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What is This?

From design experiments to formative interventions

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Abstract

So-called "design experiments" have been presented as a radical alternative to traditional experimental designs in behavioral sciences. A closer scrutiny of design experiments shows that they share the basic linear methodology of traditional randomized controlled trials, and thus ignore resistance and agency of learners as a source of surprise and novelty. Formative interventions based on Vygotsky's principle of double stimulation offer an alternative that builds on and purposefully fosters learners' agency. Formative interventions may be characterized with the help of an argumentative grammar which proposes (a) the collective activity system as a unit of analysis, (b) contradictions as a source of change and development, (c) agency as a crucial layer of causality, and (d) transformation of practice as a form of expansive concept formation. These four epistemic tenets are concretized with the help of analysis of data from a Change Laboratory formative experiment conducted in a Finnish hospital. The analysis shows that double stimulation is a multi-layered and longitudinal process in which both the initial problem situation (first stimulus) and the mediating conceptual tool (second stimulus) are reformulated and enriched in successive steps. Such a process of double stimulation generates a thirdness, a new concept for the activity under transformation.

Keywords

agency, contradiction, design experiment, double stimulation, formative intervention

> *Anyone who attempts to skip this problem, to jump over methodology in order to build some special psychological science right away, will inevitably jump over his horse while trying to sit on it.* (Vygotsky, 1997a, p. 329)

> *The reputation of educational research is tarnished less by the lack of replicable results than by the lack of any deeper theory that would explain why the thousands of experiments that make up the literature of the field appear to have yielded so little.* (Olson, 2004, p. 25)

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Human learning takes place within and between complex, continuously changing activity systems. Learning needs themselves are increasingly opaque. It is not at all clear just what needs to be learned to cope with the demands of complex activities and global networks in constant turmoil. Humans—practitioners, teachers, students—are intentional and interactive beings who keep interpreting and reinterpreting the challenges and tasks they face in their own, multiple, changing, and often unpredictable ways. They do not neatly obey the laws of linear causality. The practical usefulness and ecological validity of research on learning based on classical well-controlled experiments are more questionable than ever.

In the past few years, the United States educational authorities have aggressively launched legislation and national guidelines that define the "gold standard" of educational research. The "gold standard" emphasizes the use of randomized controlled trials, the selection of valid control groups, and "scalability" implying large statistical samples and multiple research sites.

The "gold standard" correctly sees educational research as interventionist research. The randomized control trials are meant to assess the effectives of educational interventions. The model of intervention research is taken from fields such as medicine and agriculture. As one observer put it:

> For instance, if I want to test the effectiveness of weed control measures, I randomly assign different plots of crops to the experimental or control conditions. Then, they all get treated the same otherwise as far as weather, fertilizer, hours of day light and other pests. The crops are monitored and observations are made throughout the growing season and a person might be able to see the result visually if the results are remarkable enough. But the telling evidence is in the yield, when the crops are harvested. If there is a significant difference in yield in all the experimental plots as opposed to the control plots, then we might attribute it towards the independent variable, which in this case is weed control. (As cited in Engeström, 2009b, p. 318)

The "gold standard" thinking in educational research starts from the assumption that researchers know what they want to implement, how they want to change the educational practice. In other words, the intervention and its desired outcomes are well defined in advance. The task of research is to check whether or not the desired outcomes are actually achieved.

Educational researchers are in a bind. On the one hand, many of them recognize the limits of randomized control trials and seek ways to conduct and legitimize more practice-based and creative and theoretically ambitious research. On the other hand, there are strong administrative, financial, political, and "scientific" pressures to stick to the proven assumptions and methodological rules of positivist science. It is no wonder that many attempts at methodological innovation turn out to be weak compromises.

In this paper, I will propose a radical methodological approach that I call formative interventions. The approach is inspired by the methodological ideas and experiences of L.S. Vygotsky and his colleagues and students. My version of this legacy has been worked out over a period of some 20 years of research in the Finnish school of developmental work research (Engeström, 2005; Engeström, Lompscher, & Rückriem, 2005).

I will begin by examining the recent interest in so-called "design experiments" or "design research," which I find to be still captive to the linear view of interventions typical

of the "gold standard." After that, I will discuss the contribution of some sociological analyses of interventions, pointing toward the crucial importance of agency in developing a viable interventionist methodology. I will present Vygotsky's central ideas of the interventionist methodology called "double stimulation," and conclude by pointing out four key differences between linear and formative interventions. This leads me to present "the argumentative grammar" of formative interventions with the help of four foundational epistemic threads or tenets that inform the methodology.

