perhaps because of these advances, little attention has been given to unpacking the meaning of "Science for All" in current policy and practice. Achievement scores, tightly aligned with content standards, remain the gold standard for documenting the impact science education has on learners, allowing other potentially powerful constructions of what it means to learn science fall away to the side as less important. Does science for all equate to all students achieving adequate test scores around a particular body of content? What implication does this stance have for other ways students may demonstrate knowledge and practice in science content, or how or why one might choose to engage in their classrooms, communities or society scientifically? Is national economic vitality and security the crux of an education in science? Should science literacy be about fostering the acquisition of the canon of western science as evidenced by exam scores? Should attention be given to promoting a core student identity as a future productive member of the labor market?

The impact of globalization on science education seems to be explicit and cannot be underestimated in recent global efforts as well. For example, identifying and then franchising "best practices" in science, technology, engineering and mathematics (STEM)

education has been pushed by many in the US and Europe in order to "harmonize" STEM curricula among the nations in the European Union and in the United States in order to produce a skilled, "globalized" workforce (Yuan 2004). Thus, even as the goals of "Science for All" aiming to equip all students to "think for themselves and face life ahead" are encouraging, the personal goals and aspirations of individual students seem likely to be marginalized by reform-based practices crafted to instruct students on how and what to think in order to ensure they contribute productively to building a robust economy. While many assert that it is necessary to "globalize" science education along these lines if a nation is to maintain its economic viability in the global economy (Charlton and Andras 2006), such an approach situates science education as a means to an end—that of producing skilled labor for global STEM related industries, with a specific emphasis on ensuring economic viability for the home nation.

Our own work in low-income urban communities however, disrupts these very intentions and gives us pause to examine how and why one might author a place in science. Take the case of Amelia for example. Amelia was a student who started 6th grade science labeled as a "problematic student" by the science teacher. However, as she started participating, together with both her parents, in a series of science fieldtrips (including "fun" oriented sessions like a fishing trip as well as more traditional science field trips to science museums and botanical gardens) organized by her school, Amelia authored for herself an identity-in-practice as the resident student field-trip expert that was fundamentally grounded in the relationships she and her parents developed with the science teacher in these out-of-class settings. As the teacher started to position Amelia as the field trip "spokes-student" by calling on her field-trip experiences to share with the rest of the class as publicity for future fieldtrips, Amelia's authority gained from such fieldtrips translated into the more traditional space of the science classroom where her identities-in-practice transformed from that of a disinterested student to one of Mr. M's target science students. Amelia started to enjoy science, she even rated science as her favorite subject in 6th grade. She hopes to study science in high school and college, yet she has aspirations to eventually pursue art as a career.

This brief example calls into question how science education often positions students as particular kinds of science learners, with particular participation trajectories. If we merely looked at Amelia's in class participation in 6th grade science in the beginning of the school year, she could have easily been positioned as an "outsider" (Costa 1995) whose background is incompatible with science. In other words, teasing out how Amelia's participation in the figured world of fieldtrips influenced her subsequent participation in the figured worlds of the science classroom afforded us a different take on Amelia's authorship and agency in learning science. Even as Amelia professed to aspire towards a career that is not in science, we believe that "Science for All" means working towards providing a robust and meaningful science education for all students regardless of their intended long term science trajectory such that they can make informed everyday decisions based on their expertise in scientific literacy. By taking up "noncommodified forms of knowledge, relationships, activities, and aspects of life," (Carter 2005, p. 575)—knowledge that are not directly quantifiable nor neatly measured by traditional test scores—as reflected in the participation in the school fieldtrips by Amelia, her parents and the science teacher, we argue that we can pay better attention to who girls are and who they want to be with and through science. We further argue that those aspects of science education which are decidedly noncommodified and un-economic in focus—the focus of reform efforts such as "Science for All"—can help to shift attention away from a sole focus on national economic vitality and security to include how the teaching and learning of science can serve

the needs and interests of students and the roles they may want to play in their families, communities and society.

Thus in this paper we take up three key questions:

1. What identities-in-practice do two Latina students author in the science classroom?
2. What is the relationship between authoring new identities-in-practice and a girl's agency and science learning?
3. What does "Science for All" mean when viewed through the lens of these two girls' identities-in-practice?

We believe that understanding these girls' identities-in-practice in the science classroom will help us advance our understanding of why and how youth choose to engage in science and the role they seek to author within science-related communities. We believe that by paying careful attention to how and why urban girls author identities-in-practice, we can gain deep insight into the noncommodified forms of knowledge, relationships and activities that girls often employ to participate in science related communities in ways that are culturally and socially just and sustainable.

Feminism, science and globalization

Global feminism is a phrase we use to describe the ideas emerging from the most recent wave of feminist scholarship attentive to transnational and globalization issues while drawing upon critical, anti-racist and postcolonial perspectives (Mohanty 2003). Global feminism weaves together a variety of women's issues, keeping central the tension between women's differing experiences, knowledge, and socio-material situations due in large part to geopolitical location. Across the global feminism movement, there are three themes around which theory development, research, and political action coalesce: (a) that globalization is gendered, potentially causing more harm towards women because it perpetuates inequality; (b) that globalization requires new "tactics" for foregrounding women's rights that attend to the feminization of poverty, migration and unfair labor practices, while at the same time work to re-invent globalization in support of women; and (c) that solidarity is an important intellectual and political activity for organizing and communicating women's geopolitical experiences and knowledges for transforming globalization (Gill 2006).

When taken into the sphere of science education, global feminist perspectives put into focus the idea that science and education are entrenched in economies and political realities. It has been argued that scientific research is one of the pioneers of global communication especially at the post-doctoral level, where highly qualified individuals travel the globe to work in renowned research laboratories (Charlton and Andras 2006). Nations tend to specialize in certain niches in science so as to economically diversify to better complement the sharing of resources amongst nations. For instance, Germany is cited as the country with the most number of Nobel prizes in Chemistry. The argument is then extended downstream, that it is important to "progressively globalize" lower science education so as to efficiently develop a "trading medium of internationally standardized and quantitative educational credits—for instance, standard certificates, objective comparative examinations, and a hierarchical qualifications structure which will almost certainly be based on the United States system" (Charlton and Andras 2006, p. 896). Such

a standardized system "will operate like a free trade area in economics—to benefit the participants at the expense of those who are excluded" (p. 872).

Yet those critical of these kinds of colonizing globalization trends, like global feminists and critical theorists, argue that such a corporate approach to science distances the latter from the act of situated knowledge and identity production. In other words, such a corporate approach has deflected attention away from how economics and politics play a role in the production of knowledge and explanatory systems, has swept away contradictory class interests, and has failed to raise questions dealing with what knowledge counts most, for whom, and for what purpose (Calabrese Barton and McLaren 2001).

For example, Carter (2005) argues that the catch phrases of globalization discourse such as "global citizens" and the "knowledge economy" make manifest the international contest nations are engaged in where knowledge is the principal currency and schools and classrooms the competition rink. Since information technology as well as science based research and development are lucrative economic goldmines, there is a need to produce skilled labor to serve in these sectors. Education reforms, including "Science for All," are therefore criticized as economic investments by the state, aimed largely towards creating human capital especially in light of Sputnik and reports such as *A Nation at Risk*. Such competition takes shape in international testing instruments such as the TIMMS for Math and Science, where outcomes are narrowly defined to measurable scores in the subject areas. International students regardless of ethnicity, gender and socioeconomic backgrounds are homogenized in such testing instruments, further alluding to the myopic determination of the economic agenda which has been uncritically applied to education through such measures. Furthermore, terms like "global citizens" and "knowledge economy" are also problematic in that they mask the inequitable distribution of resources and opportunities afforded only to certain students i.e., inequities in education, by projecting the illusion that all students start from an even playing field and therefore have equal support to work towards being globally mobile and equally employable through such reform efforts as "Science for All".

Global feminists further argue that in addition to denying the corporate approach to science education, real efforts towards equitable science must take into account how geopolitical location matters in how and why girls learn science across the globe. Such a stance is antithetical to the perspective of globalizing science education. The notion of globalizing science education rests in standardizing curriculum and learning outcomes regardless of context, described as the "evolution towards a common 'educational language', a standard educational structure, examinations and evaluations" (Charlton and Andras 2006, p. 870). For science education, such a language is "factual, objective, descriptive and precise" (p. 871), essentially the language of traditional dominant science discourse that is white, middle class and male. Not only is gender treated as a non issue, the proponents of globalizing science education are unapologetic in their promotion of such a science education reform agenda in pursuit of comparative advantages in the international market place (Bishop 2004). Some would argue these globalizing tendencies are at the heart of US reform initiative science for all (Carter 2005).

