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Forum

On the societal nature of praxis and organic research

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Abstract

In its focus on social practices, the feature article presents an interesting theoretical framework for rethinking not only where and how knowing and learning in science education exhibit themselves but also we might change our own research practice. The framework is not new to me, as I have advocated it explicitly for more than 15 years. But over time it became apparent to me that some particularities of participation in practice may be grounded more strongly in an orientation towards the *societal* nature of any human praxis. In this forum contribution, I present a theoretical approach built on societal-historical activity theory that also takes activism as a major category for theorizing participation. This approach not only covers the extent of the social practice framework but also allows us to make thematic the production of inequity and restrictions to access science and engineering that are characteristic of many societies.

Keywords Cultural-historical activity theory; society; consciousness; subjectification; personality; revolutionary praxis

Forum response to William R. Penuel (2014), Studying science and engineering learning in practice.

> A famous Latin proverb says, "Non scholae sed vitae discimus [we do not learn for school but for life]." Life therefore has to be the perspective through which we look at learning rather than the school (or classroom). We can understand what happens in classroom when total (individual, collective) life is our unit, but we cannot understand total (individual, collective) life when the STEM classroom is the unit. (Roth and van Eijck 2010, p. 1031)

The feature article discussed in this forum argues for science education research that focuses on how people use science and engineering *in* social practice while

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This review essay synthesizes and expands on issues raised in William Penuel's paper entitled: "Studying science and engineering learning in practice." DOI:
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participating in collective efforts that transform current ways of cultural and economic production. I am sure that the author would agree that my introductory quotation is consistent with his quest for taking a different perspective of learning, which his emphasis on science and engineering *in* and *as* social practices appears to suggest. I suspect he would agree despite his hedge that the social practice perspective is more analytic than prescriptive. In this article Penuel articulates, from the perspective of a framework that is marked in its entirety by the writings of Jean Lave, an approach to science and engineering education that I have begun advocating 15 years ago in a move to study social practices. Influenced by Jean Lave (1988) and grounded in a strong view of situated cognition I suggested that we needed to deinstitutionalize science education and investigate "participation in activities as these are shaped by individuals-acting-in-settings" (Roth and McGinn 1997, p. 502). Like William Penuel today, we also pointed to the fact that the "structural properties of activities . . . arise from the interaction of multiple aspects of a setting including psychological, material, social, historical, political, and economic factors *as these are seen by the actors themselves*" (p. 502, emphasis added). Moreover, I already had been arguing for investigating learning while students "engaged in some form of activism" (p. 506). Most importantly, perhaps, I suggested that the students' activities "do not need to remain confined to the institutional walls. Rather, these activities can become part of public and political processes" (p. 507). A dialectical materialist approach allowed me to describe and explain that the very nature of practice is its own transformation so that we do not just participate in a practice but, in and through our participation, change the very practice as well as our forms of participation (Goulart and Roth 2006). Thus, it is not that there is some trajectory from some periphery (margin) of a community to its core, but every instance of practice is central | marginal simultaneously, which allows us to explain why some core (central) practice all of a sudden disappears and new (marginal) practices emerge and become the central ones. Penuel justly points out that communities are not to be treated as containers but as dynamic intersections of people, tools, and activities – not unlike what we described by saying that "inherently are heterogeneous in terms of the activities, competencies, rules, and means that can be observed; they therefore are heterogeneous with respect to the practices that they actualize" (Roth and Lee 2006, p. 31). As a result, activities and their products are "heterogeneous assemblies of a range of elements including standard practices, material and linguistic resources, sets of breakdowns, and ongoing concerns" (Roth and McGinn 1997, p. 503).

In the course of my inquiries, I came to see that science and scientific production are not limited to the laboratories of white-coated individuals but "are open to socio-political arenas" where they do not exist "separate from economics, politics, and ethics" (Roth and Désautels 2004, p. 161). We recommended viewing science education from the perspective of citizenship rather than viewing citizenship from the different STEM disciplines. We suggested that "if students were to engage in activities that directly contributed to community life, that is, if they were to enact citizenship in practice, they would also contribute to their development as citizens" (p. 163). In subsequent elaboration of the approach, I recommended a focus on scientific literacy as collective practice and provided extensive examples of the

struggles of persons-in-setting, including those of an entire part of my community that was deprived of access to running water (Roth 2003). I stated that "scientific literacy also means participating in the choreography of [a] public meeting, enacting access to participation and, thereby, contributing in different and changing ways as the event unfolds" (p. 15). I specifically proposed activity theory as a framework for doing research because it allows us to deconstruct situations in which "differences in interest, motivation, power and action possibilities are ubiquitous" (p. 17). Just as Penuel, I noted that in everyday situations, whether and how resources from the STEM discipline come in handy is itself a question of the dialectic of acting-in-setting rather than an a priori given necessity. Moreover, once we accept that what really matters is the collective working through of struggles, then individual prowess no longer matters but the *collective* achievement of goals in political-economical-ethical struggles that also put the person at stake. I also suggested focusing on the dialectic of participation, so that we can appreciate "that the real purpose of education ought to be the utilization of extant artefacts and instruments and the extension of such utilization into new forms, which are then transformed to evolve ever-new forms of cultural literacies" (Roth 2007b, p. 386). Anticipating Penuel's call for "a strategic focus on science and engineering in efforts to transform cultural and economic production," I showed how science and engineering constituted not only means but also the very contested ground upon which the political economy of one municipality played itself out and how, in the process, community health and safety came to be produced (Roth 2008b). In the process, very different aspects of changing participation come to be highlighted than this is normally the case, including the hybridity, and heterogeneity of practices and praxis as a place of bricolage and métissage in and of societal practices (Roth 2008a).

In the course of my research, I began to shift from the social practice approach of my earlier work (Roth and McGinn 1997) to an increasing framing of the contexts of research in terms of their place in society. Here – influenced by Klaus Holzkamp (e.g. 1993), who was developing a critical, Marxist theory of the human subject and who also had inspired Lave (e.g. 1993) – I was led to societal-historical descriptions and explanations of the ways in which human beings change their participation in changing societal practices in the course of their daily lives. Societal-historical activity theory is a powerful lens because it not only focuses our attention on concrete human praxis but also affords framing whole persons in the course of their life in society such that "*[t]he relation between higher psychological functions was at one time a real relation between people. . . . The relation between psychological functions genetically is connected with the real relations between people"* (Vygotskij 2005, p. 1021–1022, original emphasis) and "*Not thought thinks, man thinks. . . .* What is man? . . . a societal person = *a totality of societal relations* [obščestvennyx otnošenij]*, embodied in an individual*" (p. 1028, original emphasis). Lev Vygotsky, who is generally recognized to be the father of activity theory, articulates, in a chapter entitled "Concrete human psychology," the connections that link higher psychological functions and personality, on the one hand, and society and the *societal* relations we entertain and that reproduce society, on the other hand. A person is an ensemble of real, lived relations between people in society; all higher psychological functions that we might be inclined to attribute to persons are in fact

observable *in* and *as* real relations between people. In his program, concrete human psychology realizes a dictum that "man is in a literal sense a ζῶον πολιτικόν [zoon politikon], not merely a social animal, but an animal that can individualize only *in society*" (Marx/Engels 1857/1983, p. 20, emphasis added). In this view, real relations are the means that allow collectives (family, groups, or society) to pass on psychological functions to their children and to the next generation rather than being the means to socialize ("wild," "untamed," and "uneducated" children to make them functional citizens.