I will illustrate the methodology of formative interventions by analyzing data from an intervention study my research group recently carried out in Finland with the help of the Change Laboratory toolkit. This study concerns the formation of a new mode of working in the Central Surgery Unit of the Oulu University Hospital. This case analysis leads me to elaborate on the layered character of formative interventions. At the end of the paper, I will examine how the four tenets of the suggested argumentative grammar were implemented and what insights they generated in the hospital case.

Design experiments—design research

In this section, I will take up problematic aspects in recent literature on design experiments, or design research. I will not go back to the early formulations of this research approach (Brown, 1992; Collins, 1992), as their main arguments are widely known.

In literature on design experiments or design research the focus of attention is moved from isolated individual learners to entire learning environments or learning ecologies.

> Design experiments ideally result in greater understanding of a *learning ecology*—a complex, interacting system involving multiple elements of different types and levels—by designing its elements and by anticipating how these elements function together to support learning. (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003, p. 9)

Many proponents of design research use the notion of dynamical learning environments (DLEs) to describe their unit of analysis. For example, Barab and Kirshner (2001) define dynamical learning environments "as continually evolving as the system components (students, teachers, class assignments, resources) that constitute DLEs reciprocally interact in ways that both stabilize and destabilize the system" (p. 8).

These notions of complex units of analysis suffer from vagueness. Talking in general terms about systems, dynamics, and components is not enough. What exactly might be a useful model of the anatomy of such a dynamic learning environment? If design researchers do not specify and model the crucial components and relations of their proposed units of analysis, a decisive connection between theory and methodology is severed (for a critique of the concept of "learning environment," see Engeström, 2009a).

In discourse on "design experiments," it seems to be tacitly assumed that researchers make the grand design, teachers implement it (and contribute to its modification), and students learn better as a result. Scholars do not usually ask: Who does the design and why? This linear view is associated with notions of perfection, completeness, and finality. This is exemplified by the use of the absurd notion of capturing "all variables."

> In design experiments there are many dependent variables that matter, though the researchers may not pay attention to them *all* [emphasis added]. ... [T]he goal is to identify *all* [emphasis added] the variables, or characteristics of the situation, that affect any dependent variables of interest. (Collins, Joseph, & Bielaczyc, 2004, p. 20)

As a byproduct, Collins et al. endorse a variable-oriented approach to research without questioning the extremely problematic notion of causality behind it (Maxwell, 2004).

In the account of Collins and colleagues (2004), the methodology of design research is basically a linear progression of six steps, starting from "implementing a design" and ending with "reporting on design research" (p. 33). As the process begins with implemention, the making of the design in the first place is not even included in the methodology. Thus, there is no need to problematize the issue of who makes the design and guided by what theory or principles. In a similar vein, Cobb and his co-authors (2003) seem to take it for granted that it is the researchers who determine the "end points" for the design experiment.

> In addition to clarifying the theoretical intent of the experiment, the research team must also specify the significant disciplinary ideas and forms of reasoning that constitute the prospective goals or endpoints for student learning. (p. 11)

The stepwise linear notion of design research is also explicated by Bannan-Ritland (2003, p. 22). Cyclic iterations serving the refinement of the design complement but do not challenge the basically linear image. This is made clear by Middleton, Gorard, Taylor, and Bannan-Ritland (2008), who depict both the traditional model of experimental research and the model of design research with the help of cyclic images, then conclude that "design experiments are valuable methodological additions to the standard procedures that already include randomized controlled trials and other traditional experimental studies" (p. 42).

This linear view ignores what we know of interventions as contested terrains, full of resistance, reinterpretation, and surprises from the actors below. Cobb and co-authors do mention that design experiments conceived by researchers create discontinuity—but that does not seem to require any further reflection.

> The intent is to investigate the possibilities for educational improvement by bringing about new forms of learning in order to study them. Consequently, there is frequently a significant discontinuity between typical forms of education (these could be studied naturalistically) and those that are the focus of a design experiment. (Cobb et al., 2003, p. 10)

The main difference between "gold standard" interventions and design experiments seems to be that the former expects the design of the intervention to be complete at the outset while the latter, recognizing the complexity of educational settings, expects the design to proceed through multiple iterations of "refinement." But even design experiments aim at closure and control. The emphasis on completeness, finality, and closure is condensed in the idea of design experiments as "refinement." The implication is that the researchers have somehow come up with a pretty good model which needs to be perfected in the field.

