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FORUM IDENTITY POLITICS IN SCIENCE AND SCIENCE EDUCATION

IDENTITY POLITICS, LEARNING, AND ACADEMIC SUCCESS

Nancy: Karen raises interesting questions regarding the way in which *Public Engineering School* (PES) seems to be a very different kind of learning setting than what we find reported elsewhere in the literature. In particular, PES seemed less able to accommodate diversity than many K–12 settings. My hunch is that she is absolutely correct on this point, and that we need to think more carefully about how the politics of inclusion/exclusion operate in the variety of learning settings of interest to us.

Margaret: Karen's article is a striking example of how the politics of inclusion/exclusion affect learning and academic success, and I agree with Nancy that this is an area that needs much more attention in learning settings. After all the work that has been done by anthropologists, sociologists, and others to expose the persistent correspondence between student social or power hierarchies and academic success, it is astonishing and discouraging how infrequently these issues are seriously considered in discussions of subject matter learning. Much research and popular opinion about subject matter learning – be it in science, mathematics, reading, or engineering – seems to assume that the right curriculum and good teaching will produce student learning and academic success, regardless of students' social positioning, perspective, or differences. In other words, students' social worlds are viewed as either homogeneous or irrelevant to learning as long as good instructional materials and methods are used. Karen's article makes clear that social stereotyping and social constructions of identity have everything to do with learning opportunities afforded and realized.

Karen: Like most people who talk about engineers and engineering, PES operated with a rhetoric of sameness, as if there were no diversity before women began to attend in greater numbers in late 1960s and members of racial and ethnic communities somewhat after that. It is important to note that there was nothing "the same" about white, middle-class men at PES, and to note that several PES faculty who had attended over 30 years earlier found only a few new terms used among student engineers, indicating that men's diversity had a long history. Thus, while science, and sites of science practice, may be masculinized, this should

Cultural Studies of Science Education (2006) 1: 309–324
DOI: 10.1007/s11422-005-9011-8

not be interpreted to mean that all (or even most) men are equally well off there. Thus, at PES, even many of those who would be expected to be included were included only in peripheral ways. While I agree that PES is different, especially that hierarchies of belonging at PES may be more heightened, I suspect that we lack the empirical evidence to say that other sites of science learning are all that different. In fact, I wonder if physics and earth sciences (where, like engineering, women's numbers have grown quite slowly) might have many of the same kinds of ordering principles. I suspect that the biological sciences, however, are in fact quite different.

Margaret: Biology is an interesting example to consider. While it is true that U.S. women's numbers and percentages in biological science courses, degree programs, and graduation rates have risen dramatically over the past 25 years, women's representation in high-status, high-paying careers in biology or medicine has not improved nearly as much. This fact suggests that the social ordering principles that affected high-performing women like Marianne at PES may operate later (in graduate school, in medical school, during residencies, etc.) in fields of biology where the terminal degree comes after college.

Nancy: There is much work that could be done in a variety of settings. The science disciplines may not matter nearly as much as the academic focus and aspirations of the school/class. Many high schools are attempting to teach integrated sciences rather than the traditional year of biology, earth science, chemistry, and physics. Part of the rationale for this is that real-world scientific problems often extend beyond conventional science discipline boundaries. It would be interesting to know what difference this might make in the meanings of science produced in such classes. Is there more of a "citizen scientist" that is produced or do we have the same cultural production of a physicist anytime the instruction veers in the direction of doing physics?

Margaret: I suspect that integrated science classes will not (alone) succeed in producing diverse meanings of science that have lasting or widespread impact. At PES, the design courses were intended to be a context for real-world engineering work, and based on Karen's article, they did not change the overall situation there. Of course, individual students may benefit greatly from opportunities for real-world experience – to learn new skills, to consider new career directions, etc. – but the effects of these opportunities on social hierarchies are minimal.

Karen: I concur. In fact, I suspect that unless and until efforts are made to explicitly teach about hierarchical social relations and to think more systematically about educational practices that uphold them little progress like that we envision will result.