In the foregoing paragraphs, I show that the social practices framework has shaped my research for quite some time; but I also have moved on because of a sense that there was something missing, which perhaps was the declared analytic stance opposed to the more prescriptive stance that I was also seeking. I always wanted to be an "organic intellectual" (Gramsci 1971) whose work makes a difference in and to the struggles of real people. The purpose of this symposium contribution therefore is to add to, engage, and reframe some of the issues raised in the feature article. I begin by articulating societal-historical activity theory, which constitutes my ground that both frames my reading the feature article and leads me to add some features that are central to my own orientation towards science education: its descriptive explanatory and its prescriptive dimensions. I then take a closer look at (a) activities, practices, and boundaries that are at the origin of societal inequities and (b) the constitution of subjects and persons in and by praxis. I conclude with a call for a *societal* orientation to the study of science and engineering *in, as*, and *for* revolutionary praxis.

Societal-historical activity theory

Cultural-historical activity theory has been proposed as a powerful framework for understanding teaching and learning not only in the context of formal schooling but also across all forms of activity oriented towards the generalized satisfaction of needs (Roth and Lee 2007). In this forum contribution, I follow the originator of this theory Aleksei N. Leont'ev (1983) and qualify the theory as *societal*-historical [obščestvenno istoričeskogo] and praxis/practices as societal [obščestvennaja praktika]. This, then, provides me with a lens both to look at human society for describing and explaining consciousness and human praxis *across the entire lifespan*. This theory, more than the *social* practice framework Penuel sketches, provides a more encompassing view of life in *society*, the interlinking of the various productive, societal-historically specific human activities, the trajectories of individuals through different activities in their daily lives, the formative *societal* relations *in* and *as* which higher functions exist and appear, and the results on their individualized consciousness, personality, and knowledgeability across a different practices and forms of participation. Being in school is only one small part of what members of society do and where they engage in struggles: everyday and along their life spans. We bring up children, conduct home life, go to work, ride bicycles or drive cars, shop for groceries, participate in environmental groups, garden, keep bees, or renovate (parts of) our houses. That is, even in the course of a single day, we participate in

different forms of activity (defined below), with different forms of struggles and subjectivity while continuing to be denotable as the same persons (personalities). As human beings develop, the total number and nature of the activities in which they participate changes. Yet our participation and struggles in all of the diverse activities that constitute society makes who we are as persons, our personalities: we become parents, students, scientists, shoppers, environmentalists, gardeners, beekeepers, and so on. To explain who we are, our life form, and our human consciousness in the course of our entire life in *society*, we need a comprehensive framework for theorizing the practice-constitutive movements within and across activities, their coherences and incoherencies, precisely to be able to theorize the differing and differentiating struggles that constitute who we are. Because of the emphasis that social psychologists such as Vygotsky and A. N. Leont'ev place on society, we need to look at its evolutionary and cultural origin.

Society as network of generalized need-satisfying activities

Societal-historical activity theory was designed to model how human *society* emerged as a result of the continuous evolution of life generally and the development of the human psyche specifically beginning with single-celled organisms to the present day (e.g. A. N. Leont'ev 1959). Grounded in dialectical materialism as Karl Marx developed it (e.g. Vygotskij 2005), the theory operates on the assumption that complex systems evolve from units that already harbor all the potential for complexity much like a seed harbors all the complexity that a tree displays in its relation to the environment. It is a "concrete psychological theory of consciousness, which has opened entirely new perspective to the science of psychology" (A. N. Leont'ev 1983, p. 107). Beginning from simple animal groups that hunt collectively and fashion and use tools – such as, for example, chimpanzees – human society evolved as the generalized activity of control over the environment unfolds through an increasing division of labor, each leading to a new form of life and society sustaining activity. Although each individual initially produced needed tools to satisfy a need, as this can be observed among chimpanzees, tool production and need satisfaction eventually became two different activities. Today, society constitutes a network of interlocked activities all of which contribute to the generalized control over the conditions and generalized need satisfaction (Fig. 1). It is precisely here where the network characteristics of social practice theory Penuel describes have their origin. But it is a theory of *society* rather than a theory of the social that makes this network intelligible, for the great apes, too, have *social* relations and culture without, however, having human forms of consciousness. It is characteristic of human society and its representational capacities that affords, for example, engineers to design tractors that are produced in manufacturing activity. Farmers use tractors to till their fields and harvest grain. The grain is used in the making of bread, which ultimately satisfies a human need. Although engineers do not produce bread, in exchange for their contribution to the generalized conditions and need satisfaction (which requires representational capacities to make the absent rewards present before they actually exist), they gain control over their individual conditions and need satisfaction. Each productive activity does not just

produce something, but it produces an ideal or material good intended for use or consumption in another activity. This very fact alone shapes activity generally and the associated ideal reflection (consciousness) particularly. Moreover, the diagram also exemplifies that society is a network totality so that no scientific activity *ever* could stand on its own, including its forms of consciousness, practices, subjectivities, or struggles. The diagram makes visible Penuel's insistence on the difference between schooling practice and other practices all the while showing the interconnectedness between them, the knot-work parts of which each person traverses in the course of daily life. It is this same interconnectedness that leads to the knot-work character of the human psyche and human personality (A. N. Leont'ev 1983).