> Design experiments were developed as a way to carry out formative research to test and refine educational designs based on theoretical principles derived from prior research. This approach of progressive refinement in design involves putting a first version of a design into the world to see how it works. Then, the design is constantly revised based on experience, until *all the bugs* [emphasis added] are worked out. (Collins et al., 2004, p. 18)

> Design research should always have the dual goals of refining both theory and practice. (Collins et al., 2004, p. 19)

Collins et al. (2004, pp. 18–19) compare educational design research to the design of cars and other consumer products, using *Consumer Reports* as their explicit model for evaluation. They don't seem to notice any significant difference between finished mass products and such open-ended, continously co-configured products as educational innovations (for co-configuration, see Engeström, 2008; Victor & Boynton, 1998). A strange obsession with completeness and control runs like a red thread through their argument.[1] "Thus, in the jigsaw, all pieces of the puzzle come together to form *a complete understanding* [emphasis added]" (Collins et al., 2004, p. 23)

A similar fascination with completeness is demonstrated by Middleton et al. (2008) in their notion of a "compleat" design experiment which culminates in a "definitive test."

What this overlooks is that "one can never get it right, and that innovation may best be seen as a continuous process, with particular product embodiments simply being arbitrary points along the way" (von Hippel & Tyre, 1995, p. 12). Perhaps more importantly, much of the literature on design experiments seems to take for granted the traditional designer-led model of innovation and ignore the recent turn toward user-led or "democratic" innovations (von Hippel, 2005).

To sum up, recent literature proposing design experiments or design research as a methodology for educational research suffers from serious built-in weaknesses. While there are many different versions of design research, it seems fair to conclude that the following weaknesses are quite pervasive. First, the unit of analysis is left vague. Secondly, the process of design research is depicted in a linear fashion, starting with researchers determining the principles and goals and leading to completion or perfection. This view ignores the agency of practitioners, students, and users. It seems blind to the crucial difference between finished mass products and open-ended social innovations, as well as between designer-led and user-led models of innovation process. Finally, in much of the literature on design experiments, a variable-oriented approach to research is tacitly endorsed, without questioning the underlying problematic notion of causality.

These limitations pertain to the general idea and approach of design experiments as explicated in key papers on the topic. There are certainly individual design experiment studies which in significant ways have been able to overcome some of these limitations. However, recent collections on design research (Kelly, Lesh, & Baek, 2008; van den Akker, Gravemeijer, McKenney, & Nieveen, 2006) mainly enrich and elaborate rather than question and challenge the basic assumptions laid out in key papers a few years earlier.

Lessons from sociological intervention research

Sociological intervention studies differ from educational ones in that there are usually no safe institutional walls to protect the intervention from the vagaries of the outside world. Perhaps this is why the linear view I observed in design research is much less easily adopted in sociology. A good case in point is the work of Norman Long (2001).

> Intervention is an on-going transformational process that is constantly re-shaped by its own internal organizational and political dynamic and by the specific conditions it encounters or itself creates, including the responses and strategies of local and regional groups who may struggle to define and defend their own social spaces, cultural boundaries and positions within the wider power field. (Long, 2001, p. 27)

Long uses words like "struggle," "strategy," "power," and "position"—words that are conspicuously absent in recent literature on design experiments (in fact, not only these words but also the terms "agency," "motivation," and "resistance" are missing in the index of the recent handbook of design research; Kelly et al., 2008).

> Crucial to understanding processes of intervention is the need to identify and come to grips with the strategies that local actors devise for dealing with their new intervenors so that they might appropriate, manipulate, subvert or dismember particular interventions. (Long, 2001, p. 233)

In other words, resistance and subversion are not accidental disturbances that need to be eliminated. They are essential core ingredients of interventions and they need to have a prominent place in a viable intervention methodology. Melucci (1996) extends this point into a threefold methodological guideline for intervention research.

> What we must recognize is that actors themselves can make sense out of what they are doing, autonomously of any evangelical or manipulative interventions of the researcher. ... Secondly, we need to recognize that the researcher–actor relation is itself an object of observation, that it is itself part of the field of action, and thus subject to explicit negotiation and to a contract stipulated between the parties. ... Lastly, we must recognize that every research practice which involves intervention in the field of action creates an artificial situation which must be explicitly acknowledged. ... [A] capability of metacommunication on the relationship between the observer and the observed must therefore be incorporated into the research framework. (pp. 388–389)

In other words, interventions in human beings' activities are met with actors with identities and agency, not with anonymous mechanical responses. If agency is not a central concern in the methodology, there is something seriously wrong with it.

