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11. BECOMING AND BELONGING

*From Identity to Experience as Developmental Category in
Science Teaching and Teacher Education*

[Thinking/thought] is always already a timely self-reproducing and disappearing moment in the *total life* of the individual. (Marx/Engels, 1969, p. 247, emphasis added)

The *psychological* nature of man—the totality of societal relations, *transposed to the inside, having become the functions of the person, the forms of its structure*. (Vygotskij, 2005, p. 1023, original emphasis, underline added)

The real basis of the personality of man is the totality of the by nature societal relations of man to the world, that is, the relations that are *realized*. This happens through his activity, more precisely, through the totality of his manifold activities. (Leont'ev, 1983, p. 201, original emphasis)

The three introductory quotations articulate a (cultural) societal-historical perspective on the nature of human beings. Three points stand out; and these constitute something like the essence of the societal-historical approach that in recent years has become of increasing importance to theorizing activity, cognition, consciousness, and personality (e.g., Roth & Lee, 2007). First, thinking and thought are functions of the total life of the person, not merely of the momentary engagement with some task, such as the particular lesson taught or its conceptual content. Taking the *fullness of life* has recently been suggested as a minimal unit for approaching individual development in the context of science and to understand student learning and personality (Roth & van Eijck, 2010); here I suggest taking the same approach to understand the who, what, when, and where of becoming and belonging as a science teacher. Second, anything that we may identify as typically human, such as all those dimensions that we denote by the adjective *psychological*, is the result of the *totality* of *societal* relations that a person has entertained in her/his life. Vygotsky directs us to two important dimensions for understanding human beings: the *totality* of life, here with respect to the relations with others, and the *societal* nature of these relations. That is, who I am is the result of the totality of societal relations, viewed from a historical (diachronic) perspective. Third, personality has to be understood in terms of all the societal relations that a person engages in during any given day, week, or year. That is, we have to approach science teaching through a lens that considers this participation in schooling as integral part of all the activities that a person simultaneously (synchronically)

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all the activities that a person simultaneously (synchronously) participates in—e.g., as parent, shopper, commuter, athlete, beekeeper, or gardener.

Identity has been considered to be an important category¹ for conceptualizing what science teachers do, how they do it, and how they develop in the course of their professional work (e.g., Roth & Tobin, 2007b). Thus, identities have been defined as “conceptions of ourselves . . . conceptions of others about us and our conceptions of others’ ways of ‘seeing’ us as we act, behave, think, perform, feel, and position ourselves in activity” (Varelas et al., 2007, p. 205). There is a problem, however, because this category either treats the person as something constant and independent of any context; or constitutes the person as the sum total of all the situated micro-identities that they have across the different fields of their participation (e.g., “science identity,” “mathematics identity,” or “identity as a parent”) (e.g., Tobin, 2007). Moreover, saying that I have a science identity when in fact what I do in other areas affects, and is affected by what I do in science teaching—e.g., when my increasing environmentalism led me to make different curriculum choices—appears to be a considerable misnomer. An alternative is to think the person in terms of the totality of its societal relations (Vygotskij, 2005) and the totality of its societal activities that realize these relations (Leont’ev, 1983). In this approach, society is the integrating unit that gives us the sense of constancy and continuity in the face of the constant physiological and psychological changes that we undergo. The Deweyan category *experience* or the equivalent Vygotskian category of *pereživanie*, both of which take the person-acting/emoting-in-the-environment as minimal analytic unit and category of understanding, is the associated theoretical tool because there is a continuity of experience in the face of the pervasive change. This approach to teacher development takes into account the totality of a person’s life and the totality of societal relations (Jóhannsdóttir & Roth, 2014). Who the person can be is a function of unit as a whole; and because experience is continuous, who a person can be has to be viewed in a whole-life perspective. In this chapter, I exemplify how the category experience from societal-historical activity theory provides us with opportunities to theorize becoming in and belonging to science teaching. Becoming and belonging undergo both continuous (quantitative) changes, such as when science teachers learn while teaching, and abrupt (qualitative) changes, such as when someone changes career to become a science teacher or drops out of science teaching. I begin by articulating aspects of my own becoming and unbecoming (as) a science teacher to constitute the concrete case materials that exemplify a theoretical alternative to the identity concept for theorizing science teaching.

UN/BECOMING (AS) A SCIENCE TEACHER

Some people become science teachers and eventually retire; others become science teachers and then, for one or another reason change what they do for a living; and yet others become something else and then decide to become science teachers. All people, however, whether teaching science or earning a living in other ways, also participate in many other forms of activities as part of their daily lives. The follow-

ing autobiographical account exemplifies these multiple forms of becoming and belonging. The account provides the concrete materials of societal relations I contributed to *realizing* and of which I am the result. I use the notion *becoming-as-a* to refer to the changes I undergo within a form of activity and the notion *becoming-a* to refer to the changeover that occurs when I take up and participate in a new form of activity.

Teaching as a Career Possibility

My earliest memories pertaining to the idea of teaching were around fourth and fifth grade; I think I wanted to be a mathematics teacher. However, after an academically disastrous fifth grade, which I repeated because of weak performances including in mathematics, I no longer wanted to become a teacher.

Years later, once I had completed an academically oriented high school and the two years of college level² that completed that part of my schooling experience, teaching became once again a possible option for a future career. Having had three A+ and one A in my four fine arts courses at the college level, becoming an art teacher was my first choice. However, I was full of doubts about my artistic competencies and, having the sense that I might not be successful, I finally chose one of the possible combinations for teacher certification: physics and geography. The first subject had been one of the two academic majors at the college level, and I had finished it with a B. Geography had been my most favorite subject in all of schooling, and I had tended to get A or A+. However, when I saw the academic advisor for the physics education program, he told me in no uncertain terms that I would never make it much beyond second semester. He explained that the fact I had not chosen mathematics as my cognate subject, I must fear the subject or not be good at it. Unbeknownst to him, my final grade in mathematics, my second major at the college level, was the lowest of all grades in my final report card (C+). As mathematics constitutes a foundational aspect of physics, he said, I would never be able to cope with the demands of the courses. I no longer remember the details, but it may have been in spite that I responded to enter the program that ends with a masters of science degree as a research physicist, with mathematics and chemistry as my minors. Five years later, I successfully completed the program and was one of only three students in my 22-student cohort³ whose thesis results were published in a scientific journal. I gained professional experience during the last stages of my degree program by working in the development of mechanical tooth brushes and in the developing and testing of probes that measured the flow of heat in healthy and inflamed gum tissue.

In the early part of my life, (science) teaching was a possibility I entertained repeatedly only to abandon them again as other career options became more salient. These opportunities are not a function of my subjectivity but rather are possibilities that exist collectively, for other members as well. It is a feature of societal life rather than of the individual.