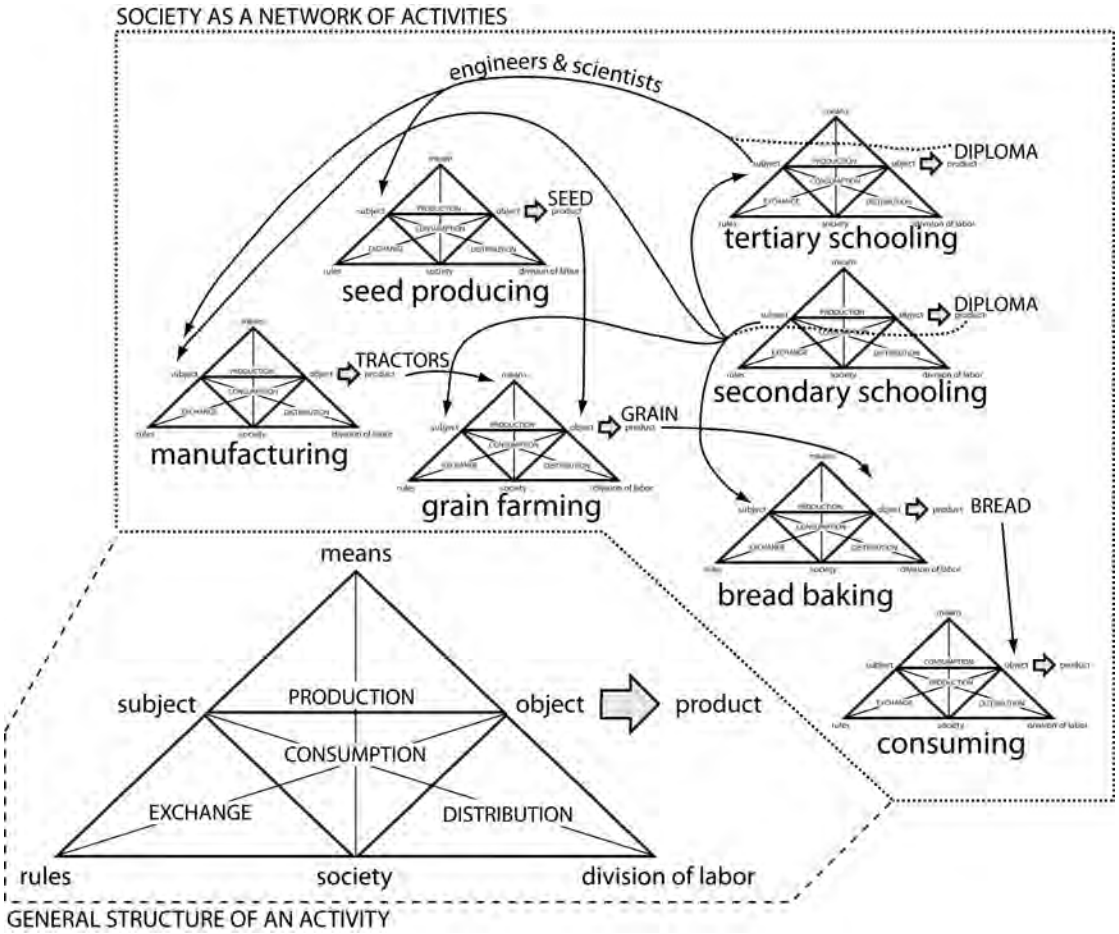

Fig. 1. From a societal-historical activity theoretic perspective, society constitutes a network of activities (Tätigkeit, dejatel'nost'), each of which contributes to the generalized control over conditions and generalized satisfaction of needs.

From this perspective we might ask: what are the concrete generalized societal needs that the different levels of schooling produce? Despite all ideological claims that might mobilize "knowledge" or the "educated individual" to produce an answer, the one real, concrete type of thing that schooling produces are diplomas, which

regulate access to become a part of the productive subject in other systems of activity (Fig. 1) (e.g. Roth and McGinn 1998). Schooling is a concrete human activity that creates a hierarchical order that reproduces rather than changes classist society (Foucault 1975). We all know that and how middle-class parents in particular insist on accountability and quarrel with schools about their children's grades or the "quality of teaching," because they have so much at stake in assuring that their children maintain "the good life." Working class families do not engage schools in the same way. Although Penuel notes that the practices of schooling produce failure, his social practice framework does not provide an explanation for this phenomenon. Societal-historical activity theory, however, does so by focusing on the actual products of schooling activity: grades and grade reports. Unsurprisingly, students, parents, teachers, principals, and superintendants are oriented towards the production of grades rather than towards the production of knowledgeability. It matters little that and when students graduate from high school or college (e.g. Harvard) with "misconceptions"; what matters are the grades that determine the degree of access persons will have to other activities and practices.

Penuel articulates the changing nature of social practices. This is an important issue that science education researchers often neglect. In societal-historical activity theory, grounded as it is in dialectical materialism, change is implicit. In this respect, the triangular models of activity that are perpetuated in the literature are deceiving, because these represent synchronic perspective, as if the activity was frozen in time (e.g. Roth in press). In fact, even though Fig. 1 seems to belie it, my textual description of societal-historical activity already takes into account the continuously changing nature of the fundamental category: activity. Thus, the theory begins with single cellular organism and, providing a basic mechanism of quantitative and qualitative changes, provides a general account not only of animal evolution and speciation but also of the qualitative shift that occurred with anthropogenesis (Roth 2009). In fact, *activity* is the fundamental category because it is a (non-self-identical) unit of difference and change: across space and time. Thus, the very execution of an action produces change: in the material of the object, in the body of the subject, and in consciousness (Marx/Engels 1857/1983). It is this change that societal-historical activity theory describes and theorizes rather than a stable structure (e.g., that depicted in Fig. 1).

Activity as minimal unit bearing all characteristics of society

Central to activity theory is its attempt to establish units analysis, and corresponding *categories*, to replace the elemental analysis of traditional psychology. In societal-historical activity theory, *activity* is taken to be one such minimum unit that retains all the characteristics of society that also determine the nature of the relations between persons and of persons to themselves (Fig. 1) (A. N. Leont'ev 1983). Activity was the original seed, which subdivided to give rise to a network of activities that constitute society much like the egg cell, once fertilized, gives rise to an entire organism. The English term, as the feature article, is actually confounding two concepts clearly distinguished in the Russian and German languages of the founders of activity theory (i.e., Marx and A. N. Leont'ev) – with

serious consequences for the misreading and misuse of the theory (Roth 2013a). Already implicit in the description provided in the preceding paragraph, activity is *productive* activity that meets a generalized human need: it is dejatel'nost'/Tätigkeit. This orientation toward productive activity is clear in the original works, for the term dejatel'nost'/Tätigkeit always is paired with the adjective societal (stem: obščestvenn-/gesellschaftlich-) rather than social (stem: social'-/sozial-). The same English term is also used to translate aktivnost'/Aktivität, two terms that simply denote vital activity, business. Being kept busy in school or completing a task in school science are not activities in the sense of dejatel'nostej/Tätigkeiten, for the latter have collective objects/motives toward which the activity is oriented. (The expression object/motive is to capture the Russian/German predmet/Gegenstand in the theory, an abstract object that also embodies the [ideal] motive, as distinct from objekta/Objekt, a concrete object [A. A. Leont'ev 1969].) In this article, I employ activity *exclusively* in the sense of dejatel'nost'/Tätigkeit.