In educational research, one of the few scholars who have taken this seriously is David Olson (2004).

> Research in the human sciences, it may be argued, is less designed to dictate what one does than to provide information that agents, both teachers and students, can use in making informed decisions about what to do in the multiple and varied contexts in which they work. (p. 25)

Vygotsky's method of double stimulation

In his quest for a new psychology based on cultural mediation of higher mental functions, Vygotsky was very conscious of the need to build a methodology that would correspond to the character of the theory.

> This methodology [study of reactive responses based on the S–R formula], which easily establishes the response movements of the subject, becomes completely impotent … when the basic problem is the study of those means and devices that the subject used to organize his behavior in concrete forms most adequate for each given task. In directing our attention to the study of specifically these (external and internal) means of behavior, we must conduct a radical review of the methodology of the psychological experiment itself. (Vygotsky, 1999, p. 59)

The methodology Vygotsky, Leont'ev, and Luria developed has been characterized by different names. Vygotsky (e.g., 1997b, p. 68, 1997c, 1999, pp. 57–59) used at least the names "experimental-genetic method," "instrumental method," "historical-genetic method," and "method of double stimulation," somewhat interchangeably. In this paper, I will use the "method of double stimulation."

As van der Veer and Valsiner (1991) put it, in double stimulation experiments, "the subject is put in a structured situation where a problem exists … and the subject is provided with active guidance towards the construction of a new means to the end of a solution to the problem" (p. 169). Vygotsky (1978) himself described the methodology as follows:

> The task facing the child in the experimental context is, as a rule, beyond his present capabilities and cannot be solved by existing skills. In such cases a neutral object is placed near the child, and frequently we are able to observe how the neutral stimulus is drawn into the situation and takes on the function of a sign. Thus, *the child actively incorporates these neutral objects into the task of problem solving* [emphasis added]. We might say that when difficulties arise, neutral stimuli take on the function of a sign and from that point on the operation's structure assumes an essentially different character. (p. 74)

> By using this approach, we do not limit ourselves to the usual method of offering the subject simple stimuli to which we expect a direct response. Rather, we simultaneously offer a *second series of stimuli* that have a special function. In this way, we are able to study the *process of accomplishing a task by the aid of specific auxiliary means;* thus we are also able to discover the inner structure and development of higher psychological processes. The method of double stimulation elicits manifestations of the crucial processes in the behavior of people of all ages. Tying a knot as a reminder, in both children and adults, is but one example of a pervasive regulatory principle of human behavior, that of *signification,* wherein people create temporary links and give significance to previously neutral stimuli in the context of their problem-solving efforts. We regard our method as important because it helps to *objectify* inner psychological processes … . (pp. 74–75)

It is important to note that the second stimuli, the mediating means, were not necessarily given to the participants in any ready-made form.

> In experimental studies, we do not necessarily have to present to the subject a prepared external means with which we might solve the proposed problem. The main design of our experiment will not suffer in any way if instead of giving the child prepared external means, we will wait while he spontaneously applies the auxiliary device and involves some auxiliary system of symbols in the operation. … In not giving the child a ready symbol, we could trace the way all the essential mechanisms of the complex symbolic activity of the child develop during the spontaneous expanding of the devices he used. (Vygotsky, 1999, p. 60)

Van der Veer and Valsiner (1991) point out the fundamental challenge this methodology poses to the experimenter who wants to control the experimental situation.

> The notion of "experimental method" is set up by Vygotsky in a methodological framework where the traditional norm of the experimenter's maximum control over what happens in the experiment is retained as a special case, rather than the modal one. The human subject always "imports" into an experimental setting a set of "stimulus-means" (psychological instruments) in the form of signs that the experimenter cannot control externally in any rigid way. Hence the experimental setting becomes a context of investigation where the experimenter can manipulate its structure in order to trigger (but not "produce") the subject's *construction* of new psychological phenomena. (p. 399)

In other words, the participant's agency steps into the picture. To fully appreciate the radical potential of the methodology of double stimulation, we need to reconstruct Vygotsky's more general conception of intentionality and agency. Vygotsky (1997b) described this artifact-mediated nature of intentional action as follows:

> The person, using the power of things or stimuli, controls his own behavior through them, grouping them, putting them together, sorting them. In other words, the great uniqueness of the will consists of man having no power over his own behavior other than the power that things have over his behavior. But man subjects to himself the power of things over behavior, makes them serve his own purposes and controls that power as he wants. He changes the environment with the external activity and in this way affects his own behavior, subjecting it to his own authority. (p. 212)

Vygotsky (1997b) pointed out that voluntary action has two phases or "two apparatuses." The first one is the design phase in which the mediating artifact or "the closure part of the voluntary process" (p. 213) is, often painstakingly, constructed. The second one is the execution phase or "actuating apparatus," which typically looks quite easy and almost automatic, much like a conditioned reflex.

Classic examples of culturally mediated intentionality include devices we construct and use to wake up early in the morning. Vygotsky's examples of voluntary action are mostly focused on individual actors. This must not be interpreted as neglect of collective intentionality. According to Vygotsky's famous principle, higher psychological functions appear twice: first interpsychologically, in collaborative action, and later intrapsychologically, internalized by the individual.

> V.K. Arsen'ev, a well-known researcher of the Ussuriysk region, tells how in an Udeg village in which he stopped during the journey, the local inhabitants asked him, on his return to

Vladivostok, to tell the Russian authorities that the merchant Li Tanku was oppressing them. The next day, the inhabitants came out to accompany the traveler to the outskirts. A gray-haired old man came from the crowd, says Arsen'ev, and gave him the claw of a lynx and told him to put it in his pocket so that he would not forget their petition about Li Tanku. The man himself introduced an artificial stimulus into the situation, actively affecting the processes of remembering. Affecting the memory of another person, we note in passing, is essentially the same as affecting one's own memory. (Vygotsky, 1997b, pp. 50–51)

Vygotsky's colleague A.N. Leont'ev (1932) focused on the social origins of intentional action. He pointed out that signals given by foremen, the rhythmic sounds of a drum, and working songs gave collective work the necessary direction and continuance. The interpsychological origins of voluntary action—and collective intentionality—would thus be found in rudimentary uses of shared external signals, prompts, as well as in reminders, plans, maps, and so on.

Vytgotsky's methodological principle of double stimulation leads to a concept of formative interventions which are radically different from the linear interventions advocated both by the "gold standard" and by the literature on design experiments.[2] The crucial differences may be condensed in four points:

1. *Starting point:* In linear interventions, the contents and goals of the intervention are known ahead of time by the researchers, and the intervention itself is commonly detached from vital life activities of the participants. In formative interventions, the participants (whether children or adult practitioners, or both) face a problematic and contradictory object, embedded in their vital life activity, which they analyze and expand by constructing a novel concept, the contents of which are not known ahead of time to the researchers.
2. *Process:* In linear interventions, the participants, typically teachers and students in school, are expected to execute the intervention without resistance. Difficulties of execution are interpreted as weaknesses in the design that are to be corrected by refining the design. In formative interventions, the contents and course of the intervention are subject to negotiation and the shape of the intervention is eventually up to the participants. Double stimulation as the core mechanism implies that the participants gain agency and take charge of the process.
3. *Outcome:* In linear interventions, the aim is to complete a standardized solution module, typically a new learning environment, that will reliably generate the same desired outcomes when transferred and implemented in new settings. In formative interventions, the aim is to generate new concepts that may be used in other settings as frames for the design of locally appropriate new solutions. A key outcome of formative interventions is agency among the participants.
4. *Researcher's role:* In linear interventions the researcher aims at control of all the variables. In formative interventions, the researcher aims at provoking and sustaining an expansive transformation process led and owned by the practitioners.

Intervention may be defined simply as "purposeful action by a human agent to create change" (Midgley, 2000, p. 113). This definition makes it clear that the researcher does not have a monopoly over interventions. Organized activity systems such as schools and

workplaces are bombarded by interventions from all kinds of outside agents (consultants, administrators, customers, competitors, partners, politicians, journalists). And inside the activity system, practitioners and managers incessantly make their own interventions. We as researchers should not expect nicely linear results from our efforts.

Toward an argumentative grammar

In his discussion of design research in education, Kelly (2004) took up the foundational issue of an "argumentative grammar" that is needed to formulate a viable methodology.