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Teaching as a Career

After completing my masters degree, I moved to Canada, the country where my parents had met and married. I was looking for a job as a research physicist in Montreal. But at the time, there was an economic recession. Although all my peers in Germany had jobs even before graduating, I could not land a job as a physicist here in Canada. For some reason, I eventually started looking for teaching jobs even though I had no accreditation. But because there were many schools in isolated areas, where the teacher turnover was extremely high (30, 40, and even 50% of the teachers leaving, some even midway during the school year), the relevant school boards were hiring even though in the bigger cities teachers with less than 10 or 15 years of experience were laid off. In the Canadian north it was possible to start out without any teaching credentials. My second interview landed me a job as a middle school teacher in the isolated village of St. Paul's River (Quebec) on the lower north shore of the Gulf of St. Lawrence. Here I taught science, mathematics, physical education, personal development, and fine arts.

Having had rather negative experiences as a school student, I organized my science and other teaching according to my best learning experience: doing my own research as a graduate student. As a teacher of seventh-grade biology, I took full advantage of village life, taking the students out to do field research during the weekly double period that took up the entire afternoon curriculum (Roth, 2010). The students were learning to do random, strip, and grid sampling. They studied different forms of succession in the areas surrounding our village. The eight- and ninth-grade students did physical science, a curriculum entirely organized around investigations, which I assisted students to expand into extended investigations. In physical education, I combined systematic forms of training, something that I had learned about as a world-class rower, with games, where students experienced increasing successes because their physical strengths and endurance levels were improving. In fine arts, I also combined systematic investigations with providing opportunities for individual expressions and artwork. Everything was organized around small groups, and students progressed at the rate appropriate for each group. There were as many exams as there were groups, each exam tailored to what the students in each had contracted with me as their content coverage and achievement. As the first year went on, I not only felt becoming a better teacher but also was liked by students and parents alike.

My experience after the first year was so positive that I decided that teaching rather than doing time in a scientific laboratory was the career of choice. I took the equivalent of two educational psychology courses during the summer and then taught a second year. We moved and I took a year off to take a number of education courses required to obtain a provisional teaching certification in Newfoundland. During the year I was hired to teach high school general science and computer science—again with a focus on student inquiry and small group work. Many students returned to school in the evenings to work on projects. There was so much going on at school generally and in my computer and science classrooms specifically that the assistant superintendent, whose school board office was next to the

high school, came to me one evening to ask what I was doing to the students that led so many to come back to school. Returning to school outside of regular hours was something special in this Newfoundland community, where 75% of the 18–25-year olds were unemployed and where schooling did not offer any advantage to finding a job. I told him about the way I used student-directed inquiry and individualized, contract-based curriculum; and I told him about learning through investigations rather than through lectures. This was revolutionary in the early 1980s. He suggested that I should aim for becoming a curriculum specialist at our school board level so that my approach would impact the entire system. But becoming the specialist required that I obtain an advanced degree in education. He first suggested doing an MEd, but immediately continued saying that I was easily capable of doing a PhD. I had never been capable of doing an advanced degree and therefore never considered that option—though some physics professors had suggested it to me towards the end of my MSc work. With the help of the assistant superintendent, I identified a program at the University of Southern Mississippi that would satisfy both my interest in furthering my science background (I would start a second PhD in physical chemistry) and in science curriculum.

In the course of teaching, I underwent change—not so much because I intended it but as a result of my participation in (societal) relations with others, students, colleagues, principals, and superintendents. That is, not only as a subject in and of the activity of schooling but also subject and subjected to the activity, I changed in the face of using “I” to denote some whole associated with a body that others might denote as that of “Wolff-Michael Roth.”

New Possibilities and Realities

After beginning the PhD program during the summer of 1985, I returned to teaching only to enroll fulltime in the summer of 1986, and I was thereby setting myself up for departing from my teaching position. My degree was to be from the College of Science and Technology rather than from the science education doctoral program offered in the College of Education and Psychology. In that latter college I only took statistics courses. Adding two courses to my regular program requirements gave me a second doctoral minor (in educational research, statistics, evaluation). I chose physical chemistry as my first minor. My doctoral research became a study on the development of proportional reasoning using the think-aloud method and multivariate statistical analyses. Engaging deeply with the science education literature, the research bug was getting to me. I was able to coax my supervisor, who had not done research for some time, into doing a research project. In doing this project, I not only learned *doing* statistics, which previously I knew only symbolically. The paper subsequently was published in the *Journal of Research in Science Teaching*. My course in factor analysis provided the opportunity to study independently—to do something that would teach my professor something he did not already know. My paper on confirmatory factor analysis was later published in *Science Education*. In these forms of participating in academic pursuit and societal relations to others—my professors and the academic community—arose my ac-

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quaintance with a new form of activity: knowledge-production by means of research. Being highly successful in my physical chemistry minor was associated with the idea of doing a second PhD and becoming a physical chemist. At the time of beginning a second PhD program, I renounced my position as a science teacher in Newfoundland. But after a boring semester of taking graduate courses in chemistry—professors often turned out less successful than I in doing the word problems at the end of the book chapters and yet demanded submitting to their will and opinion—I decided that I could land an academic job. I was offered a tenure track position in elementary science education in the Faculty of Education at Indiana University (Bloomington, IN).

Working at Indiana University became another life-changing period of my life. First, I encountered some scholars with a penchant for constructivism. I realized that what I had learned during my doctoral studies and the research I had done was part of an old paradigm in the course of disappearing. But it appeared nearly impossible to me to retool and to publish enough to become tenured and promoted. Second, the heads of the department and the leader of the science education group told me that I was not smart enough to make tenure and promotion. Third, I ran into trouble with the administrators because I did not pass students when they had not fulfilled the requirements of a course even though they demanded me to change the grades. Fourth, in addition to the difficult work situation, there were several challenges in my personal life. My second term had barely started when I began looking for jobs in areas that I really felt competent: as a science teacher or science curriculum specialist. Academia was no longer an option. I decided never wanting to have anything to do with university. Out of the different job offers I received, I took that as a science department head and physics teacher at Appleby College, a private school that prepared students for college and university entry.

In this account, we observe how the very participation as a subject in one form of activity, associated with continuous (quantitative) change, contributes to preparing a sudden, qualitative change into another form of activity. Moreover, the qualitative changes set me up for different forms of continuous change—e.g., increasing knowledgeability towards a PhD physical chemist versus increasing knowledgeability as a science teacher educator.