The fundamental difference between all other theories of knowing and societal-historical activity theory is the fact that concrete material praxis, as in productive activity, is reflected (has its parallel) in consciousness. In fact, consciousness is the result of praxis and the societal relations it implies, always oriented toward the control over condition. Whereas constructivist theories highlight that individual knowledge is not true but viable, a point that Penuel rightly makes, societal-historical activity theory grounds itself in Marx's second thesis on Feuerbach when it comes to the relation between material activity and its reflection in consciousness:

> The question whether human thought is true is not a question of theory but a *practical* question. In praxis man has to prove the truth, that is reality and power, the this-sidedness of his thought. The argument over the reality or non-reality of thought, which isolates itself from praxis, is a purely *scholastic* question. (Marx/Engels 1846/1958, p. 533)

The fact that there are identifiable moments in an activity – subject, object, product, means, rules, society, and division of labor (Fig. 1) – does not mean that these are the elements from which activity is built: none of these can be described and explained on its own. This is so because, being part of a whole, any identifiable moment implies all other moments (parts). Talking about the individual subject independent of the generalized productive activity and, therefore, of all the other moments of activity, leads nowhere but to pure abstraction and idealization. On the other hand, the category *activity* is not an abstractum but a unit of concrete change; to push this point, I recently proposed *activism* as the pertinent category of analysis (Roth 2010) – fully consistent, for example, with Penuel's descriptions of the struggles in the FreshRoots organization or the practice of *counter-mapping*. Thus, the analysis is not that of a static structure but of an extended productive process*-in-the-making, where the asterisk marks the provisional and temporary character of the process itself (Roth 2013b). Heraclitus already noted that a person never steps into the same river twice: as flux it always changes. Dialectical materialism evolved in the endeavor to capture a living, always changing material and societal world (only dead things do not change). To do so, dialectical materialism uses dialectical

categories. Such categories are non-self-identical precisely because they refer us to *change* and, therefore, *not to* states but, at best, to multiple states *simultaneously*. Such categories, therefore, as useful to denote the struggles Penuel refers to, all the while implying the changing nature of these struggles.

The societal character is found at all levels of activity

Activity is oriented toward a *societal* motive [obščestvennyj motiv]; but the goal-directed actions of individual subjects realize an activity – driving a tractor (action), when used in factory testing, realizes manufacturing (activity) but realizes farming (activity) when used to harvest grain. There is therefore a mutually constitutive and implicative relation whereby activities determine actions, but actions realize them. Similarly, contextually conditioned operations realize actions but are executed only in view of goal-directed actions – e.g., I am conscious of the sentence I intend to write (goal-directed action) but my fingers do so without requiring conscious thought (conditioned operation). Societal-historical activity theorists *insist* on the fact that any observed operation is comprehensible (intelligible) only in its relation to the specific activity (object/motive) that it contributes to realizing. In fact, some have extended this claim to the domain of neuropsychology, suggesting that even the neural processes can be modeled appropriately only by taking into account societal-historically specific activity (Luria 2003). Aleksandr Lurija recommends that "the same scientific principles of investigation" suitable "in the study of the elementary forms of physiological processes" also are "adequate for the study of human conscious activity, its social-historical origin, and its complex hierarchical structure" (p. 73). This is so because thoughts do not think, persons think. Persons stimulate their brains from without using words and other signs; and anything outer *is* societal, integral part of *societal* relations (Vygotskij 2005).

The societal character of development within and across activities

Societal-historical activity theory allows us to think development along two dimensions simultaneously. As apparent from the work of Vygotsky quoted in the introductory section, higher psychological functions and person are the result of *real societal relations with others*. Within specific activities, individual persons are in the subject position (Fig. 1). Because of the continuously developing nature of human activities generally and all their moments and interrelations of moments specifically, there is a developmental process that I denote by means of the category of *subjectification*. I use this category to focus attention on "the production . . . of a body and a capacity for enunciation not previously identifiable within a given field of experience" (Rancière 1995, p. 59); this field, here, is constituted in and by the activity system. The identification of the body – which occurs "through a series of actions" in and by this body – "is thus part of the reconfiguration of the field of experience" (p. 59). The category of subjectification takes into account that persons are both subjects of (and thereby determining) collective activity and subject and subjected to (thereby determined by) collective activity. It is this subjection that explains the struggles rather than the agency that is often associated with social

practice theory. Penuel simply asserts that the "struggles are always connected to larger historical, political, and economic struggles," but it is in societal-historical activity theory that this assertion and the connection between the personal and the historical finds its explanation. The *societal* relations within each activity are the loci of subjectification: this is where the subject individualizes itself. Participating in farming, I continuously become (develop) as a farmer; participating in engineering firms, I continuously become (develop) as an engineer. My participation, therefore, is not constant but changing; and this changing participation is itself a manifestation of the changing nature of activity as a whole.

As persons, however, we participate in multiple and diverse ways in multiple and diverse societal activities during any single day and along the lifespan. The person, as Vygotsky points out in the quoted passage, is the ensemble of the *societal* relations. In societal-historical activity theory, personality is theorized in terms of the totality of activities and societal relations that we constitute and that constitute us. Participating in any societal activity we contribute to realizing its object/motives, which in fact we take up and that orient the process of our continuing becoming. A person, therefore, is constituted by the totality of object/motives that s/he contributes to realizing – a point that Vygotsky and A. N. Leont'ev have taken over from Marx. And it is this interconnection of very different object/motives that allow us to understand personality itself as a continuing and ever-changing struggle (i.e. there is nothing like *iden*tity, from Lat. *idem*, the same). As these object/motives are societal in nature, our personalities are entirely societal: I am a physicist, a shopper, a parent, an environmentalist, a gardener, or a beekeeper. Each person reflects the entire society in the way a raindrop reflects the whole world in and of which it is an integral part. However, even though this defines the person entirely in collective terms, the hierarchy and connections between these different subjectivities is highly individual even in the case of two twins who do everything together. This conceptualization allows us to think what happens when persons move from activity to activity, where they take the relevant subject positions leading to different forms of consciousness and, therefore, subjectivity.