Nancy: PES has a very focused mission: by the time the students finish their program they should know engineering practices sufficiently well to fully engage in them in full-time employment or perhaps in graduate school. This is a relatively narrow mission compared to K–12 settings, and PES is almost certainly justified in excluding anyone who does not share this commitment. After all, it is almost certainly this common commitment that allows them to focus their efforts on students learning the kinds of practices that should provide more or less direct access to engineering organizations.

Karen: I cannot disagree with Nancy's statement that "PES is almost certainly justified in excluding anyone who does not share this commitment [to know engineering practices sufficiently well to fully engage in them in full-time employment or perhaps in graduate school]," but want to interject that we must be wary about giving PES sole control since there is so much about campus life that could be better. Via cultural processes for becoming an engineer, they seem to unnecessarily constrain – instead of promote – access to engineering organizations. Even when incorporating design engineering into the curriculum, they did so in ways that could not recognize this new form of practice, could not distinguish fabricated results from work that will stand the test of time. Thus, I wonder about PES being the arbiter of who can in fact demonstrate that they "know engineering practices sufficiently well . . ." when campus assessment routines cannot ascertain this.

Margaret: I agree that PES has a much more focused mission than K–12 education and that focused mission surely affects the kinds of identities that are promoted there. However, I am not convinced that the way the politics of inclusion/exclusion works at PES is very different from K–12 settings. In K–12 settings, various kinds of student identities are produced, and these identities may co-exist and flourish in ways that can accommodate many students. Nonetheless, it is still the case that hierarchies of student identities develop beginning in elementary school, and these hierarchies have profound effects on individuals' status, prestige, and academic trajectories. Although there may be more varied identity productions in K–12 and somewhat separate hierarchies, K–12 student identity productions and hierarchies privilege certain kinds of people and behavior while devaluing or ignoring others, just as they do at PES.

Margaret: What is different about PES is that career identities, which are only vaguely produced in K–12 (as Jean Lave and Etienne Wenger (1991) argued in *Situated Learning*), are prominent along with student identities. More so than K–12, PES is a narrowly focused, apprentice-like transitional learning setting in which (already good) engineering students are supposed

to be converted to professional engineers. Identity productions take place in a more constrained context influenced not only by societal expectations regarding good students, gender, and age but also regarding professional engineering careers. Thus, the space of identity production is more limited, and the consequences of the politics of inclusion/exclusion more stark. But the processes would seem to be the same.

Nancy: I think I can easily concede that the processes are the same. The contexts are different. PES is interesting in that it appears to be a form of schooling that provides access to engineering. Granted, this access is far from perfect. The strong academic bias of the program means that its graduates may still lack important practical skills that engineers need. However, one of the problems with much of schooling is that the competence one gains from participating does not provide access to much of anything except *maybe* more school. The practices of school science tend to be very school-ish. A very common response to this is that we ought to make school science more like "real" science. There are many science educators who argue for an authentic scientific inquiry that mimics the practice of scientists. But, does this not point to a potential drawback to such an approach? Might this not, as Margaret put it, limit "the space of identity production?"

Margaret: I think Nancy makes an important point about the potential drawback of using real-world (or authentic) practice as the model for improved science or engineering education. Both academic engineering and real-world engineering have contributions to make. Replacing one with the other will not solve the problem of how best to encourage, prepare, and recognize people for their competencies.

PRODUCING PRIVILEGE NOT COMPETENCE

Nancy: The problem is that some of the exclusion or marginalization is accomplished using criteria that are unrelated to competence in engineering practices. In fact some of these practices of exclusion look to me to be just really bad habits.

Karen: It seems important to recognize, I think, that exclusion and marginalization at PES, like that at other places, occur simultaneously with inclusion and valorization. One of the striking features of PES was that the campus intentionally selected students because of their sameness along a set of academic criteria that are remarkably similar to those used at other engineering campuses across the US, then over time, through complex campus cultural processes, differentiated students into an extreme hierarchy of prestige and status. I suspect that these were not so much "bad habits" as intentional ways of life. What seemed to be missing at PES

was a deep-seated commitment to the kinds of social justice that prevail, at least in theory, in K–12 settings. For instance, PES had a tradition of producing an academic-over-practical hierarchy of forms of engineering practice even when it was an all-men campus, and did not seem to have ways to think of women as part of this set of educational practices. Such a site, where educational processes are simply taken for granted and not a set of ideas always under examination, a campus that already produced "diversity" among demographically identical white men and took for granted that this way of life was in fact the one that anyone going into engineering would value, lacks ways – processes – to reflect on its practices and change to become more socially just. That is, the value set that we take for granted in K–12 education did not seem to exist at PES and, simply put, how to educate engineers "just is," instead of "is just."