Teaching Physics and Heading a Science Department

Doc[tor Roth], you love to learn, don't you? (Eleventh-grade students)

Teaching physics at Appleby College (Oakville, Ontario), I started where I had left of—teaching science in and through student-designed and directed inquiry and small-group work (Figure 11.1). I introduced students to computing technology for data collection and mathematical modeling software and statistical analysis programs, which allowed us to make connections to calculus and linear algebra. Again, students came to the physics laboratory in the evenings—which was easy for those who lived in residence. Students spent time in the physics lab in such numbers and to such an extent that the school administrators asked the lab to be



Figure 11.1. In my introductory physics course, relating with/to students in the process of producing a concept map, which I documented both to publish about and to improve upon as classroom practice..

locked at 10pm. As I refused to do so, the library-supervising teacher had to take on the job of kicking out students, who returned only 30 minutes later to continue.

The physics laboratory became a learning space. It was open to everyone after hours on a first-come-first-serve basis; it was also open to everyone during the day with the sole proviso that those scheduled for a physics class had priority. During the lessons, the doors were open to visitors, other teachers who wanted to see or participate in teaching or use the computers, and students. In the evenings, students came to do not only physics but also to work for their other school subjects. Everyone was a learning resource for everyone else. I was in my office that joined the physics lab when some eleventh-grade students came to make the statement in the introductory quotation to this subsection. Working in this context was a time of becoming as a science teacher and, in so doing, a time of increasing belonging to the field. But concurrently, other ways of becoming and belonging occurred.

During the summer following my first year, I was teaching a summer course in physics for elementary school teachers. In the university bookstore, I found, bought, and then read copies of *Cognition in Practice* (Lave, 1988), *Laboratory Life* (Latour & Woolgar, 1979), and *The Manufacture of Knowledge* (Knorr-Cetina, 1981). These three books turned my life around—once again. Knowing that two well-known scholars—Ken Tobin and Jay Lemke—were thinking highly of my work (they had attended a conference session where I, as a high school teacher, presented a paper on the semiotic analysis of science learning), the thought

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arose that I could do what these three books were describing: ethnographic work on scientific or mathematical cognition in practice. I bought a camera and started recording what my students were doing in physics experiments, concept mapping, or what they were saying about knowing and learning in science. My original purpose was my becoming as a science teacher, to improve upon the classroom learning environment. But I started writing up what I was learning following the genres of published qualitative studies (e.g., the work of Ken Tobin and Jim Gallagher). Even though many scholars at the time found it hard to get their qualitative research published, every article I wrote as a classroom teacher was accepted. All of a sudden, life as an academic became salient again as an option. That is, while still teaching, there already existed a second career option. Simultaneously, my relations with the school administration became more difficult. I started applying in the US (where I was again in a relation) and Canada, but did not take initial offers until I received one as a statistician teaching courses attended almost exclusively by educational psychology students in the Faculty of Education at Simon Fraser University (Burnaby, BC). A qualitative changeover had occurred from teaching science and directing a science department at the high school level to teaching statistics at the university level.

Here again, we observe continuous becoming within a form of activity that sets up the conditions for a qualitative change in career and participation in another form of activity. All of those activities are constant at the collective level of the society and, therefore, are constant; but the motives of activities are realized differently and in different relations to other activities within the individual member (me).

Teaching Statistics, Doing Research, and New Opportunities

I enjoyed teaching statistics, which I approached as investigative student-centered participation, where after running some analysis, we would all come together to discuss printouts and what we could learn from the similarities and differences. Over a four-year period, I also taught a couple of science methods courses, which were less fun because the students asked me for recipes of how to teach and rejected what I showed them in videos of my own teaching as both very inspiring and useless (students, all of whom already had a minimum of a bachelors degree in science did not think they could teach in this manner). Working at the university allowed me to engage in further classroom research while teaching with local elementary teachers. Because my peers who had graduated with their PhDs during the same year were already going up for promotion and tenure, I felt way behind. I vowed to be ready for promotion and tenure in half the normal time, three years, and to be ready for attaining full professor status in six years.

The classroom research turned out to be so successful that I achieved the first of these goals. Shortly after promotion, the position for an endowed professorship came up, and I was asked to apply for the position based on my research in the area of the learning sciences. After two more experienced researchers did not take the position because the university declined their requests for spousal hires, I was of-



Figure 11.2. In the process of videotaping (researching) a lesson in a second-grade class.

ferred the position as (endowed) *Lansdowne Chair of Applied Cognitive Sciences* (University of Victoria, British Columbia). When I arrived in my new job, I found that there was little interest in the kind of work I was doing (applied cognitive science, learning science) or in the relevant courses I offered to teach. Much of the research I had done was qualitative (e.g., Figure 11.2) so that over a few years I had developed considerable competencies in a variety of qualitative methods. Thus, I took on teaching graduate course in qualitative research methods. These assignments furthered my competencies so that I became interested in writing research-based textbooks on research methods.

What I do today has nothing to do with science education in the traditional sense of preparing teachers to teach science. Instead, only some of my research pertains to the learning of science in formal and informal settings. At the university, I do not count as a science educator. I am never invited to serve on search committees in the field or on committees dealing with science education as a program option for future teachers.

Being trained as a statistician I also had conducted and continued to conduct research using an increasing number of qualitative methods. Associated with the research was a change in knowledgeability that prepared me for a change in teaching responsibilities and, therefore, for a change in the particular form of subjectivity: from a statistician to a specialist in and author of qualitative research methods. Quantitative changes in the research field prepared the conditions that made possible a qualitative change in the content of my teaching.

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Lessons from Un/Becoming (as) a Science Teacher

In the preceding account, we observe that already as a young student, I was thinking about becoming a teacher. The very possibility of thinking to work as a (science) teacher is the result of relations with others in society generally and with the experience of schooling as an activity specifically.⁴ The *motive* of teaching (science) is a generalized one, existing in a society and as a result of its history (there are still societies, e.g., in the Amazon, where the activity of schooling does not exist). In the activity of schooling, teachers, as students, are subjects even though institutionally they are located differently—in a division of labor to produce what schooling produces: grades and school leaving certificates (e.g., Roth & McGinn, 1998). Then, after an early interest, the negative experiences contributed to shifting interests and motives—the result of the different forms of activity that constitute the society and that make possible participation. These other activities—such as gardening, which led to my desire to become a gardener—also were familiar to me directly or vicariously, through reading books or, later in life, through television. The individual human being at the intersection of all the societal activities, which are the very source of career options and choices, need to be part of any holistic theory of science teaching. It needs to include how the different options come to offer themselves up to a person and how the individual then makes the decision of one over another. We also need to be able to explain the change in the possible options available to the individual.