In short, the ideology of globalization translated into education goals and reform efforts seem to promote a core student identity as merely a future productive member of the labor market. Students are thus viewed as marketable commodities rather than unique individuals. Such an ideology of globalization can alienate groups who adopt "anti-market" identities resulting in a struggle over the meaning and value of knowledge (Carnoy and Rhoten 2002). We believe that science education researchers are therefore called to critically question the form and function of science education reforms. Part of this questioning

ought to emphasize the importance of working towards a science education that "values noncommodified forms of knowledge, relationships, activities, and aspects of life" (Carter 2005, p. 575). We agree with Carter and further argue that critical to valuing noncommodified forms of knowledge, relationships, and activities is understanding how and why these ways of knowing and being can help to reduce the distance between science education, identity, and knowledge production. One approach to doing so, which we outline in the remainder of our paper, is to focus on student *identities-in-practice* and, from a global feminist stance, think through how such identities-in-practice provide both contexts and tools for fostering individual and collective agency.

Reinventing globalization through the lens of identities in practice

Drawing our cues from Gill (2006), we believe that these feminist concerns regarding science, education, and globalization, require the invention of new tools if we are to move forward intellectually and politically towards a more equitable instantiation of "Science for All." Learning science is about struggling over the meaning and value of local/global knowledge at the same time it is learning how to participate in transnational discourses about labor, values, and individual and community roles, rights, and responsibilities. Understanding these dimensions to learning involves more than attention to achievement outcomes as historically defined. Take the case of Kozoll and Osborne's (2004) research on the relevance of science to the life worlds of migrant students, for example. These authors reveal to us the possibility of a deep and enduring engagement with science through non-prototypical experiences. They suggest that science has a higher plausibility of being recruited into a student's sense of self when more than its intrinsic value as a discipline is applicable to the lives of these migrant students. Studies like these imply that students' ontological development with regards to science, that is, how students develop identities while engaging in science, is an area that should not be ignored if science education is indeed to serve the needs and interests of all students.

Identities-in-practice

Lave and Wenger's (1991) framework of situated cognition emphasizes the link between learning and identity formation. Learning is viewed as legitimate peripheral participation where new members are inducted into a community of practice as apprentices. Therefore, to learn in that community means to become "a different person with respect to the possibilities enabled by these systems of relations" (p. 53). The 6th grade science classroom can be viewed as one such community of practice where members are bound by specific ways of being endorsed by the science teacher who is the "master practitioner." Students in negotiating their membership are crafting identities and developing certain ways of being in the science classroom while engaging in activities and tasks and in relating to the teacher and their peers. As students engage in science in their classroom, they are acquiring certain identities that are related to who they are and who they want to be as they engage in this community of practice. Learning science is thus manifested through the transformation of "identity-in-practice" in the science classroom. Moving towards full membership entails "an increasing sense of identity as a master practitioner" (Lave and Wenger 1991, p. 101). Learning science is thus manifested through the transformation of "identity-in-practice" in the science classroom.

Bringing our understandings of identities-in-practice into a global feminist stance demands that we pay attention to the idea that one inhabits multiple worlds and is involved in diverse communities. The consequence is that we have to think about how any given individual has a repertoire of identities when seeking membership in a new community of practice, and that these identities are often hierarchically valued or positioned by others through power relationships and societal structures. Thus, the formation of a new identity is contingent on the tensions and negotiations between differing and potentially opposing identities. Agency arises from this "space of authoring" when worlds and identities collide in the struggle to author a new identity in a new space (Holland et al. 2001, p. 63). "Identities-in-practice" in the context of this research therefore refer to the identities students acquire or choose to adopt in the science classroom.

The term "identities-in-practice" rather than "identities" is an important distinction because we believe that the environmental factors of the specific community in practice, in this case, the science classroom, exert significant influence on how novice members, such as students at the start of the school year, adopt their in-class identities-in-practice. The science classroom is populated by members who are positioned with hierarchically ranked authority. How novice members negotiate their relationships with the official authority (e.g., the science teacher) and more established members of the science class community (e.g., recognized good science students) determine how their identities-in-practice evolve in the classroom. Evolving identities-in-practice can be inferred from the way students choose to interact with other members, the decisions they make with regards to the assigned tasks in the science classroom, the opinions and questions they raise and also their silence should they choose not to participate.

Figured worlds and identities-in-practice

It is useful to think of communities of practice as "figured worlds" (Holland et al. 2001) in considering the dynamics of authoring a new identity. Holland and her colleagues posit a framework for the development of an identity-in-practice carved out in figured worlds. Figured worlds are socially situated, and are "peopled by the figures, characters, and types who carry out its tasks and who also have styles of interacting within, distinguishable perspectives on, and orientations towards it" (p. 51). Individuals have the proclivity to be drawn into certain figured worlds to shape and be shaped by them in authoring an identity. The act of authoring an identity is necessitated via a constant state of dialogism where "sentient beings exist in a state of being 'addressed' and in the process of 'answering'" (p. 169).

On initial entry into a figured world, novices gain social positions that are accorded by the established members of that world. How novices choose to accept, engage, resist or ignore such cues shape their developing identity-in-practice and determines the boundaries of their authoring space, which is driven by a sense of agency. In the struggle to establish an identity in a new figured world, it is important to consider the influence of the other worlds in which one simultaneously inhabits.

For example, Fordham (1993) highlights the substantial social cost African-American female students had to pay in abandoning their native identities in exchange for academic success. In the figured world of their high school, the standards and regulating norms privileged the quiet, White, male student. The girls "were compelled to assume the identity of the 'Other'… they cannot represent themselves; they are forced to masquerade as the authentic, idealized, 'Other'" (p. 132). The prevailing "culture of power" subjugated the

native identities of the African-American girls, who came to accept the quiet, white male identity and its accompanying dispositions as claims to status. Holland and her colleagues remind us that this process of arriving at a particular positional identity happens over time via daily struggles and encounters.

Fordham's story of the African-American girls has simplified the school as one figured world pitched against the native figured world of the girls. In reality, students can belong and move between various hierarchically ranked figured worlds within the context of school. Brickhouse et al. (2000, p. 443) are mindful of the complexities of these dialogic interactions of these worlds when they reminds us of the affinity groups students belong to, such as "a good student, a basketball player, a gossip" and how these identities affect the space of authoring a science student identity in the science classroom. Even within the science classroom, students can enact varying identities in different figured worlds. Examples of these include a whole class context, small group projects, or out of school science-related activities, such as fieldtrips and museum visits.

We choose to emphasize the plurality of identities-in-practice (IdPs) instead of a singular "identity-in-practice" (IdP) as described by Lave and Wenger. A community of practice is not static. Neither is it comprised of only a single space. Global feminists remind us of how communities cut across time and space. The identities-in-practice that are manifested when a student is asked to speak during a whole class discussion differ from those manifested when she is engaged in a small group activity, which in turn may vary from those adopted when the student is immersed in an individual project. Even these spatially determined figured worlds in the science classroom are influenced by larger social and global trends. A student may develop a repertoire of identities-in-practice from which she operates depending on the nature of the space she finds herself in at any given context in the science classroom.

We believe the lens of identities-in-practice, when coupled with a globalist feminist perspective is a powerful lens with which to understand how science for all might be further unpacked in an effort to resist the hegemonic tendencies of globalization. Like the girls in Brickhouse and Potter's (2001) study or the migrant workers in Kozoll and Osborne's study show us, there is a need to delve deeper into the meaning of "Science for All" where the noncommodified forms of knowledge, relationships and activities that make up the engagement in science of all students become the foci of science teaching, learning and science education research.

Overview of research context

The Inquiry School (TIS) where the study was conducted is situated in a poor neighborhood in the south Bronx. TIS is a new school set up in the premises of a failing large K-8 school. This large K-8 school has 910 students, 45% of whom are African American, and 55% are Hispanic. A telling indicator of the socioeconomic status of these children is the fact that 90% of the students are on the school's free lunch program. During the research, TIS served two grades of students, the sixth and seventh. Each class in TIS had between 28 and 32 students, with a roughly equal distribution of boys and girls. As the school has a science focus, each class of students (except the bilingual class) gets five periods of science each week, with each period lasting 45 min. The school was chosen both for the demographics of the students it serves (e.g., high poverty, minority ethnicities) as well as for its focus on Science.

The principal of TIS

The principal of TIS is young and dynamic. He knows every student by name and actively recruits parents to partner with the school in the education of their children. The principal is always looking for grants to diversify and enrich the education of the students. During the first year of the study, he managed to procure a large grant that stipulated the involvement of parents on science-related fieldtrips. As a result, many parents went with their children, for the first time, to overnight science camps and participated in other fieldtrips and workshops that included the dissection of marine animals and making grape juice in specially held parent workshops. Students also receive a free copy of the New York Times everyday. Although deeply committed to his students, the principal is also acutely aware of the stakes that are directly dependent on student performance in standardized tests in the context of the school being restructured from a failed school. Therefore, there is also a strong emphasis on test preparation and student test performance at TIS. Centralizing control is thus exerted on TIS through such accounting measures and performance indicators which are directly related to the globalization approach to education.