Nancy: And neither modest changes in demographics or curricular reform seemed able to shift the meanings of being an engineer. I wonder if part of the problem is that PES and other engineering schools are generally regarded as being successful at producing engineers. The societal problem of having insufficient numbers of scientists and engineers, particularly American-born, is generally thought of as a problem with K–12 schools not preparing adequate numbers of students. Whereas K–12 schools are under constant fire for not fulfilling their social justice goals, elite schools like PES are not held accountable.

Karen: Yes, engineering schools tend to be recognized as successful at producing engineers – a rather surprising result when you consider how many students leave engineering majors between their first year at college and graduation. Findings like those of Elaine Seymour and Nancy Hewitt (1997), in *Talking About Leaving,* simply do not seem to have made much of an impact in engineering education research or reform conversations. Much of the dialogue is about tweaking the curriculum, such as adding courses related to science, technology, and society so that students learn more about the non-technical side of engineering work.

Margaret: PES is an elite school in many ways, but I think it's crucial to note that it is a place where students receive a terminal degree that gives them access to a specialized profession. In whatever setting terminal degrees leading to a profession are given, social hierarchies of inclusion and exclusion have heightened salience and influence. Many would say this is appropriate – no one wants a construction engineer who isn't really good at designing bridges that will last for years, no one wants a surgeon who isn't really good at surgery. What is scary about Karen's findings, as Nancy says above, is that exclusion or marginalization is accomplished (at least in some cases) without regard for criteria related to competence in engineering. Some people who don't appear to be especially competent

engineers are recognized as successful at PES, while others who appear more competent go unrecognized. Nancy: Furthermore, I saw no evidence from this account that there were any rich subcultures that existed that could provide support for heterogeneity within PES. While all the students almost certainly shared a desire to be an engineer, there were also diverse understandings of what this actually meant – and those understandings that deviated too far from the norm were marginalized.

Karen: Most students were in fact "Nerds," because only the rare few could in fact ascend to the academic and social stratosphere of the Over-Achievers. Students who were marginalized, thus, fell too far from the "preferred" or hegemonic sort of engineer. PES valued and promoted this preferred student via reward structures built around very high grades – which were quite difficult to maintain and tended to require cheating, exploiting others, or cutting corners – and visibility on campus-wide committees governing campus life. And, contra a rhetoric that the world needs more engineers who can really "do" engineering (what Nerds manage to demonstrate if anyone cared to look for it, which academic assessment tasks seldom can), PES valued an academic way of life that sees only a very limited part of the complex set of practices needed for engineering work, though the preferred academic-engineering was in line with engineering graduate school requirements (the way of life enjoyed by engineering faculty, many of whom have little industry work experience). Thus, part of the heterogeneity that existed at PES was of its own creation, and it could not distinguish the nuances of engineering practice being demonstrated.

Margaret: Exactly, and more. What is so tragic about Karen's account is that someone as accomplished in engineering as Marianne could end up so marginalized and disregarded, while less accomplished men could stay at the center and reap the rewards. Surely this is not what engineering faculty or practicing engineers want, and surely it is not what engineering companies or the public need. Karen has given engineering a clear message about the price of tradition and social stereotyping in the field.

Nancy: In contrast, I do believe that you can find rich subcultures within many K–12 schools, particularly large high schools, where students voluntarily affiliate with a number of different subcultures in ways that can provide support for the variety of identities a particular student may wish to pursue. There are subcultures of nerds, theater kids, jocks, etc. The boundaries around these subcultures are fuzzy and dynamic, and overlap with other subcultures. We should not, however, overly romanticize these subcultures, because as Eckert and Foley note, they are not all equally productive and valued.