Activities, practices, boundaries

The feature article argues for a *social* practice perspective on learning (in) science. I wholeheartedly agree. But I wish to extend the framework so that it includes ways of articulating the macrosocietal structures and forces as well as the transactional relations that constitute society in and through patterned societal relations. Penuel correctly emphasizes that we need to study science and engineering not only *in* practice but also *as* practice. In fact, we might add that we need to study science and engineering *for* practice, which then allows us to explain the societal-political ethico-moral nature of science and engineering (e.g. Roth 2007a). Penuel does note that one useful approach for "diagnosing inequity with respect to participation in and across social practices is to employ ethnographic methods for 'following the person' across different settings." The article does not however provide a map that would allow us to situate these settings and the

relations that these different settings have relative to each other. The societal-historical framework presented above, because it explicitly theorizes society in its entirety as a knot-work of societal activities, indeed provides a map (Fig. 1). This provides us with a map for theorizing the emergence of personality as a function of the different forms of participation and struggles. Such a map enables us, for example, to explain the difference between students who participate in environmental activism as part of their schooling experience versus students who participate in environmental activism as part of their out-of-school life. There are differences across such even between those experiences when organized within schooling.

Each activity is defined by its object/motive that serves the generalized societal control over condition and need satisfaction. Every practice, characterized by *activity-specific* actions and operations, is oriented toward the object/motive. Thus, whatever students do in the activity of schooling is mediated by its object/motive. It makes no difference whether students to a cookbook lab, copy lecture notes from the chalkboard, or engage in environmentalism. As long as the outcomes of their labor end up in the garbage can because these do not contribute to meeting collective needs and control, there is no value to the labor (Roth and Barton 2004). The really produced outcomes are grades – there is a division of labor between teachers, students, and school – which end up on a report card and, cumulatively, on a graduation certificate. Thus, even going to a science museum or participating in a workshop that introduces children to environmentalism and traditional ecological knowledge is not experienced as "fun" when the ultimate production is a grade. It is precisely because grades (grade reports) are the object/motive of schooling rather than knowledge that "cheating" is a viable option: Students and instructors focus on the production of grades rather than on changing participation in disciplinary practices. This makes schooling radically different from other activities so that it does not suffice, as Penuel suggests, "following the person across settings . . . to give an account of how people successfully adapt their knowledge, skills, interests, and identities across different settings as they engage in everyday, routine activities to create 'connected' or extended pathways for themselves." In fact, I would formulate social practice theory stronger to imply that there are no (stable) knowledge, skills, interests, and identities that are adapted to settings, but that we focus on continuously changing participation in changing praxis. More than Penuel, my personal preference is to focus on continuous *becoming* rather than the adaptation of existing structures and dispositions.

We may anticipate a difference, however, when students, as part of their schooling activity, participate in environmentalism, where the outcomes of their work become something that benefits society (local community) as a whole. This is precisely what my research group has observed and documented in several empirical studies (e.g. Roth and Lee 2004). Students who contribute environmental knowledge to the community and who actively contribute in the struggles required for changing the environment (planting trees, cleaning up creeks) learn differently and different things than those who merely accomplish another (graded) task in a science museum or outdoor workshop. If the same students were to participate in environmentalism outside of schooling, then they would have shifted into a different

system of activity, with a different object/motive, productions, divisions of labor, rules, means of production, or objects. The result would be different forms of societal relations, different forms of consciousness, and, therefore, different forms of practice, subjectification, and personality. As ethnomethodological scholars have pointed out in both science and mathematics education (e.g. Greiffenhagen and Sharrock 2008), one must not abstract practices and relations from concrete praxis and the particular rationality that is at work, a praxis that is constituting and being constituted by that lived, sensuous work. At an abstract level (e.g., tree) everything looks the same (e.g., a desert palm, a mango tree in a lush tropical forest, and a crippled birch in northern Canada); in concrete praxis, there is a difference, with consequences, for planting one (type of) tree rather than another.

The feature article orients us towards inequities and the ways in which "access to practices is organized." I both agree and want to sharpen the argument in stating that the very inequities and the boundaries (borders, glass ceilings, etc.) that become apparent are themselves used in the differentiation and integration within and across societal activities. Whereas the different activity systems in which students partake at home, in school, with their friends, or as shoppers have different object/motives and, therefore, are associated with different processes of subjectification, subjectivities, or roles in relevant divisions of labor, all of these are integral to who a person becomes. Thus, those very boundaries *are constitutive* within the person (personality). For science students, as for electricians or mariners, the "boundaries" themselves constitutive of school learning, and schools build such boundaries when they put students in different rooms for science, arts, mathematics, and disrupt coherent "practices" because of institutionally determined temporalities rather than because of the temporalities internal to the practice. For example, the stories about the gap between the theory that electricians learn in college and the everyday praxis of being an electrician is part of what an electrician becomes (e.g. Roth 2012). In fact, more-experienced electricians often articulate for apprentices what college teaches and what they really do at work. Whereas there tends to be a critical edge to these narratives, journeymen and master electricians are competent when it comes to defending their actions in terms of "the electrical code [standard]" and the relevant theory. That is, the boundary is part of the lore of the field, constituted and constituting, experienced as discontinuity and integrated into ever-changing personality.

While I received a draft copy of the feature article and while beginning to work on a commentary, I was also doing fieldwork concerning knowing and learning of commercial airline pilots. On the day I arrived in the field, I knew little to nothing about the job in the cockpit. I literally had entered a foreign part of this world. I was completely unfamiliar with the practice of flying, the tools that exist in a cockpit, the "rules of engagement," the kinds of competencies valued, the "(non-) technical skills," the "enabling" and the "basic skills." Science education scholarship, as does the feature article, might emphasize the boundaries, "third spaces," and discontinuities I should have experienced. Yet all the while this was initially foreign, I never did experience discontinuities between my work in the head quarters of the airline and the other activities in which I concurrently was a constitutive subject and associated subjectivities: I was a husband, doctoral supervisor, member of the

scholarly community, consumer (as hotel guest, traveler), invitee, mentor to junior peers, and counselor to the family of a mentee that has had all of a sudden found itself in a tragic situation of mental illness. More so than the *social* practice framework Penuel articulates, societal-historical activity theory allows us to anticipate both differentiation, integration, and struggles between and implied by these multiple, diverse activities.

Fig. 2. Sitting in the position where normally an evaluator would sit, I not only anticipated instrument readings, their relevance to the flight, and predicted pilot actions.