> An argumentative grammar is the logic that guides the use of a method and that supports reasoning about its data. It supplies the *logos* (reason, rationale) in the methodology (method + logos) and is the basis for the *warrant* for the claims that arise. (p. 118)

I see the argumentative grammar as a set of basic epistemic ideas or threads that run through and connect theory, methodology, and empirical research in any serious research approach. Such epistemic ideas are at the same time both substantive assumptions about the nature of the objects of research and heuristic meta-level tools for the practical conduct of intervention, data collection, and analysis.

> What, therefore, is the logos of design studies in education? What is the grammar that cuts across the series of studies as they occur in different fields? Where is the "separable" structure that justifies collecting certain data and not other data and under what conditions? What guides the reasoning with these data to make a plausible argument? (Kelly, 2004, p. 119)

I will take up four epistemic threads or tenets as elements of an argumentative grammar for the methodology of formative interventions. These threads are: (a) activity system as a unit of analysis, (b) contradictions as a source of change and development, (c) agency as a layer of causality, and (d) transformation of practice as a form of expansive concept formation. These four are not meant to be an exhaustive set.

Activity system as a unit of analysis

We may discern three generations in the evolution of the prime unit of analysis within cultural-historical activity theory (Engeström, 2001). The first generation, based on Vygotsky's work, centered on mediated action as a unit of analysis (see Zinchenko, 1985). The second generation, based on Leont'ev's (1978, 1981) work, took the collective activity system as its molar unit of analysis. At present, many activity theorists in various parts of the world are focusing on interactions among two or more activity systems, which requires a third generation unit of analysis where minimally two activity systems have a partially shared object.

The anatomy of an activity system may be depicted with the help of the triangular model that I have developed elsewhere (Engeström, 1987). As is evident in Figure 1, activity theory sees the object as the crucial factor that gives durable direction, purpose, and identity to an activity. As activity systems become fragmented by their inner
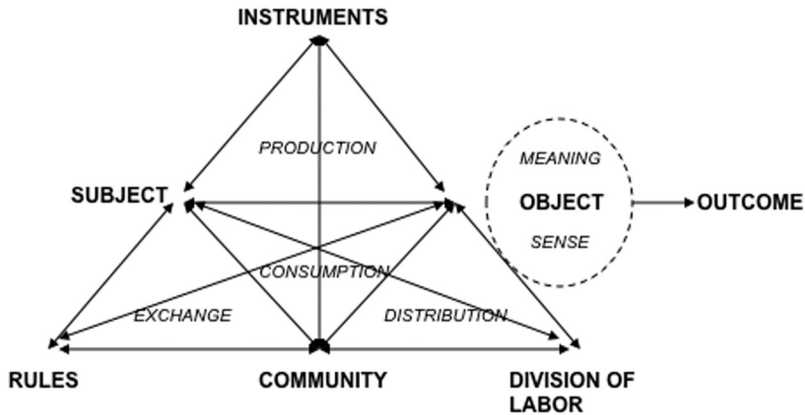
Figure 1. The activity system (Engeström, 1987, p. 78)

contradictions, the object of activity tends to get blurred or lost. The methodology of formative interventions is oriented to the rediscovery and expansive reforging of the object of activity.

The unit of analysis is usually a conceptual idea strictly for the researchers. In formative interventions, we turn the unit of analysis into an external auxiliary means, a mediating conceptual tool, for both the participants and the researchers. The triangular models of activity are typically presented and explained to the participants at an early phase of the intervention. Thereafter, they are repeatedly used to analyze and redesign various aspects of the participants' activity.

An important aspect of activity-theoretical units of analysis is the constant movement between the long historical time perspective of object-oriented activity systems and the relatively short time perspective of goal-oriented actions (Engeström, 2000). Development, understood as qualitative transformations, is driven by an expansive reconceptualization of the object and motive of the entire *activity*. But such transformations are both initiated and implemented in daily work *actions,* in deviations from the prescribed course of actions and in mundane innovations. The crucial issue is movement between these two levels.

For formative interventions, the key implication of activity system as unit of analysis is that interventions need to be embedded and contextualized in the participants' meaningful life activity. An intervention that limits itself to the transformation of actions and ignores the motivational dynamics stemming from the object of the activity may be technically effective in the short run but is unlikely to have durable formative influence in the long run.

Contradictions as a source of change and development

What makes change possible in the first place? This is where activity theory builds on the concept of contradictions. No terrain of activity, no matter how stable and resistant, is

free of inner contradictions. Contradictions are not the same as problems or conflicts. Contradictions are historically accumulating structural tensions within and between activity systems. The primary contradiction of activities in capitalism is that between the use value and exchange value of commodities. This primary contradiction pervades all elements of our activity systems. An activity system is constantly working through tensions and contradictions within and between its elements. Contradictions manifest themselves in disturbances and innovative solutions. In this sense, an activity system is a virtual disturbance- and innovation-producing machine.