At the end of college level, the possibility of becoming a teacher was salient in my consciousness again, though the particular subject areas differed, associated with the different interests in my life, interests that are reflections of interests and motives in society more generally. These interests, as the career options, were inherently realizations of possibilities that exist at the collective, societal level. But they were realized in me with different salience; and, similarly, the actually existing societal activities as orienting images had different salience for my peers, some of whom went into medicine, which, though I had the grades to obtain a university placement within at most one semester, was a non-option for me.⁵ Then, there was a double shift in the salience of options; and, important here, I am not aware of any useful theory that would account for such shifts. First there was a shift from the option of teaching fine arts, my most favorite subject at the time, which was also my most favorite hobby at the time, next to being a rower and member of the German national rowing team. Interestingly, although I was an elite athlete—at the time runner-up in the junior world championships—becoming a coach or a physical education teacher never entered my mind. A second shift occurred when in response to my choice of enrolling in the program to become a certified physics and geography teacher, the counselor articulated doubts about my ability to succeed in physics because the first two years would be the same as doing a masters of science degree. Becoming a physicist is not something that I somehow constructed in pure subjectivity. Instead, in society, there exist many possibilities for making a living and for taking control over one's personal conditions by contributing to the control over collective conditions. The collective conditions are controlled by

means of the different societally motivated activities that produce the things we use and consume individually and collectively. There are qualitative changes from one option to another that we need to be able to theorize as such.

As a student in the physics program, my competencies changed as a function of taking courses, doing labs, and completing the research that led to my masters thesis. These changes are more-or-less continuous, therefore quantitative, and need to be theorized as such. That is, in addition to modeling the discontinuities between qualitatively different possibilities and actualities (development), our theory of change in the process of becoming (as) a science teacher also needs to be able to handle continuous change (learning).

My autobiographical narrative shows that after graduating, the search for a job as a physicist turned up no opportunity. In part, I ascribed this to different societal conceptions of what a physicist does and is good at. In Germany, my peers ended up in a variety of industries, wherever the employers were seeking individuals with general problem-solving skills in ill-defined settings—one took a position in the toilet paper industry, another one worked on the reduction of noise generated between the wheels and tracks of streetcars, and a third found employment in the dismantling of the first German nuclear submarine only to switch subsequently into the civil service taking a job as a safety officer. Others continued and did their PhDs, following which at least one became an academic and another took a job with the Carl Zeiss company in the manufacture of semiconductors. That is, my peers took jobs that Canadian companies tended to fill with engineers, whom German companies tended to be too narrow in their search for solutions.

It was in the search for a job that teaching science emerged as an alternative that had not existed for me before. With the job offer of teaching in a fishing village in southern Labrador, there was a qualitative shift in my career trajectory—similar to the shift from fisherman to teacher that we have described and theorized for an individual in Iceland (Jóhannsdóttir & Roth, 2014). Of course, this shift is the result of a complex configuration. I was indeed willing to go to this isolated village, accessible only by boat, bush plane, or, in winter, by snowmobile from a small airport about 35 miles away. Moreover, the possibility only existed because many other individuals with teacher training and teaching certificates did not want to teach in this village and in similar villages. Then, while teaching, I got better at teaching science by teaching science, I was *becoming as a science teacher*—much in the way we would later describe this as a process of *teaching to learn* (Tobin & Roth, 2006).

It was in and because of teaching that new, unanticipated opportunities arose—but my assistant superintendent did see such an opportunity. At first, it was through him that I became aware that doing a PhD was a possibility that would open up further career options. While I was enrolled in the program, new opportunities arose for me—first the one of pursuing studies and change the field altogether (physical chemistry), then of becoming an academic in the field of science education. All of these possibilities, however, already existed collectively. Realizing any one option was but a particularization of an already existing collective possibility. There were continuous qualitative and quantitative changes in my life until I ended



Figure 11.3. With my beekeeping mentor (right) while attending to the bees, trying to locate the queen, whose is the only egg-laying individual in the colony.

up being an assistant professor of science education. I was becoming *as* an academic, only to undergo another qualitative change when I was becoming *a* high school science teacher again. Here, I continued in the process of becoming *as* a physics teacher. Simultaneously, I also was becoming *as* a researcher, when I learned to do qualitative research while doing qualitative research—it had not been part of my doctoral training but was a possibility that arose through reading qualitative research articles in science education.

Most importantly, perhaps, what I was doing in any one activity was changed by what I was doing in another. For example, beekeeping (Figure 11.3) contributed to changing how I thought about life, and, therefore about the ways in which human beings—in whom life realizes itself in one particular way—relate, know, and learn. In bees, it is the colony that stays alive while and whereas individual bees tend to live only months, in some instances only weeks (e.g., foraging bees in the summer). Similarly, for us humans, society endures even though each of us dies. I all of a sudden realized what ethnomethodologists denoted by the term “immortal society” (e.g., Garfinkel, 1996). This in turn changed my theoretical and empirical choices, and, because my peers identify me with what I write, also who I am for others in the scholarly community (e.g., of science education).

My career choice to be a science teacher and department head appeared to be definitive. Yet, with an unanticipated success in publishing the work I was doing as a teacher, new opportunities arose eventually leading to another qualitative shift and career change that would take me out of science teaching altogether. The quantitative changes in my professional competencies (as a teacher, as a researcher) were interrupted and *changed in kind* with the qualitative changes in moving be-

tween careers. That is, the kinds of changes in competencies an outside observer would have seen and reported in me as a physics teacher are different from the kind of changes that they would have observed, described, and theorized after my becoming a professor.

In my autobiographical account, there are qualitative changes between career options and jobs. There are theories that emphasize the boundaries between such careers, as well as the differences between the job and other aspects of life (e.g., Aikenhead, 2006). But in all of the changes characterizing my life, there is a sense of continuity of experience in the face of discontinuity. My sense as a human being is not that of a fractured identity (e.g., Giddens, 1991). Instead, my life, as the life of any other human being, is one of multiplicity and heterogeneity. This heterogeneity does not come from the outside, as some stable self moves across boundaries. Instead, this multiplicity comes from the very nature of being human and being a member of society (Roth, 2008b). In fact, any discontinuities become part of thinking about the continuity of our lives, as I showed in a study of becoming an electrician, where the differences between school- and workplace-relevant knowledge are constitutive of being and becoming an electrician (Roth, 2014b). The dominant forms of experience change with the qualitative changeover between activities. Yet as a professor, I also was drawing on my experiences as a science teacher; and as a science teacher, I also was drawing on competencies and experiences as a (doctoral and academic) researcher. In both, my training and experience of working as a physicist continued to operate. As a general science, mathematics, and physics teacher, my competencies as a research physicist and applied mathematician allowed me to teach in ways that were not accessible to many or most of my science teacher peers. As a researcher employing qualitative research methods, I approached the collection and analysis of data in rigorous ways that characterized my work as a natural scientist. That is, in the face of the qualitative changes in the forms of experience, there was also *continuity* of experience: past experiences were resources in new experiences even though I was a subject in—subject and subjected to—qualitatively different forms of activity. That is, there is continuity in the face of discontinuity; and there is discontinuity in the face of continuity. Rather than self-identity, being a person, being human, means multiplicity, heterogeneity, hybridity (Roth, 2008a)—and I have not even mentioned all the other activities in which I am a subject every single day (e.g., permagardening, beekeeping, cycling, cooking, photographing, or shopping for groceries).