Karen: At PES, the notion of a subculture seemed less relevant because many Over-Achievers used the efforts of Nerds - through homework

sharing, teamwork efforts, and so on – to maintain their standing on campus. Thus, there was no dissolution into different camps, but a symbiotic relationship among student engineers affiliating with different ways of life on campus, relationships that rose to the level of parasitic for some went-too-far Over-Achievers. I have always wondered if there were not more of this going on in high schools when one moved into the academic work of students, areas of practice that neither Eckert nor Foley entered. The area of science laboratory teamwork seems a good place to study social interactions where the stakes are very high for those students who affiliate with academic excellence. I suspect that here student-student power relations might become clearer than they would be in a stand-and-deliver classroom. For instance, we know that women are not thought of as scientists, but we do not know to what extent this notion of the preferred scientist influences classroom teachers as they think about individual students' contributions to teamwork products, or to what extent the kinds of skills demonstrated in such products are aligned with different forms of science practice, etc. But, for myself, what I saw at PES was only a somewhat more heightened version of what I experienced in math and science classrooms in high school and what my daughters thought was happening to them in middle and high school science classrooms (which sent them strong messages about not pursuing science studies). Thus, I do not think that we have studied sixth- to twelfth-grade sites of science learning with enough attention to issues of cultural production of scientist identities.

REFLECTIONS ON REFORM

Nancy: I certainly agree that we do not know enough about 6–12th grades sites of science learning. I wonder about the girls in physics classes who are also very high achievers. Are they seen as excellent scientists or merely as excellent students? Does being an excellent student mean that you are great at doing school science, but not at doing "real" science? Does working hard to succeed in school science have the pay-off many assume it has? I recall Heidi Carlone's study of ninth-grade physics in a school where they adopted a new curriculum that was intended to appeal to a broader range of students than traditional physics. Like the curriculum reform described here, the results did not make much of a change in terms of the meanings of science and scientist. Although many of us in science education have long advocated for science classrooms to include more teamwork and opportunities to be creative in the science products that are produced, it is also now clear that these forums are often not empowering for girls and women.

Margaret: Karen raises an interesting point about the supporting role played by Nerds in the accomplishments of the Over-achievers. Were there to be more in-depth studies of 6–12th grade science classroom collaborations, I would not be surprised to find many high-achieving girls playing supporting roles (whether they realize it or not) for boys. In a section of Karen's dissertation not reported in this article, she discusses in some detail the kind of teamwork she observed at PES. A clear message from her discussion is that simply forming teams or assigning group work does not produce desirable learning outcomes. In many cases, group work was divided up according to the existing expertise of individuals: If someone was known to be good at interacting with strangers, s/he got that part of the assignment; if someone was known to be good at CAD, s/he got that part of the assignment. In this way, pre-existing skills were rewarded and perhaps extended, but chances to acquire new skills were minimized, and chances of reproducing conventional gender roles were high.

Nancy: I find this all very discouraging.

Karen: Yes, it is. In fact it is likely worse than one can gauge from journal articles or this discussion. I recall when my transcriber (a former teacher-ed student and elementary math teacher who needed summer work) called me after finishing the senior student interview tapes. Her first remarks concerned the way that the senior women sounded on tape relative to first-year student-interviews transcribed earlier. She was profoundly distressed, almost depressed, to hear the confident "I can conquer anything" voices of first-year women students replaced by very soft-spoken, hesitant-to-answer, hedge-your-bets women seniors. Parts of engineering (and engineering education) culture have always seemed pernicious to me, even when I believed that I could conquer all of the obstacles. I have gained strength to keep writing about it from having others recognize that it really is this way.

Nancy: It seems as though curriculum reform efforts are unable to change cultural meanings of science or engineering. The larger presence of women in engineering or in physics seems ineffective in changing the overall culture since women and men who cannot be recognized as engineers are either not admitted or are marginalized in ways that limit their influence. If PES is like other engineering schools, it probably has a much more ethnically diverse student body now than it did a few years ago. Yet, it is very hard to remain optimistic that these changes will have a positive impact on the culture.