Mr. M, the 6th grade science teacher

The partner teacher, Mr. M, had 5 years of experience teaching urban students at the inception of the study and is committed to teaching science for social justice. He is a firm advocate of student-centered science learning and uses different student-empowering pedagogical strategies such as group discussions, projects, student presentations and role-play. Students in his class thus have access to different "spaces" for science learning, suggesting differing identities-in-practice that may be encouraged to develop in these varying learning contexts. He had also set up his classroom to be inviting to students with a menagerie of class pets including dwarf hamsters, frogs, fish, snakes and a praying mantis. Many students asked for permission to care for these animals in time slots such as before school and during the lunch hour. Mr. M also had clearly defined rules and endorsed identities in his classroom. Most of the time, he enforced his rules strictly. Of Irish and Italian descent, Mr. M was the only Euro-American in his classroom of minority students. He had immense rapport with the majority of students, many of whom regard him as their favorite teacher. Due to his admirable classroom management and relational ties with many of his students, Mr. M was the resident "expert-teacher" other teachers look up to and consult with. After the second year of the study, Mr. M was promoted to head of the science department of TIS.

Neighborhood of TIS

The neighborhood in which the school is located is a harsh one marked by high poverty. It is a predominantly Black and Hispanic neighborhood. From the windows of the 6th grade science classroom, corroded overhead subway railings are in clear sight. On route to the school from the subway station, one passes a funeral house, a dollar store, a mechanics shop and a few small eateries including a fried chicken and pizza place, a deli and a Chinese take-out restaurant. The walls of the apartment blocks as well as the metal grills of shops are liberally scrawled with graffiti. Gritty apartment buildings, many with broken or badly repaired windows, surround the school. There is a small grocery stall across the

school where students like to frequent for snacks and a gospel church known for its service to the needy in the neighborhood with free gifts of groceries, household essentials and clothing made available on different days of the week. The church opens its doors at noon and a long line of minority folk can often be seen quietly queuing for aid from early morning. Fights among weapon-totting street gangs (many of whom count TIS students as loyal members) erupt often at dusk and we were cautioned by the principal to leave the neighborhood before dark whenever possible.

Method

The methodology used for this research study is in the tradition of ethnographic case studies. The two cases presented in the findings were drawn from a larger case study set of seven girls. The girls were followed through the whole 6th grade school year where the researcher was a participant observer in the classroom for three out of five 45-min science lessons a week. Data collection methods included field notes from participant observation, video footage of the girls engaging in science lessons and interview transcripts from five face-to-face semi-structured focus group interviews. As a participant observer, Edna took on various roles such as the teacher's assistant in helping him get materials ready for the lesson to sometimes co-teaching the class. During class times, she also had the opportunity to interact with each case-study student as she sat with them during group work sessions. This also gave the students access to more than one teacher and more opportunities to ask questions. Field notes taken during these sessions complemented the video footage of the whole class that was being filmed and helped create a more detailed description of the going-ons in the science classroom. Each week, we also had informal meetings with Mr. M during one of his prep periods to share our observations as well as to brainstorm ideas for the lessons. Mr. M thus provided the project with constant member checking in his active involvement.

A repository of data was built up for each case study girl. Our data was coded by both authors and discussed at weekly research meetings. If disagreement existed on the meaning or application of codes, we debated differences until we reached consensus. Case by case analysis was undertaken with iterative open coding that is inductive and in vivo in nature. The coding scheme was both girl-centered as well as event-centered. Emergent themes from this twin-coding system informed subsequent axial coding where relationships were established. For girl centered coding, we combed through the data for different lessons in each of the figured worlds featuring the participation of each specific case-study girl. For example, we looked at how Amelia participated in the figured world of the whole class as well as in the figured world of small groups. We watched videos of the lessons, plowed through field notes and read her interview transcripts, all with her as the main focus in bid to understand her participation from her perspective. How did Amelia participate? What salient out-of-school identities did she invoke in her participation, if any? What resources did she draw on in her participation? How did her community of practice respond to her participation? How did she respond in turn? These were examples of what we looked for in the data. Event centered coding focused on specific interesting episodes, or lessons that resonated especially well with Mr. M or the students. An example would be the Animal Project where we looked at how each of case-study girls chose to do this individual project work, guided by similar questions as for the girl-centered coding. Emergent themes from this twin-coding system informed subsequent axial coding where relationships were established. For example, when looking at Amelia, we found that an emergent theme with

her was how she regularly invented new rules in science class through different event episodes. We then moved on to analyze the conditions in which she did so, the consequences of her inventions, her strategies and pin-point actions in inventing rules and so forth.

We surfaced student identities-in-practice by analyzing how each case-study student responded to the teacher-endorsed identities in each of the figured worlds of the science class. We also paid close attention to episodes where the girls engaged in science activities in unexpected or unconventional ways, as this reflected on interesting identities the girls chose to present to the science community of practice. We then collated each girl's identities-in-practice that was manifested in the different figured worlds of school science into her 6th grade school science "identity kit" (see Figs. 1a, b below). Possible links between particular contexts in the community and student manifested identities-in-practice were explored, as were potential changes in the case study students' identities-in-practice both spatially (in the different figured worlds) and temporally (as the school year progressed). As strong analytic themes emerge (i.e., supported by substantial data), axial and selective coding were then undertaken. Grounded theory was applied to surface categories that arose from the text, as well as formulating the emergent concepts into tentative theories (Bernard 2002). Constant comparative methods were applied to the categories and themes as they emerged. Data was triangulated through the different methods used in collection (e.g., fieldnotes, video-footage, interviews with students and Mr. M).

The pivotal roles of student identities in practice

We present two cases drawn from a larger data set of seven girls. These two cases intrigue us because of the juxtaposition between the similarities of the girls' science practices with the differing trajectories these practices afforded the girls. This juxtaposition throws into sharp relief the pivotal role student identities-in-practice play in determining the learning outcomes for individual students and their peers. We illustrate the relationships between the various identities-in-practice in each student's identity kit, sometimes characterized by tensions and negotiations, other times united in a synergy that ushered in novel pathways which aided the student's border crossing into the world of school science. A general portrait of each girl is presented, including narratives on the identities-in-practice authored and the science practices the girls engaged in the figured worlds of school science. We follow the portraits with a cross case analysis of the two cases.

Ginny in 6th grade science

Ginny is a Hispanic girl who lives in the Bronx with her mother and 14-year old step-sister, Jessie. Her parents are divorced and she spends the weekends with her father in Queens where she attends art class and spends time with her father's extended family "always having parties and eating." Her father is a mechanic and works with boilers while her mother is a clerical staff.

Fair-skinned and rosy-cheeked, Ginny was gregarious and cheerful. She was also very good at drawing and had won an art competition in Queens, where her winning entry was then featured in a calendar. Ginny also enjoyed listening to music, dancing and playing games on the computer. Ginny was a good science student with grades that hovered in the range of 85–100. She had a lot of initiative and would stay behind to help the teacher clean

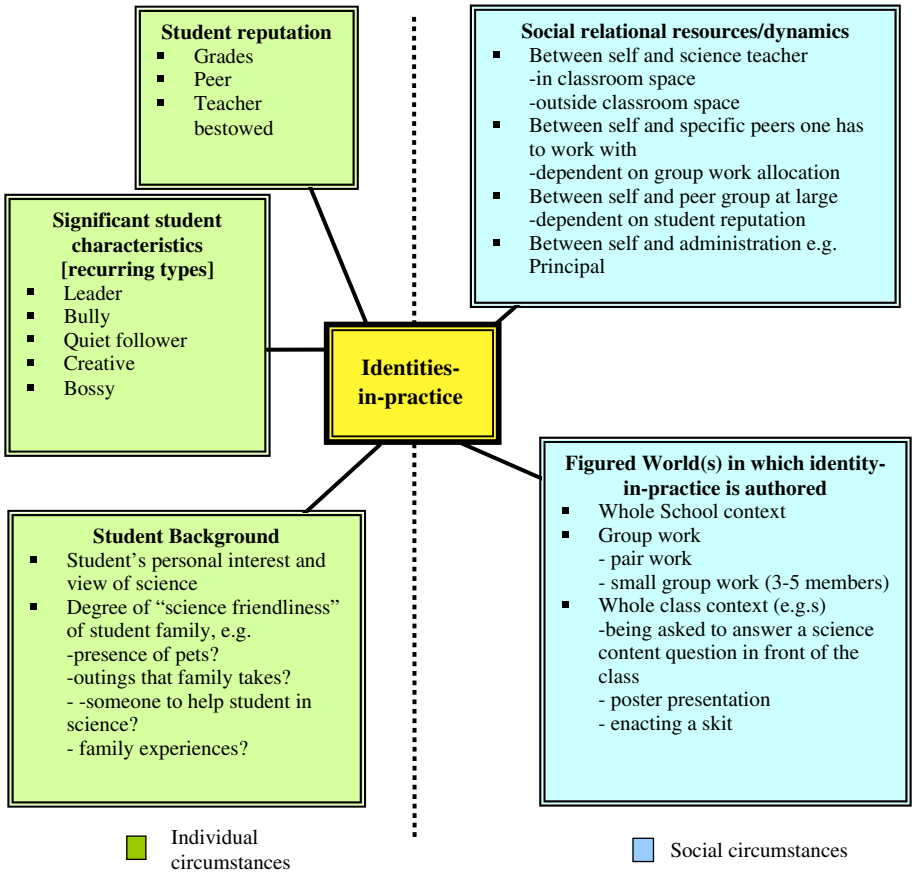

Fig. 1 Student's identity kit—how a student's authoring of identities-in-practice in science class is influenced by both individual and social circumstances (**a**) Ginny's identity kit, (**b**) Amelia's identity kit

up the classroom. Oftentimes she picked up the broom on her own initiative after science class is over. The science teacher also called on her regularly to help him put up posters along the school hallway. Ginny had a good relationship with the science teacher, often popping into his classroom often early in the morning en-route to her home room. She also organized a surprise birthday party for the science teacher, bringing the snacks and soft drinks for the lunch time party. She was very popular with her friends who found her generous and giving. Unlike most of the students in the school, Ginny packed her own lunch which always included a bag of chips which she invariably shared with all her friends, even if everyone got just two pieces of chips each.