A SOCIETAL-HISTORICAL PERSPECTIVE

In the preceding section, I provide an autobiographical narrative of science teaching in my life, as a career option and as an actualized career, followed by a brief analysis that accounts for the societal nature of the different forms of becoming (as). Although my life is marked by its particularities—there is no individual on earth with exactly the same experiences—this life generally and its particulars specifically constitute concrete realizations of possibilities that exist collectively. Among all the theories of learning and development that I have contributed to in

the course of my scholarly life—including neo-Piagetian, information processing, cognitive, discursive, discourse psychological, phenomenological, (radical, social) constructivist, socio-cultural, and societal- (cultural-) historical—only the societal-historical approach has offered itself as a theory that can handle all the intricacies required for understanding the quantitative and qualitative changes in career, interest, consciousness, and personality (Roth, 2007b).⁶ Earlier I was indeed drawing on the concept of identity, which led me to articulate it in terms of dialect of identity (e.g., Roth, 2006). But the very notion of identity—from Lat. *idem*, the same—left me dissatisfied because of the many aporia associated with it (Roth & Tobin, 2007a). Self-sameness appeared to me to be an oxymoron in the face of the continuous changes we undergo in living: biologically, physically, psychologically, emotionally, or sociologically; and it appeared to me to be an oxymoron in the face of feeling continuity in and across my life in the face of obvious differences and discontinuities when I was doing scholarship, teaching statistics, teaching science, teaching qualitative research methods, shopping, beekeeping, gardening, or being and athlete. This dissatisfaction was subsequently expressed for me in the notion that the only thing two individuals have in common is that they are different from everyone else (Nancy, 1993); and, as I added later based on dialectical grounds, we are different from ourselves when considering that our living means we are changing. That is, in the face of living, the idea that something remains the same requires explanation rather than being a starting point for theory. In the following, I articulate aspects of a theoretical approach that provides a satisfactory approach to *un/becoming (as) a science teacher*. It is a theory that looks at science teaching from the synchronic and diachronic fullness of life in society, characterized by non-self-identity rather than (self-) identity (Roth, 2009b).

Activity, Subjectification, Personality

The societal-historical position for understanding anything psychological or sociological takes societal activity as the minimum (analytic) unit and category of understanding (Leont'ev, 1983). As a consequence of the inherently societal relations, “We become ourselves *through others*” (Vygotskij, 2005, p. 1021, emphasis added). That is, we cannot understand individual persons outside their participation in societally motivated activities—farming, manufacturing, vacationing, or consuming. We share with others taking part in these activities, where we take the same or similar subject positions, which is what we have in common with others. Thus, there are others who, as I, teach science, statistics, or qualitative research methods, shop groceries, keep bees, garden, cook, or cycle. There may even be some who participate in pretty much the same societal activities as I do. We would be said to “share a lot of interests or aspects of identity”; and yet we would differ in the relative salience of these different activities in our lives and in the relative salience of the relations between these activities.

Any part of an activity is mediated by the activity as a whole—each part is a function of all the other parts and, therefore, of the whole as well. There is therefore a dialectical relationship between the *subject* of activity and the other parts of

activity, including the *object/motive, tools, rules, community, or division of labor* (Roth & Lee, 2007). For example, as a researcher I work with data (object) to produce new knowledge reported in journal articles (motive); as a teacher, I work with students in a division of labor focusing on curriculum (object) to produce grades and report cards (motive). As a grocery shopper, I take part (am subject) in the activity of exchanging goods (motive); as a hobby cyclist, I participate in leisure activities (motive, need); as a beekeeper, I contribute to the effort of guaranteeing the survival of this threatened species so important to human food; and, producing nearly all the vegetables we eat year round, I participate in permaculture. Who I am requires taking into account all of these different forms of participation. As a subject of academia, forms of participation and change differ from my participation in the activity of food exchange; and the latter form of participation differs from that of being a hobby cyclist. That is, not all of these activities are equally salient and important in my life, yet all are but realizations of collective possibilities that exist in society. My personality can be understood in terms of the knot-work of all societal activities in which I participate, which therefore is the collective aspect of my personality; and this knot-work is defined by hierarchical relations that are highly individual.

There are therefore two aspects our theory of change needs to take into account (Roth, 2013). First, as a subject in a particular activity—e.g., as a science teacher, a statistics professor, a beekeeper—I change through my simple participation, even though this change may be slow and almost or completely invisible on first sight. Such changes may be referred to as *subjectification* (Roth & Radford, 2011). On any given day, I participate in and belong to many societal activities, with differences in the subject positions I take, the conditions *to which I am subject and subjected*, and the forms of subjectivity involved. The concept of identity leads to emphasis on discontinuity, to the notion of a fractured identity. For example, Tobin (2007) writes about his “identity as a prominent science educator” (p. 19), “urban street identity” (p. 17), and his identity as an “urban science educator” (p. 18) and “urban educator” (p. 18). At the same time, he “considered some parts of [his] identity as relatively stable across fields” (p. 19). How these different micro-identities are connected and just what is constant is not theorized, however. Societal-historical activity theory can provide help. Thus, the category of *personality* a knot-work of subject positions associated with the knot-work of activities that constitute society (Leont’ev, 1983) allows us to theorize continuity and difference simultaneously. Together, subjectification and personality provide us with theoretical tools to understand the quantitative (learning) and qualitative changes (development) that characterize our lives, including the processes of un/becoming a science teacher (dropping in and dropping out) and becoming as a science teacher (learning, growing professionally, and even burning out).