Margaret: It is hard to be optimistic, but I think the case of PES (as well as many others) makes clear that our efforts at educational reform must be much more thoroughgoing and comprehensive than we have been able to accomplish in the past. This will take determination, force, and money.

COMMUNITY, FIGURED WORLD, OR CULTURE?

Margaret: Perhaps it's time to talk a little about the theoretical concepts that Karen uses in this article.

Nancy: Although Karen prefers to write about PES as a "figured world" rather than a "community," her description very much reminds me of some of the critiques of "community." For example, Nel Noddings has described the "dark side" of community in which people find themselves excluded by a strong majority culture. There can be coercion toward conformity and homogeneity. Iris Young suggests that "community" is the wrong metaphor entirely, and that cities are a better model for affiliations that allow for freedom and diversity. While I find Young's ideas intriguing in terms of the way in which they accommodate limitless diversity, there are no shared commitments. I don't think anyone is ever going to be an engineer if they are not given access to communities with a commitment to engineering practices.

Karen: Yes, I agree about the critique of communities, and am especially conscious of Marilyn Friedman's call for "dislocating the community." I think that engineering is something more than a community, and wonder if its obduracy comes from deeper imaginings, if you will, about what it is and about how the world is supposed to work, without seeming to have any way to reflect on these and imagine a different kind of world. I think that "figured worlds" captures this better, makes these "imaginings" more apparent, more open to study and critique. That said; let me comment on connections between becoming an engineer and being given access to communities with a commitment to engineering practice. My contention is, though I probably have not said it well enough, that women could have deep trouble belonging if the figured world of engineering encapsulates within it an unexamined inability to recognize women as members – precisely what I have noted. In other words, when an engineering figured world makes of women people who cannot be noticed there as engineers, then it matters little what women can or cannot do, whether they have access to communities or not, etc. PES seems not to be gender blind – because it clearly sees women as if they are no more than men's romantic interests (shades of *Educated in Romance*), as if they are valued only if they are pretty, which cannot connote belonging as an engineer according to the campus trope. Nor does it seem to be gender neutral – because when unpacked it clearly, routinely, and regularly discriminates against women. Might we say that it is gender near-sighted or narrow-minded? PES sees with a particular set of filters, those aligned with a certain set of preferences for some kinds of engineers ahead of others, and these are tightly linked to the curricular structures in ways that have not been documented in other studies like Dorothy Holland and

Margaret Eisenhart (1990), Douglas Foley (1990), and Penny Eckert (1989) – though she does provide some information about how school structured peer-group life out of classrooms contributed to identity production; while Signithia Fordham (1996) and Michelle Fine (1991) both made strides when discussing how schooling structures contributed to race/ethnicity marginalization.

Margaret: Out of self-interest, I would say that our *Women's Science* (Eisenhart and Finkel, 1998), which owes much to Karen's contribution, examines some of the ways collectively-held ideas about gender (the culture of romance, the myth of gender neutrality) are connected to organizational structures like schools. But more importantly, I agree that "figured worlds" connotes something about deeply held, taken-for-granted images of how the world works that are not captured by the concept of "community." What I don't understand about figured worlds is why or how it is an improvement over the concept of "culture" which I and many others would define as collective, taken-for-granted models of how the world works. It seems to me that all the points that Karen makes above about women being excluded from the figured world of engineering could be made using culture instead. What do we gain with the concept of figured worlds?