At the end of my 8-day stay in the field, I was sufficiently familiar with the work of pilots that I was able (a) to read the complex array of instruments in a complex environment of the cockpit (Fig. 2) and (b) to anticipate many pilot actions (aspects of practice) in the cockpit during two commercial flights. How this familiarity arises from unfamiliarity and how the everyday familiarity with the world supports the emergence of aspects of the specialized practice of flying a commercial airplane is precisely the issue. Penuel gesticulates in that direction when suggesting that research needs to follow persons across settings. Societal-historical activity theory, more so than his social practice theory, does provide us with a handle on the issue of our movement within and across activities. Precisely because our human nature is societal, whereby our personalities are the result of the ensemble of the *societal relations* that we participate in, there is a "common sense" rationality that constitutes the foundation of *every* specialized human field of endeavor at a particular point in time (e.g. Mannheim 2004). In the different activity-constituted and activity-constituting arenas, different aspects of the common forms of rationality are emphasized and developed leading to the apparent differences when we move from societal arena to societal arena. But whatever I do as a husband,

colleague, mentor, teacher, counselor, or invitee has emerged from the societal relations I participated in since birth. These initial societal relations, as higher psychological functions (see Vygotsky quotes in the introductory section), are the basis of my personality today and of my differing, always already changing competencies in specialized changing practices. The first relations are the foundation of subsequent relations – which is why working-class lads often get working-class jobs and end up becoming working-class parents on their own (Willis 1977) and why working-class children end up much less frequently in German (Kühne 2014) and French professorial positions (Bourdieu 1979). In the research on pilot cognition, the societal relations allowed me to become familiar with the work in a cockpit in the same way that they allowed me to become familiar with the work in the family of my key participant during an evening dinner invitation.

Of subjects and persons in praxis

An important part of the feature article concerns a description of learning *in* and *as* practice. I organize the comments that follow around the subject and person. More so than the social practice theory, the societal-historical activity theoretic perspective includes the subject as one of its constitutive moment of the activity (e.g. Holzkamp 1993). We *cannot* therefore look at the subject of activity independent of all other moments of activity. That is, because the smallest unit is the activity, the subject is changed together with the activity, and the activity together with the subject. The subject is a subject*-in-the-making (Roth 2013b). Working-class lads or inner-city Afro-American females may struggle as hard as they want only to end up where they have started out – in working-class neighborhoods and slums. On the other hand, when we look at the person, who is theorized as a totality of collective object/motives, then change is equivalent to change in society, for as the object/motives in each activity change together with each individual activity, so does the person. Moreover, at the personal level, the hierarchical ordering and the strengths of the linkages may change. From this perspective on ever-changing practices, change is inevitable and learning unproblematical; problematic is the notion of knowledge (structure) (Lave 1993). In a river full of eddies, backflows, and turbulences, states are problematic; flow and change is not. Our experience of life is that of a stream full of eddies, backflows, and turbulences. Every material thing we use is in constant change; only dead things like dead languages and rocks are (relatively) constant. More so than Penuel, I focus on our being subject and subjected to conditions in addition to being the subjects of activity. My own notion of *activism*, which I propose as an alternative to societal-historical activity theory (Roth 2010) integrates the dialectic of agency and passivity: we are agents and patients simultaneously, continuously struggling (coping) with the contingencies of an emergent life. This is important, for example, to explain learning in science classrooms, which is a relational phenomenon so that even those teachers who appeared to do really well in one setting may fail to teach science appropriately in another setting, such as in many urban (inner-city) schools. It is not that these teachers are incompetent but that the situation as a whole, the particular way in

which the activity of schooling is realized, does not give rise to the kinds of practices that we may observe in a suburban private school in the same metropolis. Ending up in the slums is not a construction of the African-American female: it also is a struggle, an ordeal that she is subject and subjected to.

Becoming: as subject

Penuel points out that "the production of social practices in time and space is an important part of an analysis of learning and becoming." This integral experience of human life that we continuously become is an integral feature of my approach. Like Penuel, I assume *change and becoming* to be inevitable – even though at times it may not be immediately visible. Thus, in a five-year ethnographic study of a fish hatchery, we observed that even in the most "routine and boring job," feeding fish or cleaning concrete fishponds, change is occurring (Lee and Roth 2005). Those who do the job, over a period of years, get better at doing it and learn to distinguish someone with experience from someone who is only a beginner. But such descriptions do not yet account for the person-in-setting or for the way in which the person changes as a result of the process of subjectification.

In the approach Penuel describes, change is recognized as an inherent feature of participation. It is life itself that produces change. Praxis changes the world. Praxis *is* change: not only for the material or ideal entity transformed into some outcome but also for the subject. The latter, just because s/he does something, changes physically materially, which is reflected in continuous improvement of practice; this change is reflected at the level of consciousness, where the practitioner, as shown in the fish hatchery example, learn to distinguish performances even in the "most boring and routine jobs." Change and learning is a byproduct of human praxis. The problem of taking any static view – to which Penuel and I would be opposed – is evident in received and going conceptualizations of teacher learning. Thus, in every (societal) relation where teachers are an integral part, they change (Roth and Radford 2011). This is why they get better with years of teaching. But changes may be observed at the micro-level, for example, when a teacher rephrases a question repeatedly until it becomes answerable. In the process, she learns to ask (better) questions just because she asks questions. Over a period of several months, we may then observe substantial changes in practices from questions that lead to simple yes/no answers to productive questions that lead to extended conversation about scientific aspects of students' work. The teacher learns to ask questions even though she may never make her questioning the topic of reflection, sometimes simply as a result of interacting a lot with students where rephrasing questions becomes necessary, sometimes by following another teacher and beginning to take over her ways of asking questions. As a result of a more symmetric approach, we begin to note that not only designated students learn but so do designated teachers and not only designated teachers teach but so do designated students: the *zone of proximal development* therefore works both ways (Roth and Radford 2010). The relation allows *both* parties to learn and develop – consistent with Vygotsky's dictum that the person is the ensemble of societal relations. This, then, is a totality-of-life perspective that is more comprehensive than what the vision presents us with.

Penuel's focus on social practice also counters any notion of knowledge that could be "transferred" to other situations. He rightly suggests that we need to follow individuals across settings to see how the same embodied operations participate in the constitution of very different forms of praxis, consciousness, and the ensemble of patterned actions (practice). This was highlighted very early in the literature on "authentic learning" with the example of particular equations that are used very differently in engineering and physics (Brown et al. 1989). This is also evident in the literature on boundary objects, which shows that the same artifact or instrument has different functions and is associated with different practices when it moves from one context to another (Henderson 1991). Such research shows that even though the goal-directed action of filling in some parts of a form or referring to a particular aspect of an engineering design drawing may be the same in two contexts, and even though the conditioned operations of writing or seeing are the same, the practices they realize *are different*: consistent with the societal-historical activity theoretic approach. The category of subjectification highlights the continuous change and learning *within* a form of activity perhaps more than Penuel does in the feature article. This is so because the category highlights material changes that come with the production of a body and the associated changes in consciousness that are expressed in the capacity for enunciation, neither of which was previously identifiable in the field. Here, the focus on the *field* or *arena* constitutes an impediment to reducing changes and learning to the individual: always already a kind of nexus of societal object/motives.