In this approach, subjectification is thought as a process of change that involves both the actions of the subject and its subjection to the reigning conditions. Thus, subjectification denotes “the production—through a series of action—of a body and of a capacity for enunciation not previously identifiable within a given field of experience” (Rancière, 1995, p. 59). I point out above how my knowledgability

changes while teaching science, doing research, or while keeping bees. In the course of this participation, the very identification of this (my) body and this (my) capacity for talking about was an integral part of the reconfiguration of the respective field of experience (e.g., science teaching). In teaching, my teaching changes; and the changes in teaching change the context of my teaching. It is very unlikely that I would have become as a science teacher had I had a degree from a faculty of education prior to teaching; and it is likely that I would have become differently had I not taught in St. Paul's River but in an urban area of Montreal. Subjectification denotes the continuous and ongoing belonging to change in activity; and, in contrast to construction, subjectification integrates the dialectic of agency and passibility characteristic of all human experience (Roth, 2011). Moreover, in any activity, the subject position is taken by many persons, each of whom concretizes this possibility enabled by collective life. As a subject of activity, I belong to the community characteristic of the activity.

Personality is a category of thought that integrates the different subject positions I take on any given day and in the course of my life history. It therefore integrates the forms of subjectification I undergo, as a science teacher, professor, shopper, hobbyist, or gardener. Personality is thought as a knot-work of all the activities in which I am and have been a subject (Leont'ev, 1983). Because activities are connected to constitute society, and, therefore, are connected in that I move from participation to participation, what I do and who I become in one activity (e.g., as a science teacher) is affected more-or-less saliently by what I do in another activity (e.g., participating in international scholarship on science learning). That is, although the subject positions I take in the different activities, the knot-work of activities and the relative salience of their motives differs from those characterizing other persons. I do not therefore need the concept of boundary crossing or third space, which is used to uncouple what people do and who they become in one setting from what they do and who they become in another setting. Thus, even though all the aspects of personality (the knot-work of activities and motives) exist collectively, these are particularized differently in any specific individual. My network of participations constitutes a different hierarchy from someone else, and, therefore, characterizes my singular experience. I am (my personality is) through and through characterized by societal possibilities cobbled together in a highly individual and individualized manner. At the same time, I am not homogeneous: the knot work of participations makes my individuality heterogeneous. I am different from myself rather than homogeneous: I am changing because I live. The knot-work approach of personality leads us to a conception of the person as multiplicitous and heterogeneous, non-self-identical in synchronic and diachronic terms rather than as self-identical (Roth, 2008a). In fact, saying "my personality" is a misnomer, because the different facets of personality are the result of different *societal* rather than *my* activities—I only (choose to) participate in different activities, (the possibilities of) which always already pre-exist my participation.

Experience

Experience is another category of analysis that integrates across quantitative and qualitative changes in teaching and learning science (Jóhannsdóttir & Roth, 2014; Roth & Jornet, 2014). Experience is not something relegated to the individual but a category that includes the person and its environment and, therefore, includes the practical, intellectual, and emotional dimensions of activity (Dewey, 1934/2008). Whereas the English term *experience* allows researchers to reduce the category to the intellectual, the Russian equivalent *pereživanie* (Vygotskij, 2001) also is used in the sense of feeling, inherently imbued with affective qualities. Although the activity is spread across the context as a whole, involving the person, tools, material objects, societal motives, division of labor, laws and rules, and community, anything material is reflected in the (material) human subject on a second plane—intellectually and affectively. Experience leaves traces in the one who *undergoes* it, consistent with the statement that there is a process of subjectification that produces and marks a body. My teaching at Appleby College has left traces and has shaped me in ways that are singular to me: it has left, as Rancière (1995) would suggest, a capacity in me for producing enunciations not previously identifiable within the given field of science teaching experience but also outside of this field. That is, some of these traces that teaching at Appleby College has left in my body, because of the inchoate and unarticulated nature of experience, go unnoticed. Other traces, those when there is *an experience* (Dewey, 1934/2008) stand out such that we tend to point to “*that lesson*,” “*that person* (student, teacher, superintendent)” or “*that meeting*” as something that has changed what we do as science teachers. I still remember the students standing on the table holding on to the van de Graaf generator, which led to a pouring in of students and teachers into my classroom. I continue to remember the assistant superintendent, the relation to whom had been associated with fundamental changes in my life, career, interests, and so on. I also remember particular students because it was in the relation with them that I underwent some change—the way in which I was doing research when one of them became a co-researcher and co-author in 1992, long before it became fashionable to involve students (Roth & Alexander, 1997); and the way in which I was thinking about teaching when one student told me he fully bought into (social) constructivism but wanted to be told the right way of doing physics because he needed to get very high grades to enter the engineering program of his choice (Lucas & Roth, 1996).

We are continuously and lastingly changed by experience, which itself constitutes a continuity (Dewey, 1934/2008). This category therefore allows us to conceive of continuity across situations that other researchers theorize in terms of discontinuities: third-space, boundary- (border-) crossing, or fractures (identity). I have yet to formulate how continuity (quantitative change) and discontinuity (qualitative change) are articulated together. For example, we have used the category experiencing to theorize the changes an Icelandic fisherman has undergone while fishing and being a member of village life, then becoming a teacher, which changed the dominant form of experience all the while contributing to the continu-

ity of experience (Jóhannsdóttir & Roth, 2014). I now turn to this part of the theoretical approach to the becoming (as) a, and the belonging of, science teacher formulated in this chapter.

Continuous Becoming Involves Qualitative and Quantitative Change

In the societal-historical approach, there already exist ways of theorizing how quantitative changes lead to qualitative changes, and how qualitative changes lead to different forms of quantitative changes (Holzkamp, 1983). This theoretical tool is equivalent to a catastrophe theoretic approach used to model the emergence of new structures (morphogenesis) (Roth, 2009a). This model was used to describe and explain the conceptual change undergone by a scientific research group in the course of collecting data (Roth, 2014a); and it has shown to be useful in describing the emergence of qualitative changes from quantitative changes that lead a person from becoming as a fisherman to becoming a teacher, with new trajectory of becoming (Jóhannsdóttir & Roth, 2014). The five stages in the model are:

- The real historical conditions of some career option, a first form of experience (Figure 11.4, a);
- The objective changes in the environment give rise to contradictions internal to the experience (Figure 11.4, b);
- With the emergence of new possibilities, the trajectory of the quantitative changes in experience is different (Figure 11.4, c);
- A sudden change in the dominant form of experience to a second form (Figure 11.4, d);
- A qualitatively new trajectory of experience following the transition, with new forms of learning in the new condition (Figure 11.4, e).

In the following paragraphs, I describe how the model works in our present context.

Take the change in career. Thus, I was teaching science and computer science in Newfoundland. There was really nothing else in my life, not even a desire to do something different. I was a happy teacher, pleased with the ways in which the students took to what I was offering (Figure 11.4, a). I went for a summer to pick up graduate studies and returned to teaching in the fall, when a sense emerged that I should do the degree fulltime. Around the time when the “research bug” was catching me, new career options opened up, which really existed when I had completed the PhD (Figure 11.4, b). This opening up of new possibilities is modeled as a first elementary catastrophe. It really constitutes a *syncope*, an instant that belongs to two different orders simultaneously: where the period with one career option ends and the period of two career options begins (Figure 11.4, b). This point, where there is one option and two options simultaneously, needs to be understood and theorized *dynamically* if we want to have any hope of understanding how someone un/becomes a teacher.