Karen: I continue to struggle with delineating what we gain with "figured worlds" that is not covered by "culture." I do not think that Margaret and I, when we talk to one another about culture, need to have a notion like figured world. We share a notion of culture that encompasses a notion of human beings going about their everyday lives and continuously developing a particular interpretive vantage point on what their doings mean. I see little difference between this and Dorothy Holland et al.'s (1996) definition: "By 'figured world,' then, we mean a socially and culturally constructed realm of interpretation in which particular characters and actors are recognized, significance is assigned to certain acts, and particular outcomes are valued over others" (p. 52). Or later when they explain that being able to see from this cultural frame of reference is a second form of agency: "Human life is inexplicable without our abilities to figure worlds, play at them, act them out, and then make them socially, culturally, and thus materially consequential. This collective ability to take imaginary worlds seriously – the sort of fetishization that makes certain pieces of paper over into 'money' – is the magic that anthropologists as well as others have tried to capture in the concept of culture" (p. 280). However, I do not think that everyone who reads Holland, et al. takes culture to mean what we infer. I wondered if, in a way, using terminology like "figured worlds" makes clearer what Margaret and I mean by culture to those with a proclivity to overlook contextualizing issues or to take culture as a static way of life instead of an organic one, and if this serves to encourage ways to think beyond solitary individuals, or

pairs, and account in systematic ways for collective life in the presence of historically persistent structuring features, especially culture, as we mean it. When I write that campus identity terms are a figured world, I mean that these are the personas imagined to be acceptable on this campus, the sorts of practitioners who can be recognized as engineers here. On the one hand, these personas are quite real in the ways that they are deployed to produce belonging. On the other hand, by using the term "imagined," I infer that they could have been different, that as cultural facts of life they are not chiseled in stone but the product of student engineers' imaginings, which are mediated by campus, national engineering education, and societal practices that grow from – and produce – ideologies of privilege. I seem to have circled back to the point of wondering if "figured world" is a metaphor for "culture."

LEGITIMATE PERIPHERAL PARTICIPATION AND LEARNING TRAJECTORIES

Margaret: I was struck by Karen's point that Lave and Wenger's concept of legitimate peripheral participation does not capture the identity productions she observed at PES. In this regard, she wrote, "Rather than students moving along a trajectory toward some shared notion of 'engineer,' students went about their everyday lives deciding whether to affiliate with Greek life or not, devote themselves completely to their studies or take a more relaxed approach, align with an academic-science form of engineering or adopt the more expansive engineering form promoted in design classes." This suggests to me that we need more complex models of learning trajectories. Karen gives us a start by proposing three aspects of identity production: thinking of oneself as an engineer, performing an engineering self, and being thought of as an engineer by others. This is a useful beginning but does not yet address some implications of Karen's study; that is, that identity productions take place over time and in various contexts; are multiple, diverse and overlapping; and include accommodations to various ideologies of privilege. What are the additional concepts we need to understand learning trajectories with these characteristics? If identity production is to be a concept that can link micro- (personal, individual) and macro-levels (collective, structural) of learning across times and spaces, then we need much more elaboration of it.

Nancy: I wonder if the kind of complex learning trajectories you would like us to understand would require that we study the learning of individuals in a variety of sites and over years, if not decades. It seems unlikely that if these engineering students had not already obtained a partial identity as an engineer, they would have gained entry into PES. How did this happen?

From school? From hobbies? From families? We often seem to assume that these kinds of academic identities are formed in school. Yet, if we look in students' homes and communities, we sometimes find that these sites are very influential in helping students acquire the competencies they need to succeed in school. (This has been the case in my own work.) The material and intellectual resources found in homes and communities are also very much connected to macro-level structures. Furthermore, much of this learning may not be intentional. How does an individual develop the expectation that natural events have natural causes? It seems that such an important stance could never be learned at a single point in time. The learner might not even be aware when s/he begins to interpret the world in such a way.

Karen: Nancy's work suggests further opportunities to add to the complexity, but I am fairly well satisfied that studying the four years of college got at these students' engineer identities. At the time of my dissertation data collection, I wrote "how-I-got-into-engineering" soliloquies for each student. These were not incorporated in the dissertation, but there was a distinct difference in the kinds of stories women and men students told, which were consistent with what Judith McIlwee and Gregg Robinson (1992) reported. In broad brush, women students had been told they'd be good at engineering because they were good at math and science in classes. Some women also noted that they were going to prove someone wrong about their ability to succeed as an engineer, which I never heard from men. Men, on the other hand, tended to tell about working in wood shop and making a hutch for a mother; or working in the summer in construction and being interested in the way things fit together and being told that such curiosity was in line with being an engineer; or being good at taking things apart and configuring consumer electronics, etc. The only woman who told this kind of story about being good with tools and taking things apart and putting them together, especially in rental properties that paid her tuition, received no end of difficulty from faculty who told her to quit "messing around," to sell these properties, and to be a full-time student, though she took a full course load. First-year students did not have much notion what it was that "actual" engineers did, whether they would be good at it, or interested in doing it. Maybe they arrived at PES thinking of themselves as having engineer potential, but they did not think of themselves as engineers then, though seniors considered themselves engineers. It was pretty clear in my mind that their stories about deciding to study engineering served a less important role in building their sense of themselves as engineers, at least when compared to the impact of structural forces from campus prestige-distribution practices at PES, but this deserves a second look, possibly.