Becoming: as person

Persons change as a result of the processes of subjectification that they undergo while participating in different activities as the day goes on and in the course of their lived life. Thus, "K. Marx introduced an idea that has general significance for a truly scientific psychology. A person forms his mind while transforming the world with other people" (Meshcheryakov 1974, p. 15). The person, as theorized in the feature article, is not Marx's sensuous laboring person but is actually an abstraction. This is evident in the transfer question concerning what a person can take from one context to another. As a starting point, it is evident that a science student does not come to master – as Penuel had suggested in an earlier version of his text – "a practice within the context of school science" that they use to "gain access to other contexts for engaging in science practices and at a latter time." First, the students do not engage in a science activity (dejatel'nost'), with their engagement in science-related tasks, they realize schooling – they participate in and realize schooling practices by engaging in school-typical societal relations. Second, Penuel rightly notes that there is no person independent of activity, whatever the one or ones that we observe in progress. Rather than theorizing a person as an abstractum, we may think of it based on the documentary method (Mannheim 2004). The person then is the ensemble of the concrete manifestations that we may observe and attribute to a particular physical body. The key point in this conceptualization is that the ensemble – here, "the person" – is not the result of an addition (e.g., all subject positions taken together), a synthesis, or abstraction (e.g., what is common across

and abstracted from the subject positions). The person is a singular plural: a unique, concrete whole that manifests itself in and through its parts (subjectivity-in-activity, person-in-setting). But each part is plural, because determined by the whole, and, therefore, by all other parts. As a result, the person is different, not only from other persons but also different from itself because it integrates different (subject) positions and different times. The person is not a thing but a continued and continuing struggle, or more precisely, a struggle*-in-the-making. Because the activities and relations are characteristics of society, the person is entirely a societal process and therefore reproducing society in its actions.

The immediate consequence is that we have to abandon the notion of identity still used by Penuel – not in the least because it has been subject to critique in Continental philosophy and societal-historical activity theory for a long time. This is so because the notion does not take into account that individualization is possible only in society (see above). Already during the 19th century, the French poet Arthur Rimbaud noted "JE est un autre [I is an other]." Yet the Anglo-centric (science) education literature has not yet attempted to deal with the question of a fundamental heterogeneity and non-self-identity at the heart of the question of identity. We are different not only with respect to others but also with respect to ourselves. This also means that learners have *different* needs, aspirations, and intentions. Giving everyone "the same" learning opportunities, the same level of *access* (Penuel uses this term 47 times), is synonymous with disadvantaging some (e.g., working- and under-class children) at the expense of others (middle- and upper-class children).

More so than the social practice theory that Penuel presents, societal-historical activity theory lends itself to critical education (critical theory, critical psychology, critical cultural studies, critical feminism, etc.) and the articulation of critique because the *society,* its ruling relations – inequities, politics, economy, class struggle – are already available within the theory. Here I use *critical* not in the sense of simply being critical but in the sense of critical social practice, "fundamental organic struggle" (Gramsci 1971, p. 221) that brings about differences that make a difference to persons' lives. From a societal-historical activity theory perspective, persons are thought in terms of the ensemble of societal object/motives of the activities that they participate in. Such a *societal* focus inherently orients us to the role of the person in collectivities in the here and now and along their lifespan. Penuel notes that the National Research Council's most recent framework addresses the need "to provide access for all students to science and engineering practice" and the inequities that are "produced through limiting access to students' opportunities to learn in schools." I cannot but agree. But I also emphasize that this should not be taken as implying that all students should know "the same" science or engineering (Roth 2007b). Why should *all* students learn science rather than music, small engine repair, or home economics and, thereby gain competence in areas that are really close to home? This question is particularly interesting in the light of the fact that in the everyday out-of-school world, there exists free choice as to whether, when, where, and how to engage with science; in schools, students do not tend to have a choice and when, they often opt out. In a world increasingly characterized by such a degree of division of labor that the professors in the same department do not all

have the same competencies, skills, and knowledge, why should science not left to some just as law is? Why should we not make law or philosophy compulsory school subjects? Lawyers do not have to be chemists in a legal case where the polymerase chain reaction and identification through DNA analysis is at issue – they get PCR experts to testify. A mayor and town council do not need to know about the engineering issues involved in the considerations for a new water main – they draw on their town engineers and, if required, hire other engineers and scientists. They do not require medical knowledge in this same water issue – they call on the regional medical board to seek advice. What we need in complex situations that require very different forms of expertise (practices) are living processes and changing forms of knowledgeability that afford problem shaping and solution finding where no two individuals may know the same thing. We may then anticipate opportunities that are created for the individual expansion of control over conditions and room to maneuver through changing participation in changing collective control over conditions and collective room to maneuver.

Summarily we may say: in a complex society, the most important aspect is participation (in collective societal practices) that focuses on collaboration irrespective of individual skills and competencies. Things that matter allow the living collectivity as a whole to resolve pertinent problems. Therefore, we need to think persons through the lens of collective life struggle in society and along the lifespan. Specific skills are less important than continuous adaptability to ever-changing situations – i.e., knowledge*ability* – which led me to argue for *débrouillardise* and the person as *débrouillard* and *démerdeur*, persons who literally are part of getting a situation out of fog-like conditions and "out of shit" (Roth and van Eijck 2010). It would be more useful if students acquired knowledge*ability*, that is, the cap*ability* of creating knowledge resources on the fly, rather than acquiring the skill of factoring a polynomial or learning the Krebs cycle by heart, neither one of which they will ever see again in their everyday lives, even as scientists.

Position(ing) of the researcher

Penuel notes that the social practice perspective does not explicitly have prescriptive orientation but constitutes a descriptive and analytic framework. It is not quite clear how Penuel's social practice accounts may also be emancipatory if they are not prescriptive in the sense that they allow persons to actively orient towards changing conditions and, therefore, act in a prescriptive manner. The societal-historical activity theoretic perspective has been used to more explicitly orient towards the need to employ research to change the world. In a quotation provided in the section on activity theory, Marx points out that the reality of human thought proves itself in praxis. Marx notes that the coincidence of changing conditions and human activity can be described and rationally explained only as *revolutionary praxis* (Marx/Engels 1846/1958). This same activity also changes consciousness. Marx also points out – in the 11th thesis on Feuerbach – that the point is to change the world rather than simply to explain it. All three points provide us with material for thinking about and theorizing the position of the researcher who is following persons within and across settings.