Although many individuals might continue in their career as science teachers during and following a PhD, I had resigned from my job and for a while was work-

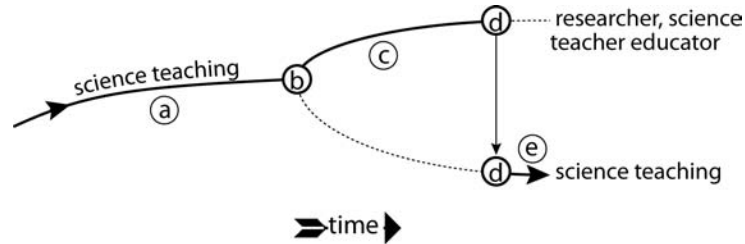


Figure 11.4. Model for times of continuous change (learning) and qualitative change (development).

ing on a second PhD. To make the diagram and explanation easier, I omitted from Figure 11.4 the semester during which this was the situation. I then entered a scientific research career with my teaching being in the area of science teacher education at Indiana University (Figure 11.4, c). As an assistant professor, I changed, learning to write and to obtain grants, publishing scientific research articles, and having first experiences in science teacher training. The forms of experience as an assistant professor differ from those characterizing science teaching: the character of learning (quantitative change) differs, both in terms of the what and the how. At some point, however, there is a change in the dominant form of experience when I left Indiana University to take up the position of physics teacher and department head of science (Figure 11.4, d). This second qualitative change, which constitutes a second kind of catastrophe in catastrophe theory, leads to a very different form of experience, associated with very different forms of learning in and through practice (quantitative changes) (Figure 11.4, e). The tipping over from one to another career may be brought about by an infinitesimal but continuous change, much like the proverbial butterfly whose wing beat in Asia changes the weather in North America. We cannot ever know whether some of the changes in my life were *caused* by the souring of relations to individuals or institutions or whether the success in publishing was a *factor*. At the same time, even though the dominant form of experience changed qualitatively (from being a professor to being a physics teacher), past experiences carried over. This is so because the “system,” here the being-in-the-world denoted by the name Wolff-Michael Roth, is *path dependent*, a technical term for making salient that the history (biography) of the system is recorded (leaves traces) in the system. Most evidently, the dual possibilities of assistant professor of science education and science teacher arose in and were the results of the preceding science teaching experience.

Three points appear self-evident. First, the new forms of experience in my physics teacher job gave rise to a new form of change in the process of doing classroom-based research. Eventually, a new contradiction arose such that there was another transition taking me back to a university career. Second, the same model can be used to describe the trajectory of becoming (as) a physicist with the contradictions in the environment (i.e., the recession and the hiring practices in Canada) that led to the opening of an alternative career as science teacher. However, the

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changes were such that a new elementary catastrophe opened up new possibilities rather than a transition back into physics. Each action, each change, opens up new possibilities while closing down others (Roth, 2014d). Finally, the characteristics of learning change with a transition from one to another career option. The process of becoming-as a science teacher is different from the process of becoming-as a professor; and here becoming-as a methodologist and learning scientist is very different than it was at Indiana University in the position of a science teacher educator.

FROM IDENTITY TO EXPERIENCE (PEREŽIVANIE)

At one point in my research career, I became interested in the notion of identity—certainly influenced by my reading of *Oneself as Another* (Ricoeur, 1992). Soon, however, and not in the least influenced precisely by my reading, I became dissatisfied with the notion of identity because it made little sense to me to talk about an individual's science (teacher) identity because the same person also might be a father, a grocery shopper, a hobby gardener, an avid cyclist (perhaps even participating in races), a researcher, a beekeeper, and a science teacher educator (e.g., teaching summer courses at the university, as I had done while being a classroom teacher). It seems evident that the very conception of identity had to lead to the idea of fractured identities (Giddens, 1991) and to the idea of boundary crossing. These notions are contradictory, because we all experience continuity in our lives, a continuity that is captured in our autobiographies. But this continuity also incorporates and is constituted by discontinuities. There is therefore continuity in the face of discontinuity; and there is discontinuity in the face of continuity. The model I propose here captures all of these aspects, with the associated quantitative and qualitative changes.

With its categories of *subjectification* and *personality* the societal-historical approach also captures other aspects of our experience. First, when participating in a particular form of activity, such as schooling (where we might teach science), we change because (a) we are subjects of activity, acting in the way we do, and thereby becoming more proficient and (b) because we are subject to and subjected to activity, affected in ways that are unforeseeable and often unwanted. But if we change because we act and are affected every instant of our lives, we are never self-identical: living means change rather than identity (Bakhtin, 1993). It is precisely because we are subject and subjected to condition that there are contradictions in the environment that lead to the elementary catastrophes in Figure 11.4: at the point of bifurcation and at the point of the more-or-less sudden tipping over into a different form of experience. Subjectification describes the process of becoming-as within a form of activity, for example, becoming as a science teacher. Simultaneously, it describes forms of becoming as in other activities: I become a more proficient shopper, father, cyclist, beekeeper, or gardener. Personality captures our multiple belonging to different forms of experience and associated change processes of *becoming-as*. Personality, the result of all the different forms of participation in the different forms of activity characteristic of society, reflects

society. It reflects society not only in the forms of subjectivity that it offers but also in the way that there are knot-works. But the hierarchies of the different forms of subjectivity, associated with the different forms of activity in which any individual participates, are different for different persons. Thus, even when someone is teaching science, this may not actually be the activity with the highest priority in the life of the person.

The advantages of working with the category of personality are clear: it allows us to understand science teaching in the context of the overall life of a person. This became salient to me, though I did not have the theoretical tools at the time, while doing research in an Australian classroom. The physics teacher appeared to be dedicated, developing software and other aspects of the curriculum to make his courses interesting, varied, and adapted to the changing possibilities that come with technology. At the same time, there we also recorded quite negative student experiences. In fact, we reported very different worlds that seemed to co-exist in this classroom (Roth, Boutonné, McRobbie, & Lucas, 1999). It turned out that physics teaching was in the fourth place of the overall hierarchy of activities in which the teacher participated, the top three being family life, religion and religious affiliation, and his missionary activities in Indonesia. That is, we cannot disconnect his physics teaching from all of the other forms of subject positions he held so that it made no sense to me to talk about his science teacher identity. There are many teachers, for example, in the southern US, who may also participate in the same four activity forms, and yet with different emphasis and hierarchical relations and with different strengths of the relations. That is, their personality would be different already structurally. But in all instances, the very possibility of participating in these forms of activity are a function of society and therefore not at all the result of individual subjectivity or construction.