Ginny enjoyed 6th grade science. She ranked it as her second favorite subject after math. Ginny's favorite piece of work done in science class was the grape juice group project. Each group had to design a protocol of extracting juice from grapes, perform the extraction, and then write up the protocol describing their product on poster paper. She liked it because it was exploratory in nature. This experiment also reminded her of how she made a smoothie at home with crushed ice, tea and fruit. Ginny saw a parallel of her home activities in science class and she liked that her science student life is relevant to her home life.

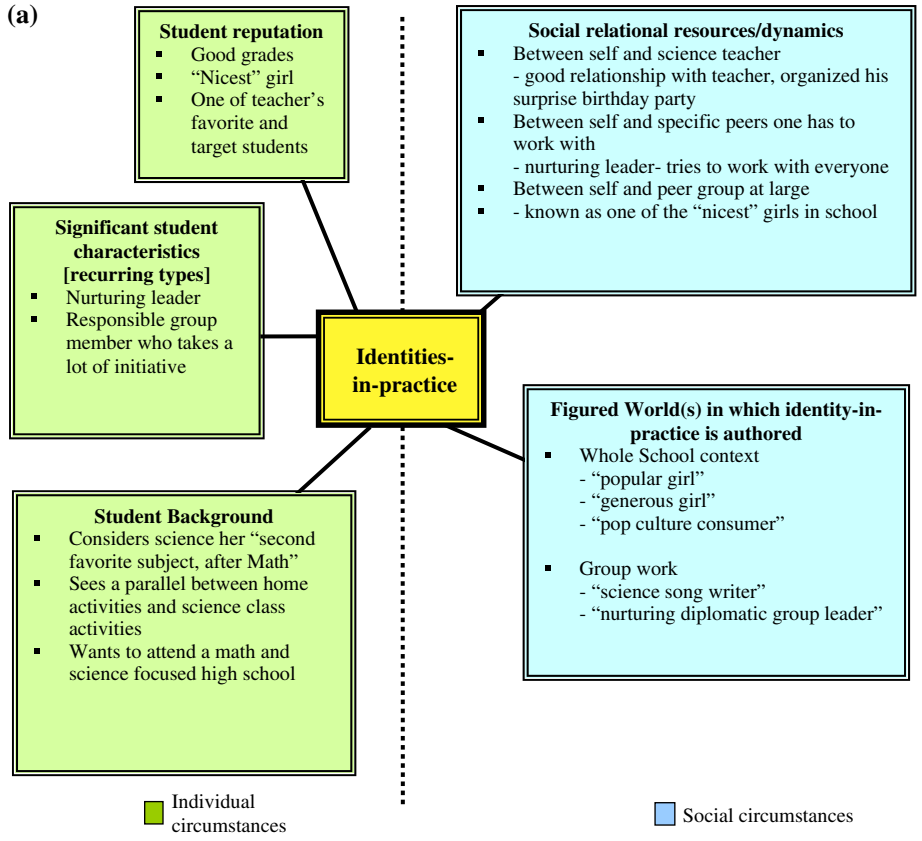

Fig. 1 continued

Ginny saw herself as a successful science student. She gave herself a 7 (scale of 1–7) on being good at science, because she said, "I pay attention, I raise my hands, and because, we use a lot of team work" (which she is good at). Compared to the rest of the class, she rated herself a 6, as there are other excellent science students like "Tricia, Pat and Jackie". She offered "beyond 7, 10! 20! 100!" for her enjoyment in science because of the activities, the teacher's way of teaching as well as the opportunity to work in teams. She wanted to continue pursuing her interest in science by attending a math and science high school. Ginny wanted to attend a high school in the Bronx focused on math and science where her sister Jessie currently is a student. Ginny has hopes to become a fashion designer in future and saw science as a tool to reach her goal since she can learn skills from doing experiments.

Ginny's participation in school science

Ginny was a highly engaged student in Mr. M's science class. She came to class prepared with her notebook and her homework done. She frequently volunteered answers in class discussion, and tended to serve as a leader in group activities. While Ginny never

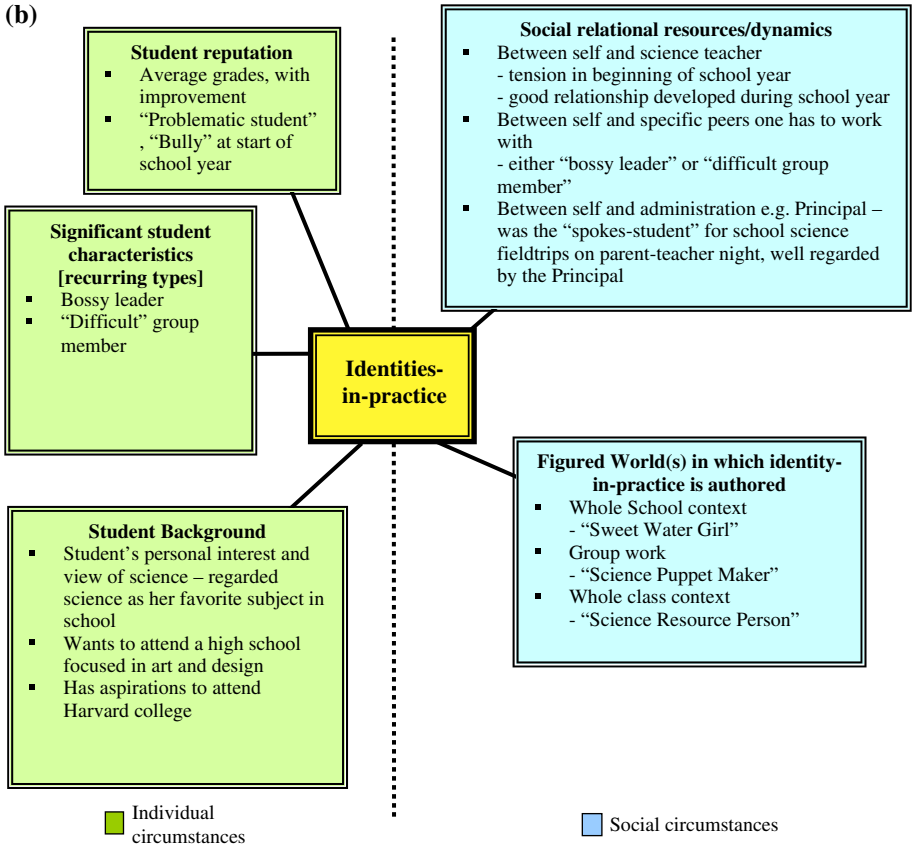

Fig. 1 continued

dominated the classroom discussion, she was well respected among her peers as someone who knew science.

It was typical of Ginny to go above and beyond the teacher's expectations on task, especially if she found the topic or task enjoyable, as was often the case when they engaged in activities that involved artwork, like poster making. It was not that often, however, that Ginny would seek to showcase these talents, as she was a rather modest girl, offering her expertise to help but not to boast or challenge others. In making sense of Ginny's participation in class we share three vignettes: Farming and Weather Patterns, Save the Animals, and the Bone Song.

Farming and weather patterns During a class session on farming and weather patterns, Mr. M. assigned a piece of group work consisting of seven questions relating to farmers and the weather. He gave each group 35 min to work on the questions and group roles were assigned for this activity. The roles include facilitator/leader, time-keeper, questioner, presenter and recorder. Ginny was assigned the role of facilitator. The members in her group were three other girls. Mr. M did not give any explicit rules as to how the activity should be conducted. Ginny embraced her assigned role as the facilitator and laid down her

own rules as to how the group should proceed. Ginny started with assigning a sequence for everyone to answer each question.

> Ok, let's get started. Everybody has to answer the question, first Melanie, then Pamela, then me, then Katherine.