From the perspective of practitioners, researchers tend to come and go. Many teachers are tired to be told from up high what to do and to be told only a few years later that they ought to do it differently. This is what Marx makes thematic in the 11th thesis on Feuerbach. Researchers, much like Marx's philosophers, come to explain praxis without changing it when the real point is to change the world. Moreover, because they do not engage in changing it, they cannot "the truth , that is reality and power, the this-sidedness of [their] thought" (Marx/Engels 1846/1958, p. 533). They do not experience that their ideas and theory do not work. Transformative (revolutionary) praxis is where the this-sidedness of theorizing shows itself, but our experience shows that the theory is often not appropriate for changing the world. Pronunciations from up high do not transform the world: *revolutionary praxis* does. This is precisely what societal-historical activity theory captures (Roth and Lee 2007): activities change conditions, and the coincidence of changing conditions and activity is the result of and results in revolutionary, that is, condition-transforming praxis (see first quotation). It is this aspect that has led me to propose *activism* rather than *activity* as the main category of analysis (Roth 2010). Research itself is made thematic as a changing praxis, but always and unavoidably so a step or two behind. From the perspective of the individual teachers, they will learn whenever they see that their control over the conditions and room to maneuver increase; they do not need to be motivated. Thus, most teachers see increasing benefits from their participation in coteaching experiences, which increases control and room to maneuver instantly because of participation in collective control; and it increases over longer time scales, because the societal relations that they are enabled to participate in become transformative and lead to development of practices and personality.

Researchers who sit on the sidelines observing the practices in a particular field by and large are viewed as irrelevant by practitioners, though they may be considered a nuisance and disruptive at times. This is clear when we take a societal-historical activity theoretic perspective, which orients us to the different productive activities in which the researcher and the researched act (Roth et al. 2002). The researched tend to be part of the object/motive in the research activity for the purpose of generating texts shared with other researchers. On the other hand, researchers tend to be centrally involved in the change of praxis when they participate in the relevant praxis. For example, in my work on coteaching, we stipulated that researchers gained access to a science classroom only when they participated in enacting and, therefore, to the development of teaching and learning of science (praxis). The presence of the researcher led to increasing the capacity for teaching, and, thereby, to increasing the capacity for learning. In the process, they came to experience not only praxis but also change in praxis from the inside. They participated in revolutionary praxis, which changed activity and conditions of schooling. As a result of their participation, these researchers also changed (including their competencies of teaching, their consciousness, their familiarity with the arenas); and they reported these changes to their scholarly community.

Research and researchers are valued in the field when the practitioners themselves anticipate an increase in power to act as a result of working with researchers. This is evident in my current work within commercial pilots, where the

company really is interested not only in an assessment metric that my colleague developed – himself a 22-year commercial pilot – but also in improving it for their purposes. We jointly funded a research project that investigates pilots assessing pilots using the same rating sheet that evaluators normally use as the basis of the required semi-annual performance rating (Fig. 3). The results of this research immediately return to the chief training officer who, together with us, makes changes to the evaluation metric and training method. The pilots bought into the project because the evaluation metric not only standardizes the two annual assessments that they are subject to but also allows pilots to anticipate the areas in which their performance levels (generally on the simulator) are assessed. By participating in the collective control over conditions, these pilots thereby gain control over their individual conditions. This is important because the assessment results may lead to the loss of their license to fly, and, therefore, to the loss of their jobs. As a result of this collaboration, the airline now views itself as a learning organization that bases its change efforts on evidence that we assist in creating.

Fig. 3. Two pilots (right), in the presence of the researcher-consultant, collaboratively rate videotapes showing the performances of pilots. The pilots can directly relate what they learn to their own performances on the flight deck.

It is precisely because the company, training officer, and pilots anticipate an expansion of their control over their work environment that they buy into research and change what they do based on the research results. They also buy in because, as our interviews show, traditional talking head workshops do not work for them, and little of what is presented is useful to doing a better job on the flight deck. However, they experience a lot of growth while analyzing and evaluating videotapes that show pilots at work, and it is through their engagement in the evaluation effort that the pilots become aware of their own practices so that they themselves come up with ways of improving these. And it was precisely in these sessions that I became familiar with the (discursive) practices of pilots described above. Our – airline,

pilots, researchers – participation changes *in*, *as*, and *with* changing practice in the way Penuel is asking us to enact social practice.

Coda: towards a view of revolutionary societal praxis

The feature article proposes an interesting framework to science educators, a framework that also appears to be transpire from current policy documents and political arenas. As my text shows, I agree with the fundamental tenets of the social practice framework, which, in fact, I have advocated explicitly for quite some time. Over time, however, I have come to find it more useful to describe and explain human praxis and practices in the context of societal-historical activity theory because of its potential affordances to launch a critique of inequities that arise within and are characteristic of society itself. I am interested in researchers as organic intellectuals, who contribute in and through their research to revolutionary social praxis by "directing the ideas and aspirations of the class to which they organically belong" (Gramsci 1971, p. 3). This requires forms of institutional ethnography (Smith 2005), which that combine microgenetic analyses typical of social practice theory and critical, Marxist theory that gets at the societal nature of activities, practices, and praxis. More so than Penuel, I insist on how the different practices of societal life are jointed, and how or why something we do in school should or could be related to other aspects in other parts of their lives. Societal-historical activity theory accounts for the kind of transitions, continuities, and inequities that are at the heart of, but not explained by, the feature article. Local theories typical of the social practice approach, because relevant *within* practices, are not suited to model *transitions* because they do not have the tools to model what happens *between* practices. Especially through its categories of subjectification and personality, the theory affords explaining changing participation across the lifespan and how science and engineering might figure into our personal development. To create visions for science education we may require theories that describe and explain the development of person as members of society engaging in multiple, ever-changing societal practices in the very instance that they are enacted and, more substantially over longer periods of time. We may need theories that "capture" life as a *process* – a contradiction, because in a representation the life is always absent – rather than theorizing stable entities that need to be animated by an outside force like the photographs that constitute a movie reel. We also may need methods – e.g. auto/biography and auto/ethnography (Roth 2005) – that allow us to learn from the life-long participation in the life of society across the various activities that constitute it. A look at the last decade alone shows that societal practices in a large number of areas have changed, especially those to relatively new technologies; while older generations still exhibit competencies in practices valued yesteryear, the younger generations often exhibit different competencies and are "weak" in those characteristic of the older generations. This continuous change of activities, practices, personalities, or life is not modeled in the "vision" that the feature article presents us.

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Bio

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