A further advantage of the category personality is that it allows us to understand continuity across difference, and discontinuity (difference) within continuity. Thus, the opening up of new forms of experience, new career options, or new activities may entail considerable changes in the forms of participation in other activities. For example, I was not very efficient as a student during my early teens, a time when it took me from 3 to 4 hours to complete homework every afternoon. (In Germany, school ended at noon or 1 p.m.) However, when I started rowing for a club, which involved training for races every day of the week, my ways of doing homework changed. From then on, I completed homework in about an hour or less. Moreover, after starting to row, my grades improved rather than decreased. That is, the participating in competitive sports activity led to substantial changes in becoming-as a student.

The societal-historical approach works with the category (unit) of experience (*pereživanie*), which captures material-practical, intellectual, and affective dimensions. We are not the masters of our experiences but create and undergo experience simultaneously. Experience cannot be reduced to the individual: how I become as a science teacher also depends on the school, principal, and students. Teachers do have burnout experiences, but these may be more frequent in urban than in suburban schools serving students from middle and upper class. Teaching science in a

private school may again be very different from teaching in public schools, where there is less access to innovative technology, and where parents have fewer financial resources to have their kids involved in certain activities (e.g., a field trip to the Galapagos Islands). In encompassing individual-in-setting, experience therefore is a category that includes internal and external dimensions in the model that integrates quantitative (continuous) and qualitative changes (Jóhannsdóttir & Roth, 2014). Qualitative changes arise from quantitative changes—e.g., when new career options emerge (e.g., Figure 11.4, a)—and new forms of quantitative change follow from a qualitative change—e.g., in a transition from teaching science to being a university professor (Figure 11.4, d). The forms of subjectification—becoming-as a person subject of, subject to, and subjected to the activity—in these careers differ. They are aspect of changes in the forms of who I am, can be, and can become.

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The societal-historical approach provides me with a set of categories—subjectification, personality, and experience—that eschew the logical contradictions that come with the concept of identity. They come with a theory of change that includes both quantitative, incremental change (learning) with qualitative change (development) of experience and integrates over continuity and discontinuity. Moreover, (infinitesimal) quantitative change may lead to qualitative change (career, career options), and qualitative change leads to (the nature of) quantitative change. The theory integrates over other dimensions of participating in and dropping out of science (education) related activities, including the affective (emotional) and ethico-moral dimensions next to the practical and intellectual (Roth, 2007a). The theory is consistent with life not only at the abstract level, but also in the way I experience it every day within and across activities, during normal stages as well as during periods of life-changing crises. “I” *feel* a continuity in the course of the day: from the moment of getting up and doing an extended period of writing, to getting on the bicycle to ride to the university, to participating in a tenure and promotion committee meeting, to discussing with a post-doctoral fellow about his latest thinking, to my shopping for a tool to accomplish a task in my renovations, to returning home to attend to the garden and cooking dinner, and to complete the day with a final check of my professional email. There is continuity of experience in the face of discontinuity; and there is discontinuity of experience in the face of continuity. In fact, the discontinuity also is constitutive of, and integral to, continuity; just as continuity is part of the fabric of discontinuity. Experience (*pereživanie*) is an appropriate category to capture this situation because it focuses on individual-acting-in-environment relations as well as on the ways in which these relations are intellectually and affectively reflected in the individual (Vygotskij, 2005). Subjectification is appropriate, because it describes how we change not because we construct ourselves differently but because of the relational aspect where individual and environment (conditions) mutually *affect* each other. Personality is an appropriate category because it allows me to understand that I am both the result of my

participation in society, and therefore that its aspects are societal through and through, and that the resulting knot-work is a singular instantiation of the associated possibilities. It reflects the fact that I have experiences possible to and shared with others in the face of evident differences. All three categories have change built in, and, therefore, refer to something continuously changing, being different from itself, rather than referring to stability and self-identity. This approach, therefore, deals with the aporias of the identity concept that I have not been able to overcome in any other way.

NOTES

- ¹ I understand *category* in the way Vygotskij (2005) presents it: as a minimum unit of thought and explanation, that is, as a minimum unit of analysis such that anything “smaller” cannot be understood without reference to the whole. A category cannot be decomposed into or composited from elements. Vygotskij (2005) is adamant that the latter approach is the historical problem of psychology.
- ² Germany has, and has had, a three-track schooling system. When I went to school, *Grundschule* (basic school) went to fourth grade. After that most students attended *Hauptschule* (general school), which ended with eighth grade. Students graduating from this track entered apprenticeships accompanied by attendance in vocational school once per week. A smaller percentage of students entered *Mittelschule* (intermediate school), which ended with tenth grade. Students graduating from this track tended to enter technical, business, and social professions (e.g., technical drafts persons, opticians). Only 10–15% of students were admitted, through entrance examinations, to *Gymnasium*, which lasted through thirteenth grade. It leads to a diploma (*Abitur*) that automatically meets the university entrance requirement. While I attended *Gymnasium*, the last two years were converted to *Kollegstufe* (college level), where students chose courses much as they do entering college or university. I was among the first students to complete *Kollegstufe*, majoring in physics and mathematics.
- ³ The cohort had started out with a total of 75 students enrolled. In each of the first four semesters, the results of the open-book examinations were used to cull those students who fell into the lower part of the bimodal grade distributions. After four semesters, only 22 students had remained.
- ⁴ I use the term *activity* exclusively in the activity theoretic sense, that is, as a societally motivated system that produces something for meeting a generalized need, such as farming cattle, producing grain, manufacturing cars and farming equipment, or baking bread. Schooling is an activity in which society reproduces itself, including all of its inequities (Foucault, 1975; Holzkamp, 1993).
- ⁵ In Germany, university entrance in a number of fields is determined by a *numerus clausus*, which means, a grade-determined limitation of access to studies (e.g., in the medical field or dentistry).
- ⁶ The work of Vygotsky and Leont’ev has been taken up in the West in various ways, which are denoted by different adjectives including sociocultural, sociohistorical, and cultural-historical. None of these adjectives takes into account that both scholars point out that any psychological feature is the result of *society*. Both use the adjective societal (*obščestvennyj*) rather than social (*social’nyj*), for example, societal relations (*obščestvennix otnošenij*) as the first instantiation of human psychological functions and personality (Leont’ev, 1983; Vygotskij, 2005). I use the term societal-historical, which translates a frequently used German adjective, because it denotes the emphasis that the two scholars made (e.g., Roth, 2014c).

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