Every member had to offer an answer before the group reached a consensus for each question. This arrangement resulted in Ginny's group being the last group to finish the seven questions. The other groups did not have such a system and got through the questions much faster, relying on the one or two members who offered their opinions. Ginny was very insistent on keeping to this arrangement and had to tell Katherine to wait her turn when she interrupted Melanie because Melanie was hesitant with her answer as she did not understand the question.

> K: My opinion is that…
> G: Wait. You have to wait. I'm explaining to M.

Ginny also took care to explain the question to Melanie again when the latter was confused, thereby encouraging Melanie's participation. Melanie has a habit of wanting to "pass" her turn, and Ginny also admonished Melanie to be more focused on the task. Throughout the group work, Ginny demonstrated nurturing, diplomatic leadership, which resulted in the fruitful engagement of all members in the content, as well as in fulfilling their assigned group roles.

Save the animals Ginny had been paired with Anthony for the "Save the Animals" poster making and presentation. Anthony had a reputation as being one of the school bullies and was inconsistently on medication for bipolar disorder. He was also well-known for his truancy and serious discipline problems. Anthony had been hand-cuffed and led away by the police for his participation in brawls in school. When in class, Anthony was unpredictable and would often erupt into temper tantrums. Less frequently, he would sometimes sleep through the entire science period. As such, he was a challenging student to work with. Most of the students assigned to Anthony's group tended to leave him alone and not engage him for fear of angering him.

Mr. M. had instructed the students, as homework, to bring pictures from magazines for their poster and also to write a rough draft of the script to be posted on their poster. Anthony did not come with any materials. Ginny, on the other hand, had a full folder of pictures, a rough draft of script, and signaled to the teacher, telling him "we have our materials" when the teacher came around checking on the groups. Ginny assumed leadership of the group in taking responsibility for both Anthony and herself, thereby allowing the group work to proceed. Instead of ignoring or dismissing Anthony, Ginny made efforts to include him in the poster making process.

Throughout the group work, she gave Anthony specific directions such as trimming the edges of specific pictures, she was able to engage Anthony and harness his abilities to contribute to the process, in spite of his not having brought anything and the risks of his unpredictable temper outbursts. Ginny consulted Anthony for his opinion on the layout and design of the poster, even though he deferred to her decisions. While working on this poster with Ginny, Anthony was cooperative and engaged with the subject matter. Ginny purposefully collaborated with Anthony in the poster making process and thus secured his interest and effort to collaborate on the project. Mr. M was pleased and surprised at Anthony's enthusiasm for the poster. He commended and praised them both for the team work, "I like the co-operation and team-work that is happening around here!" each time he

passed their table. The teacher held Ginny and Anthony up as an exemplary team that others should emulate.

The bone song One of the science teacher's (Mr. M) aims focused on equipping the students' with specific study-skills. In his classroom, he taught the students note-taking skills, going into such details as using upper case letters for headings, roman numerals for points, etc. Another skill he taught the students was making flash cards to learn and memorize key terms. Mr. M introduced a few at each lesson, with the definitions of the key terms written on the board. The key terms (without definitions) were then printed on white paper and posted on the "key terms" wall above the blackboard. Therefore, at any one time, there would be key terms related to the unit's study posted on the key term wall, with new ones added as they are being introduced with each progressive lesson of the unit, until all the key terms were displayed.

At the end of the unit, Mr. M usually administered a test. Key terms featured prominently in these tests. Students should have all the relevant key terms with their definitions written in their notebooks. Mr. M taught the students how to make flash cards of the key terms. He instructed the students to write the key term on one face of a white card and then its definition on the opposite face. Students then ended up with a stack of flash cards with which they used as study-aids for the end of unit test. Usually Mr. M gave the students some time to revise with their flashcards just before the test. He encouraged the students to test each other by reading one key term to a friend and having the friend give the definition. Ginny, in addition to making flashcards, composed a bone song, borrowing the tune of a popular song, "Mambo No. 5". In addition, Ginny's bone song was sung with dance actions touching each individual bone. The lyrics of her song are as follows:

A little bit of cranium on my head
A little bit of mandible on my jaw
A little bit of scapula on my back
A little bit of humerus on this bone
A little bit of radius on the back
A little bit of ulna on the front
A little bit of carpals just like that
A little bit of meta carpals on my hand
A little bit of phalanges on the end
A little bit of tibia on the front
A little bit of fibia on the back
A little bit of torso just like that [wiggle torso]
A little bit of metatarsals on my foot
A little bit of phalanges on the end
Just wave your phalanges, yeah yeah yeah
Just wave your phalanges, yeah.
A little bit of patella on my knee
A little bit of maxilla beneath my nose
A little bit of clavicle on my shoulder
A little bit of vertebrate on the back of my spine
A little bit of sacrum on my hind
A little bit of pelvis on my hip
A little but of femur on my thigh

A little bit of patella on my knee
Just wave your phalanges yeah yeah yeah
Just wave your phalanges yeah
(http://ed-web3.educ.msu.edu/CalabreseBarton/video.html)

As she wanted to use the tune and rhythm of the song, she had to rephrase some of the definitions, which may possibly have aided her understanding of the material as opposed to someone who memorized the definitions by rote. She was very excited about her bone song and voluntarily sang it for us. She was also joined by a few of her girlfriends whom she had taught the song to. Ginny had successfully merged her love and knowledge of pop culture with her desire to learn and succeed in school science.

Mr. M came to hear about the song when Ginny sang it for him. He liked it very much and had a copy of the bone song typed up and posted on the life science board outside the classroom. Copies of the bone song were also made for Ginny's classmates. The bone song became available as a community resource. Ginny performed well on the skeletal systems test, scoring above 95 marks. She also extended the format of the learning tool the teacher endorses and possibly convinced him of the alternative forms of revision tools that are student-chosen and student centered, tapping into resources outside of the classroom.

Amelia in 6th grade science

Amelia is a Hispanic girl who lives in the Bronx with her parents and 12-year old brother Ulysses. She has several step-siblings ranging in age from 13 to 25. Amelia's mother works in a dental clinic located in the Empire State Building while her father works in a shop that produces air conditioners for cars. Both parents also operate a food catering business.

From being labeled by Mr. M as a "problematic student" at the start of the school year, Amelia transformed throughout the school year to become one of the teacher's more prominent science students in the 6th grade. Her grades improved from the 70s to a 100 for her Animal Project. Amelia enjoyed art and drawing. When she was bored in science class, she drew pictures of flowers and members of her family which she would then show the researcher when class is over. However, such displays of boredom diminished significantly as the school year progressed in tandem with her increasing interest and success in the science class. Amelia started to enjoy science very much, evinced by her faithful attendance on the school science fieldtrips. She liked experiments and hands on activities, especially projects that required drawing since she could then combine her two favorite subjects, art and science. She brought to class the knowledge that she gained from the field trips and shared openly in class discussions. Amelia felt that science is relevant to life and gave the example of the importance of recycling and taking care of the environment, which she strongly felt is the responsibility of everyone.

Amelia liked all the work she did in science class because she felt that there were opportunities for exciting, new exploration. When asked to choose her favorite piece of work, she picked the animal project. She appreciated the autonomy that was granted in that project. Firstly, she had the chance to look up an animal that she wanted and "not one that they chose for us," "they" probably implying the teacher. Secondly, she could go to the library whenever she wanted. Thirdly, the format of the final product of the project to be presented was also decided by the student. Amelia made a poster board for her presentation. Lastly, she enjoyed that this project was solely her own, because "in groups people might say the cheetah is ugly or nice, so working by yourself is better cos you don't need to listen to anyone's opinion."

Amelia particularly enjoyed the presentation, because she "kept my eyes on everybody and I like telling kids what I know about the cheetah and how they act." She received a hundred marks for the presentation. Amelia enjoyed a certain degree of autonomy in her learning. This is evident in her choosing the largely autonomous animal project as her favorite work, where everything from the subject matter, mode of research, to the final product was student centered.

Amelia rated herself a 6 out of 7 (on a scale of 1–7) for being good at science, citing science as her favorite subject, her consistent effort in doing the work in class and the success of her exit project as evidentiary support. When comparing herself to her classmates, she rated herself a 5, as there were the "others" who always achieved top marks for tests while she manages "90 and above."

She rated both the science content and her enjoyment in science a 7, explaining that science had taught her new knowledge that she was not previously aware: "I never knew, um, petroleum make plastic, I never knew that. And I never knew about the ozone layer being destroyed, I never even HEARD of ozone." Field trips were also a contributing factor to her naming science as her favorite subject, especially when her parents could come along. Amelia's parents are on good terms with the science teacher. Amelia said "they like him too cos he's a great teacher."

Amelia wants to attend a high school in the Bronx that has a focus on the arts and design. She aspired to become an artist who can "design lots of things like a famous painting." She also had hopes of attending either Yale, Stanford or Harvard since one of her college-bound sisters is considering these schools.

Amelia's participation in school science

In the beginning of the school year, Amelia was not a central participant in her school science class. She liked to ignore school rules and often sauntered into science class chewing gum without her science class materials. By the end of the school year, however, Amelia was a deeply engaged science student, and managed to bring her grade up to a level "4," although she was still known as a bully to her peers. To describe Amelia's changing participation in class, we share three vignettes: Sweet Water Girl, Oil Spill Puppet, and Worm Poop.