Nancy: This is consistent with what Pam Loterro-Perdue and I found in a study of engineers who never studied engineering in school. These engineers were overwhelming male and credited their success as engineers to hobbies like what you describe. Although my views on this are admittedly speculative, I believe these hobbies build important engineering skills and that girls and women for the most part do not have access to them. (If you think schools are alarmingly sexist and inequitable, just take a look at other aspects of the surrounding culture!) What you show above is that boys and men have access to potentially important formal and informal engineering-related experiences. Girls and women typically have access only to formal education. Amazingly, the one exception to this rule still seemed unable to use her informal experiences in ways that others would recognize as relevant. While it is very useful to understand how learning happens in particular places, to understand learning trajectories, I think we have to look across time and space.

Karen: I agree, and find learning trajectories a particularly difficult issue and one that I may be too close to. Let me begin by asking if a "trajectory" metaphor captures what was going on at PES. And if not what might do so? I wonder if "trajectory" oversimplifies identity production, because a trajectory seems to start somewhere and end up somewhere else. At PES, engineer identity did not seem to work that way, especially for women. Though students were not that similar when they entered, faculty thought that selection criteria for applicants guaranteed students would be the same, which began the process of ignoring student diversity for classroom teaching practices. But faculty also thought of students as different, for instance, explaining the behaviors of went-too-far Over-Achievers known for exploiting others as due to their pre-college natures, which were different from the natures of students who did not behave in those ways. (Notice how this let campus practices off the hook for contributions to identity production.) On one side of the dialogic process, differentiation into a wide range of "end-point" identities (those consistent with being an engineer on this campus) became expressions of the ways students thought of, and performed, themselves relative to campus structures, just as on the flip side of the dialogic process, the campus culture (and individuals in it) thought of students using cultural frames of reference. On both sides of the process, only partial identities were performed or recognized. As an engineer, when I imagine a trajectory, I think of some mathematically describable (smooth) arc or another. But the identity production I saw at PES reminded me more of "vectoring" toward a wide range of ways to fit in. Students start in different places and move in more or less zigzag fashions; motions to the left, for instance, are met by cultural expectations that send the student back to the right somewhat, and at each turn aspects of an individual

can be shucked off (or not made visible), while new accommodations are taken up, and so on, ending up at a wide range of expected locations. I don't know how this works for women, who cannot be redirected (given cultural messages about inappropriate behaviors based on campus engineer identity terms). Do they just go off the edge of the map? Does the trace of their movements disappear? Do they just cease to vector toward anything? Men seem to vector toward different places, which then connote belonging and a variety of perceived attributes that go along with each position, one of which is that they have expertise in one of the two different forms of engineering practice. Thus, men do not have to demonstrate their expertise, since it is, in time, taken for granted or subsumed in the campus identity term that seems to fit their behavior. But, based on what I experienced in engineering and what I hear anecdotally from women engineers (current and former), women may be confronted with having to prove their expertise at every turn; nothing is taken for granted, not surprising since there are so few ways to imagine them as engineers.

Margaret: The idea of vectoring rather than a trajectory as a metaphor for describing learning is intriguing. I think it would be very interesting to develop this idea as an extension or elaboration of Lave and Wenger's conceptualization of situated learning and Lev Vygotsky's zone of proximal development. Also Jay Lemke's current work on timescales would seem highly relevant.

Karen: Point well taken.

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