Activities are open systems. When an activity system adopts a new element from the outside (e.g., a new technology or a new object), it often leads to an aggravated secondary contradiction where some old element (e.g., the rules or the division of labor) collides with the new one. Such contradictions generate disturbances and conflicts but also innovative attempts to change the activity, making the zone of proximal development an invisible battleground. The stiff rules lagging behind and thwarting possibilities opened up by advanced new instruments are a common example.

Contradictions are not just inevitable features of activity. They are "the principle of its self-movement and ... the form in which the development is cast" (Il'enkov, 1977, p. 330). This means that new qualitative stages and forms of activity emerge as solutions to the contradictions of the preceding stage or form. This in turn takes place in the form of "invisible breakthroughs," innovations from below.

> In reality it always happens that a phenomenon which later becomes universal originally emerges as an individual, particular, specific phenomenon, as an exception from the rule. It cannot actually emerge in any other way. Otherwise history would have a rather mysterious form. Thus, any new improvement of labour, every new mode of man's action in production, before becoming generally accepted and recognized, first emerges as a certain deviation from previously accepted and codified norms. Having emerged as an *individual exception* from the rule in the labour of one or several men, the new form is then taken over by others, becoming in time a new *universal norm.* If the new norm did not originally appear in this exact manner, it would never become a really universal form, but would exist merely in fantasy, in wishful thinking. (Il'enkov, 1982, pp. 83–84)

For formative interventions, the key implication of contradictions as source of change and development is that interventions need to respond to and build on the energy of contradictions in the affected activity systems. This requires that formative interventions are grounded in historical analysis of the activity system, and that empirical manifestations of contradictions in the ongoing activity are recorded and analyzed as part and parcel of the intervention (Engeström & Sannino, 2011).

Agency as a layer of causality

Maxwell (2004) calls the traditional notion of causality the "regularity" approach. It holds that we cannot directly observe causation, only the regularities in the relationships between events. The regularity approach necessarily entails a variable-oriented view of research. Causation is understood as a systematic relationship between variables rather

INTERPRETIVE LAYER	IN ACTIVITY THE ACTOR	TAKES INTO ACCOUNT, ACCORDING TO THIS OR THAT LOGIC, THAT	IF X, THEN Y ⏜ LAW, RULE
CONTRADICTORY LAYER	AS PARTICIPANT IN COLLECTIVE ACTIVITIES	IS DRIVEN BY CONTRADICTORY MOTIVES	SEARCHING RESOLUTION BY OFTEN UNPREDICTABLE ACTIONS
AGENTIVE LAYER	AS POTENTIAL INDIVIDUAL AND COLLECTIVE AGENT	TAKES INTENTIONAL TRANSFORMATIVE ACTIONS	INVENTING AND USING ARTIFACTS TO CONTROL THE ACTION FROM THE OUTSIDE

Figure 2. Three layers of causality in human action

than a causal process. In contrast to variable-based research, process-oriented research believes that causation can actually be observed and reconstructed as a real sequence of events. It uses historical methods and narrative evidence, as well as close observation and recording of unfolding chains of events.

But how does one observe and reconstruct chains of events among human beings? What kind of interpretive lenses do we need for that? Eskola (1999, p. 111) suggests that the answer lies in three facets: (a) the structure and development of the activity in which the actors are involved and its meaning to the different actors; (b) the laws and rules that actors take into account in this activity; and (c) the logics on the basis of which they do so. Eskola presents the basic explanatory schemes of traditional variable-oriented research, on the one hand, and of "realistic research in human action," on the other hand. His realistic paradigm focuses on the fact that humans do not merely react as physical objects; they act based upon their activities, interpretations, and logics. For the sake of simplicity, we may call this the *interpretive layer* of causality.

But there is more to causality in human contexts. Human beings not only interpret, they also face contradictions between multiple motives embedded in and engendered by their historically evolving communities and objects. This is the layer that makes humans look irrational and unpredictable (Engeström, 1989). This adds another layer to human causality. I call it the *contradictory layer*. What is still missing is the human potential for agency, for intentional collective and individual actions aimed at transforming the activity. Thus, I complete the picture by adding an *agentive layer* (Figure 2).