Sweet water girl The school received a grant to offer weekend science fieldtrips for students and parents, and Amelia and her parents attended every single one. Over the course of the first few months of school, Amelia became known as the "Sweet Water girl"[1] by her peers by virtue of the fact that she had been to every one of these field trips. She had gone on the overnight camping trips to Sweet Water and visited museums, participated in fishing trips as well as taken part in afternoon science workshops for parents (e.g., squid dissection). Amelia's mother gave a testimony during a recent school appreciation night urging other parents to join in the activities. Amelia also wrote a speech to share her experiences with the audience but grew too nervous with stage fright when the time came. She ended up standing next to the principal who read her speech to the audience on her behalf with an arm draped around her shoulders.

[1] "Sweet-Water" is a pseudonym for the location where the school organized an overnight fieldtrip for students and their parents.

In science class, Amelia began to share stories from her Sweet Water trips, and Mr. M capitulated, himself often asking Amelia to share her experiences. Amelia's confidence seemed to be boosted each time she shared about the trips. Amelia soon became the "spokes student" for the fieldtrips, and Mr. M would often ask her to share what she had learnt or what she did on the last fieldtrip as a means to promote future fieldtrips to the rest of the students in encouraging participation. As the school year progressed, Amelia's reputation as the Sweet Water girl grew and she became one of the most vocal and enthusiastic science students in the class. Amelia began to volunteer to answer questions as well as to read text passages from the textbook or reading packet. She also began to volunteer to help take care of the animals in the classroom or to hand out work or put up posters for the science teacher. Amelia seemed to see herself as a "science" person after going on the many science field trips organized by the school.

Amelia did not seem to "trade off" her status as a loud student who knew how to break the rules in order to take up science in enthusiastic ways in the classroom. In fact, it seemed that Amelia developed a set of rituals that allowed her to blend these worlds together. Specifically, when her teacher would ask a question, she would try to be the first to shoot up her hand, even though she may not be entirely sure of the answer. If she was not immediately called on, she would then ask the teacher if she could answer the next question, or read the next passage ensuring her participation, or she would signal to the teacher via body language or sign language to let her read/answer the next question by nodding her head or pointing to the packet and then at herself. By creating her own rules within teacher-defined boundaries in the science class, she was always successful in getting the teacher to call on her at least once during the lesson. Usually, she was able to answer the question correctly.

Oil spill puppet When working in teams, Amelia pushed very hard for her ideas and could be unreceptive to her other teammates' ideas. This often resulted in conflicts with her team requiring teacher intervention. While she had genuinely interesting ideas, her good intentions were often sabotaged by her lack of skills in teamwork. Amelia tended to refuse negotiation or compromise until instructed to by the teacher, usually in the wake of an outburst of exasperation from a team mate. Her friends described her as "bossy," but conceded that "she knows a lot about science because she has been to every Sweet Water trip."

In this narrative of the oil spill puppet, we describe how Amelia engaged in group work with two other team mates. The teacher had instructed as homework preparation for this class, that the students bring pictures cut from magazines that they would like to use in creating a "Save the Animals" poster. This poster group project grew out of individual projects that each student had done on a chosen animal. Instead of cutting pictures from magazines, Amelia created a two dimensional paper puppet that could be manipulated to simulate the effects of an oil spill from a ship in the ocean (Fig. 2). In this way, Amelia extended the classroom practice by creating an original product to illustrate her group's poster.

While Amelia contributed her paper puppet but no magazine pictures, both her teammates turned up empty handed. While they busied themselves with leafing through the teacher provided magazines, Amelia refused to help look for more pictures, choosing to concentrate on adding more colors to her puppet. When the teacher came to check on the group, Amelia proudly showed the teacher her puppet and her rough draft of text to go with the puppet. She was commended for her creation and called a "responsible group member" while the other two members, Chantelle and Jorge, were chastised.

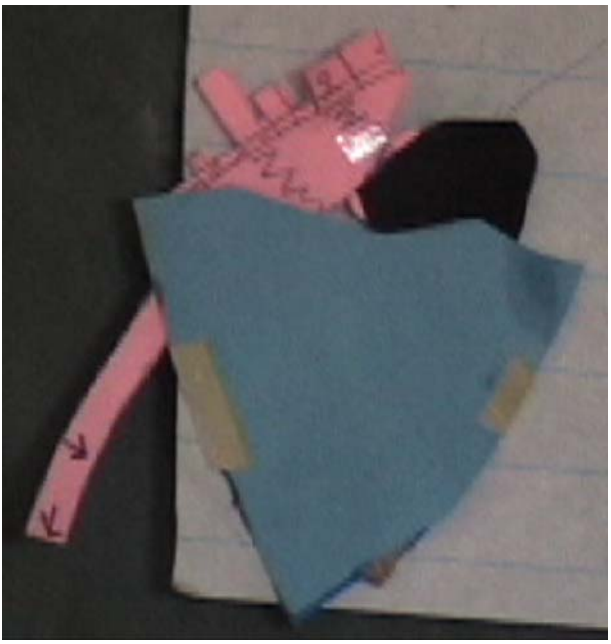

Fig. 2 Amelia's oil spill paper puppet

When Amelia tried to share the idea and mechanism of her puppet with Chantelle and Jorge, they did not understand her design and told her that she should have made two figures instead, one depicting before the oil spill and the other, after the oil spill.

In her insistence to monopolize the shared poster paper, Amelia positioned it directly in front of her instead of in a more neutral position between the three group members. She hulked over the paper and was very possessive over it as evinced by her body language. She tried to assert her leadership by passing random comments about the pictures Jorge and Chantelle were cutting out, and singing rudely while they were engaging in conversation. She shouted loudly at Jorge when he carelessly crumpled a magazine picture Amelia had subsequently chosen to complement her puppet. Jorge complained to the teacher about Amelia who encouraged them to talk to one another and to work together. The class period ended with Chantelle helping Amelia glue some of the pictures down. Jorge had wandered off in disgust.

When the poster was completed, Amelia's puppet was in the left bottom corner of the poster paper instead of taking center stage as she had hoped. This sort of bossy behavior was typical of Amelia. She did not like to be challenged nor made to change her mind. She frequently yelled at classmates to "shut up" when they opposed her point of view.

Worm poop During a unit on "*How does nature provides us with food*?" the students in Mr. M's middle school life science class were learning about decomposition, nutrient recycling, and organic matter. As part of this unit, the students made a class compost box as part of the larger investigation into "how nature provides us with food." On the day when Mr. M brought the red wiggler worms to class for the compost, he carefully constructed his lesson plan and management approaches to foster student participation while

also minimizing the number of disruptions he anticipated live worms in his classroom would generate. For example, he had the students draw up a "sense chart," which is a box with space for the five senses that they were to use to fill in their observations of the live worms before they were placed in the compost, a heuristic used frequently across the school year. Finally, he made it clear in only a way that Mr. M could, that the students could not roam the classroom, yell, throw, or in any way disrespect the worms, or the activity would end. This was typical of Mr. M; while a very hands-on teacher, he was also a rather strict disciplinarian. He had real ability to keep student excitement up, while keeping students "on task." He was generally highly successful in his management techniques. He was particular during this lesson because another class had made the compost bin just before and it was rather chaotic with everyone walking around.

After distributing the worms, Mr. M's class erupted into excited murmurings and disgusted groans. A quick look around the room showed that the vast majority of students took up the activity with enthusiasm. Students were picking up the worms, urging them to move on their tables or in their hands. Some students were commenting on how disgusting worms are, while others excitedly tried to figure out which end of the worm was which. All the while, the students by and large talked with each other about their worm observations—"the pointed part, it's the head I think"—and recorded responses on their sense charts.

In the middle of all of this, Amelia was handling a worm that defecated with the excrement falling onto her note book. After realizing what had happened, Amelia appeared both disgusted and proud, and shouted loudly to everyone who would listen: "Look! The worm pooped in my notebook! The worm pooped in my notebook!" She then left her seat with her notebook and ran towards the teacher who was standing at another table to show him the specimen. She shouted loudly to him, "Mr. M, *look* the worm *pooped* in my notebook!!!" She called to him for a few times before he gave her his attention and said "Good Amelia, you are the only one with worm poop on your notebook. Circle it and write worm poop next to it". She circled the specimen with loud groans and ewws, all the while calling to her classmates to come look at her worm poop. She then got up out of her again to circle around the room proudly showing her worm poop to each of the groups in class while simultaneously socializing, all the while being supported by her teacher in doing so. Later, during the whole class discussion of the worm observations, Amelia, who at this point in the school year, engaged infrequently in science-related conversation, was highly engaged in the whole class discussion of the worms, in part because Mr. M repeatedly made reference to her worm poop as "nature's way of recycling nutrients," a direct connection to the aim of the lesson.

Participation, positionality, agency

The cases of Ginny and Amelia are interesting to study together because their experiences in science class diverge greatly. Ginny typified a good girl student who is popular, smart, and successful in school settings. Amelia was known as a bully and is not that popular among her peers or her teachers, but develops a relationship with her teacher over the course of the year that served as a critical resource in becoming a student respected for her knowledge in science. Yet, in many ways, the girls' experiences parallel each other, as they each actively work to leverage their cultural knowledge and experiences in support of their success in science class, and as a result author new and nontraditional science learner identities that expanded possibilities for theirs and others' learning in science class. In this

discussion section, we first take a closer look at the identities-in-practice authored by the girls and how they leveraged these identities in support of greater participation and learning in science class. We then discuss the relationship between authoring identities-in-practice, agency, and learning in the science classroom, the kinds of resources which support these efforts. We also discuss how paying attention to who girls are, who they want to be and the relationships that are important to their science learning—aspects of science education which are decidedly noncommodified and un-economic in focus—can open up the dialogue around Science for All.

Developing identities-in-practice: participation as more than border crossing

Both Amelia and Ginny were successful in navigating a route with which to successfully merge their life worlds with the world of school science. It has been suggested that cultural border crossing from one's life world to the world of school science is fraught with tension for minority students (Aikenhead and Jegede 1999). However Amelia and Ginny were not only successful in charting a course of their own, but also the nature of these paths created by their newly authored identities-in-practice redefined both the journey of border-crossing as well as the destination. Ginny and Amelia's stories make problematic the notion of clearly demarcated borders between minority students' life worlds and the world of school science. They displayed agency in challenging the traditional world of school science and had shown us their success in creating new worlds of school science which had shared characteristics of both their life-worlds and the world of school science. Instead of suppressing salient identities that were crucial to their sense of self so as to fully embrace endorsed science student identities-in-practice as defined by the teacher, Amelia and Ginny purposefully authored new identities-in-practice by actively recruiting such specific, non traditionally science-oriented identities and the resources these identities conferred. They did not abandon life-world identities in order to unquestioningly adopt teacher-endorsed science identities in their "border crossing." In spite of Mr. M's strictly defined teacher endorsed student identities in his science classroom (which could be interpreted as neo-conservative), Amelia and Ginny were savvy in circumventing the "limitations" by strategically utilizing their personal, non-traditional funds of knowledge.

Ginny leveraging on her "pop culture consumer" identity in writing her bone song. Her "pop culture consumer" identity afforded her the resources of current popular music that would provide a catchy tune for studying bones in an enjoyable and meaningful manner. Her bone song is sung complete with little dance actions that point to the specific bones, aiding in accurate memory and recall of this potentially daunting scientific information. Singing and dancing, apart from being fun, noncommodified as well as not traditionally scientific, are also complementary with a girl's gendered identity. Ginny managed to merge her life-world with the world of school science by bringing in a traditionally non-sanctioned science class product created by the melding of her pop-culture consumer identity with her in-practice science student identity. In so doing, she played the role of a "gate-opener," challenging the norms of school science to accept members who do not necessarily come garbed in the traditional guise of a "good science student" along with its associated goods and dispositions (traditional good student, follows instructions, does as she is told, "nerdy scientist model" etc.).

Equally as important, Mr. M. was able to utilize the girls' nontraditional science identities-in-practice to foster new learning opportunities for the other students. Mr. M used Amelia's worm poop as a science specimen to visually illustrate the concepts of

composting, organic matter and recycling nutrients. Before Amelia made available the worm poop as a learning resource, the students had had to rely on copying the definitions of these key terms as the primary learning material of these rather challenging science concepts. Likewise, Ginny's bone song similarly benefited her community when copies of her bone song were made available as a public learning resource for the upcoming science test. Through authoring novel identities-in-practice with the support of Mr. M, Ginny and Amelia became key participants in the 6th grade community-of-practice who brokered for a new hybrid space of school science that were more inclusive of noncommodified funds of knowledge and ways of being, effectively widening the goals of science education at least in Mr. M's classroom.

Positionality & space of authoring

How students are positioned in a particular figured world of school science has important implications with regards to the students achieving their intended outcomes. The transition between figured worlds (e.g., from small group to whole class) also re-position students along the hierarchical ranks of the 6th grade science community-of-practice which can either aid or hinder a student's agenda. Such positional opportunities or constraints define a spatial and temporal "space of authoring" (Holland et al. 2001, p. 63) that is available to a student.

Amelia and Ginny engaged in similar practices with differing outcomes. They both brought in original products to the science classroom and effectively created new resources with the potential to enhance their science learning experience as well as those of their peers. Both recruited identities from other figured worlds effectively into the figured worlds of school science and authored new identities-in-practice for themselves, "science puppet creator" for Amelia with her oil spill paper puppet, and "science song-writer" for Ginny with her bone song. In this sense, both girls melded their salient other figured worlds identities with their school science identities. However, both girls were positioned differently in the context of their figured worlds which defined their space of authoring and their subsequent agency which arose from it.

In a specific figured world at any given time, a student has several identities-in-practice interacting with one another. Bakhtin describes this interaction as "dialogism" (Bakhtin 1981, as cited in Holland et al. 2001, p. 189). Effectively, each identity-in-practice represents and affords differing amounts of authority and perspectives. Each identity-in-practice is associated with specific social groups or individuals that wield differing amounts of power in different figured worlds. Authoring an identity is akin to choosing how to "answer to" the people in one's figured world at that moment in time, within the allowances and constraints of one's "space of authoring." The "space of authoring" is defined as the "broad venue where social languages meet… freighted with the valences of power, position and privilege" (Holland et al. 2001, p. 191). In this sense, identities-in-practice are always fluid. Identities-in-practice are also very intimately tied to the relational authorities one has and the space of authoring available.

While both original products made by Amelia and Ginny were acknowledged and validated by the teacher, Ginny's bone song garnered more attention and direct assistance from the teacher in its elevation of status from a private learning resource to a public one. In effect, the teacher took over the publicizing of her bone song even as the bone song as a product moved through the figured worlds of small group to whole class. Ginny was purposeful in authoring her bone song. She first "pre-viewed" her bone song with the

researcher and a few close girl friends and then the teacher, all of with whom she had positional and relational authority. Becoming a science song writer in her small group first was imbued with less risk and arguably more likely to succeed given the socially marked and ranked groups or individuals in the figured world of the whole class, any of whom may have been a potent risk factor to her authoring act. With the teacher as her bone song "manager," Ginny did not have to confront the possibility of diminished positional authority. In effect, the teacher took over the publicizing of her bone song as it moved as a product moved from small group to whole class.

Ginny's social identity when recruited as an identity-in-practice in science class became an asset to her already favorable position in science class. Her generous social identity lent itself to sharing the bone song with a few girlfriends, contributing to their success with the class test on the skeletal system. Her "good girl" identity-in-practice with the teacher no doubt influenced his decision to promote her bone song to the rest of the 6th graders. The teacher had intentions to launch the skeletal system with the next batch of 6th graders with Ginny's bone song.

For Ginny, her other figured world identities of "popular, generous girl" and "pop-culture consumer" melded synergistically with her "good science student," "good leader" identities-in-practice. The perspectives and authorities afforded by all these identities were not in conflict with one another. In Ginny's case, it seemed that her boundaries defining each identity (and therefore the practices associated with each identities) were more porous than Amelia's identity boundaries. On the other hand, Amelia struggled in her space of authoring when her conflicting identities-in-practice of "science puppet creator" and "bossy leader" jostled against each other, thereby impeding her efforts to garner the support she needed from her group-mates in that figured world of small group while they worked on the poster. The teacher did not come to her aid in lending his authority to endorse Amelia's oil spill paper puppet in the same way he endorsed Ginny's bone song. In that sense, Ginny gained more assistance from the teacher in border crossing and in gaining the affirming recognition from the teacher and the community as opposed to Amelia, who was left to her own devices.

However, when the boundaries of the space of authoring changed with the change of figured worlds, Amelia was able to capitalize on the teacher-endorsed science identities-in-practice when positioned in the figured world of the whole class. Since the audience is bound by the teacher's rules to remain silent, to listen attentively, Amelia was positioned in an uncontested space in this figured world (as opposed to the figured world of small group work previously) to showcase her paper puppet and pursue the science content within. Her chosen identities-in-practice in this project as a "science puppet creator" and a "marine ecologist" was affirmed and validated by the community of practice in this figured world of whole class presentation. Through her agency in pursuing a legitimate and validated platform for her paper puppet, Amelia created the hybrid space for her peers to share their own stories and merge their life-worlds and the world of school science.

Agency & icons as tools

Amelia and Ginny displayed a strong sense of agency through the authoring of novel identities-in-practice. They sought to answer their community-practice with a particular identity-in-practice. There was a clear indication from both girls that they desired to participate in the science community-of-practice on their own terms. When the girls created a tangible product, those products served as icons and tools that sustained their

agency. Amelia's agency was especially apparent in how she managed to promote her oil-spill paper puppet.

In spite of not having complete success in the figured world of small group when she tried to convince Chantelle and Jorge to buy into the puppet as a center piece for their poster, (resulting in a fragmented, multi-thematic poster), Amelia's agency brought about by her identities-in-practice of being the "science puppet creator" persisted and empowered her with the tenacity to keep seeking for an opportunity and a space in another figured world (whole class presentation) where the oil-spill paper puppet could find a willing audience to whom it could deliver its crucial environmental message. In the figured world of whole class presentation, with the stage set and guaranteed by teacher-endorsed identity-in-practice of science-student audiences, Amelia's "bossy leader" identity-in-practice receded while her "science puppet creator" and "marine ecologist" identities-in-practice gained validation from her peers. The paper puppet served as a potent visual reminder of the identities-in-practice Amelia wanted to author with this project and acted as a tool to sustain her agency. She appropriated the puppet as a heuristic that guided her next moment of activity.

Holland and her colleagues (2001) posit that "[i]mprovisations crafted in the moment are one of the margins of human agency" (p. 278). Amelia exhibited many examples of such agency in her practices of making a product out of the worm poop and in creating her own rules to ensure guaranteed class participation. These improvisations are fueled by her identity-in-practice as the "Sweet Water girl" and "good science student" (as the school year progressed) with its associated authority from the teacher, as well as out-of-practice identities such as her "loud and dramatic" social identity which she recruited to author new identities-in-practice that positioned her strategically to exercise her agency in the figured worlds of the science class.

In the same way, Ginny also improvised a teacher endorsed practice of making flash cards as a learning tool to song writing through effectively authoring an identity-in-practice as a "science song-writer." Her agency was apparent in that she not only succeeded in getting a non-traditional mode of learning sanctioned for science by a strict teacher, she also enjoyed herself, scored well for the test, and helped her classmates do well. In that way, the bone song became her signature that truly reflected and encompassed Ginny's sense of self and all the identities that are salient to her, both in-practice ("good science student," "good leader," "good team member") and out-of-practice ("popular, generous girl," "pop-culture consumer," "music-lover"). With her bone song, Ginny succeeded in attaining "science fluency" (Tobin 2005, p. 28) where she seamlessly appropriated resources in "novel yet useful ways as science knowledge, consisting of practices, facts, concepts, skills, interests, attitudes, and values."

Amelia's paper puppet served both as an icon of and tool for her exercise of agency. Having made the paper puppet, Amelia demonstrated ownership over the role she wanted the puppet to play, as evidenced by her highly protective body language. She also worked tirelessly at her puppet, trimming, adding colors, reworking the lever mechanism during the entire group period while her other two group members were busy cutting out magazine pictures. She tried to get the other two to pay attention to her puppet by distracting them from their tasks with songs, or throwing suggestions to change the layout of the poster into a "collage." When that failed, she concentrated every ounce of her own efforts on the puppet, up till the last minute, during the presentation on the following day, Amelia was still coloring in the puppet, continuously improving on it as she gave her piece of the presentation, as Jorge was talking about forest fires, she snuck back to the table to get a

black marker in order to enlarge the "spill" effects on the patch of blue sea so that it is more obvious to the audience seated at the back of the classroom.

Amelia's part of the presentation was the most coherent and "deep" as compared to the other two on the team. She stayed centered on the theme of oil spills and marine ecology, drew the audience into conversation with her with a community resource that is familiar to all (the state of cleanliness of a local beach) and expanded the classroom discussion to allow peers to share stories (members on the fringe of the community) and so created a space that allowed the affirmation of the narrative authority of her peers.

Both girls also exhibited agency in pursuing learning outcomes. Ginny authored a "diplomatic, nurturing leader" identity-in-practice with both the group of girls and in her partnership with Anthony. As the appointed leader of the group of four girls, Ginny created and enforced ground rules that ensured equal opportunities and participation for all members. With Anthony, she quietly authored the leader identity-in-practice by simultaneously sharing her resources with him, giving him clear instructions and involving him in all decision making processes.

Within the particular space of authoring afforded her in her partnership with Anthony, the possible dialogism between Ginny's popular social identity, being a "good science student" as well as a "target science student" resulted in Ginny choosing to align herself with the science teacher (who was always pairing Anthony with different students in search of a good team for him). She pursued the science project at hand in spite of the social risk (being the target of Anthony's temper outburst in class, being labeled as the one who works well with the school bully). It is a significant decision and speaks to the agency Ginny exhibited, especially in light of the fact that very few students in the class were willing to work with Anthony. She was not deterred when paired with a challenging, unpopular partner. She also refused to relinquish her right to produce a good poster.

Amelia's agency to ensure a space for participation was also evident in her practice of creating her own rules. She circumvented the teacher's classroom practice and resourcefully authored a "target student" identity-in-practice for herself that almost always guaranteed her an opportunity to participate in his strictly controlled classroom. In authoring this "target student" identity-in-practice, Amelia leveraged on both her "loud and dramatic" social identity as well as her "Sweet Water girl" identities-in-practice. Having been accorded the affirming identity as the most prominent participant in the science fieldtrips, Amelia sought to increase her authority in school science by authoring new identities-in-practice that can position her with more status in the 6th grade science community-of-practice.

Conclusions

The cases of Amelia and Ginny have shown us that instead of acquiring and settling on one static identities-in-practice in the 6th grade science community-of-practice, identities-in-practice are both fluid and multiple in nature. As students move between the figured worlds of school science, they are presented with unique spaces of authoring with which to create new identities-in-practice that can imbue them with added status and position them with more power to engage in science class, to move from participating as novices on the periphery of the community-of-practice towards the position closer to that of the "master practitioner" (Lave and Wenger 1991) or that of "expert." Thus, students are not necessarily bound to one identity-in-practice throughout the school year, such as that of "I don't know" students or "Inside outsiders" (Costa 1995). Indeed, through the authoring of novel,

empowering identities-in-practice, students like Amelia have shown that they can transform from the identity of an "outsider" to that of a "potential scientist" within a school year. Such a positive transformation is contingent on the cumulative success students experience daily as they seek to be legitimate participants in the various figured worlds of science class by authoring new identities-in-practice.

The purposeful authoring of novel identities-in-practice by both girls also made manifest to us their sense of agency and interest in school science. Amelia and Ginny's authorial stance debunk the stereotyping of girls low level of engagement in science. In using identity as a lens to understanding how minority girls participate in science, we have a deeper understanding of how they display agency in working to succeed in science. We see how they resourcefully draw on both essential identities and noncommodified funds of knowledge not traditionally sanctioned by the science teacher as well as empowering identities-in-practice from other figured worlds of school science to author new identities-in-practice that elevate their status. These authoring acts ushered in new opportunities for the girls to engage with the science content at a deeper level and also opened up a third space for their classmates to delve deeper into the content in a way that is empowering to them. Learning science for these girls is about gaining a space in a science world that matters to them and that builds strength from what they have to offer. The girls' stories show how the goals of science learning ought to expand to value as important a students' ontological development. After all, science is a cultural practice, serving as both a tool and a context for potential change.

Our study suggests potentially powerful, new directions for unpacking the meaning of "Science for All." An identities-in-practice lens coupled with a global feminist perspective, helps us to see the relationship between science, location, knowledge production and learning. In the case of Amelia, a student who fits the stereotype of a "failing inner city student" at the beginning of the school year, we can see how learning to participate meaningfully in a science learning community of practice was, in part, about learning how to position one's developing epistemic authority alongside a desire to remain a powerful player in her social worlds. Acknowledging and supporting this and other tensions makes possible successful transitions into more central participation in science-related communities, and arguable opening up new trajectories in STEM fields. However, her advancement was not necessarily coupled with commodified knowledge or identity formation. "Being able" in science was not a predictable feature but was something that took shape over time with her growing relationship with people, tools, and roles in the figured worlds of her classroom. We also believe that Ginny, who arguably would have been viewed as successful under traditional measures, enhanced her agency with and in science through her own efforts to enact non-commodified forms of knowledge and experience in the science classroom, opening up opportunities for others to do the same. Even as both Ginny and Amelia intend at this point in time to eventually pursue careers outside of Science (which is completely acceptable to us and should in no way disqualify them from a robust and meaningful science education), supporting their ways of engagement in science by valuing noncommodified funds of knowledge and relationships can help frame a future trajectory in science in a more realistic and appealing manner for them.

We believe that when the girls experience success in science class when participating through the perspectives of identities-in-practice, they are better positioned to be successful in taking further strides in the discipline of science in the future. Identities-in-practice as a lens opens up and reveals the girls' interests in science and displays their agency in engaging with science meaningfully on their own terms in ways that cannot be surfaced through traditional, commodified, testing instruments. Participating in science class

through newly authored identities-in-practice allows the girls to be active stakeholders of their own experiences in science class and can be a way to circumvent the homogenizing and therefore alienating shadow of globalization such that the goal of "Science for All" is reframed in broader terms than just content knowledge acquisition.

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