Here I remind the reader of the earlier discussion of Vygotsky's view of agency as originating in the use of external artifacts to reach a redefinition of a situation.

> In experiments involving meaningless situations, Lewin found that the subject searches for some point of support that is external to him and that he defines his own behavior through this external support. In one set of experiments, for example, the experimenter left the subject and did not return, but observed him from a separate room. Generally, the subject waited for 10–20 minutes. Then, not understanding what he should do, he remained in a state of oscillation, confusion and indecisiveness for some time. Nearly all the adults searched for some external

point of support. For example, one subject defined his actions in terms of the striking of the clock. Looking at the clock, he thought: "When the hand moves to the vertical position, I will leave." The subject transformed the situation in this way, establishing that he would wait until 2:30 and then leave. When the time came, the action occurred automatically. By changing the psychological field, the subject created a new situation for himself in this field. He transformed the meaningless situation into one that had a clear meaning. (Vygotsky, 1987, p. 356)

Vygotsky's description of Lewin's experiment captures all the three layers of Figure 2 in a simplified form. Initially, the participant interprets the situation as an experiment in which one must follow the rules of the experimenter. When nothing happens, a contradiction emerges between those expected rules and one's quest for meaning; there is a period of confusion, which could lead to unpredictable and "irrational" actions. However, by using an external cultural artifact such as the clock, the participant is able to transform the situation and take agentive action. Notice that agentive action in its rudimentary forms may look like non-action, or mere resistance—such as leaving the room in the experiment. It is nonetheless a radically different action from that of passive waiting or "irrational" making of noise.

Breaking away from a pre-existing pattern of activity requires expansive agency. This can be achieved by employing external cultural artifacts that are invested with meaning and thus become powerful mediating signs that enable the human being to control his or her behavior from the outside. This is the mechanism of double stimulation. It is often interpreted merely as a way to enhance performance in specific tasks of learning and problem solving. Such a technical interpretation neglects the developmental significance of double stimulation as essentially a mechanism of building novel concepts, agency, and will.

For formative interventions, the key implication of agency as a layer of causality is that the paticipants' agentic actions need to be recorded and analyzed as an important outcome. The interventionist should expect and endorse actions that question his or her plans and take the intervention in surprising directions.

Transformation of practice as a form of expansive concept formation

Expansive learning (Engeström, 1987, 2001) is a process of concept formation. This framework suggests that the very idea of concepts needs to be redefined. As Hall and Greeno (2008), point out, "[C]oncepts and their meanings develop and evolve in settings of practice and are maintained in practices because they are useful in conducting the community's activities" (p. 213). In this perspective, concepts are consequential for the lives of those who work with them. Such concepts are embodied, embedded, and distributed in human activity systems equipped with multi-layered and multi-modal representational infrastructures or instrumentalities. Complex, consequential concepts are inherently polyvalent, debated, incomplete, and often "loose." Different stakeholders produce partial versions of the concept. Thus, the formation and change of concepts involves confrontation and contestation as well as negotiation and blending. Concepts are future-oriented. They are loaded with affects, hopes, fears, values, and collective intentions. Of particular interest are "possibility concepts" (Engeström, 2007a) and

"perspectival concepts" (Engeström, Pasanen, Toiviainen, & Haavisto, 2005) which explicate time-bound collective intentions or visions of future development and change. The formation of complex concepts is not just internalization of culturally given concepts but above all externalization, generation of culturally new concepts (which also need to be internalized in use).

Expansive learning leads to the formation of a new, expanded object and pattern of activity oriented to the object. This process, known as ascending from the abstract to the concrete, involves the formation of a theoretical concept of the new activity, based on grasping and modeling the initial simple relationship, the "germ cell," that gives rise to the new activity and generates its diverse concrete manifestations (Davydov, 1990).

For formative interventions, the key implication of transformation of practice as concept formation is that the analyst needs to trace steps of expansive concept formation, from early unstable attempts and suggestions to stabilization steps such as naming and modeling.

The Change Laboratory

In the mid-1990s, researchers in the CRADLE (formerly Center for Activity Theory and Developmental Work Research) at the University of Helsinki developed a new intervention toolkit under the generic name of *Change Laboratory* (Engeström, 2007b; Engeström, Virkkunen, Helle, Pihalaja, & Poikela, 1996). Variations of this toolkit have been used in a large number of intervention studies in settings ranging from post offices and factories to schools, hospitals, and newsrooms. The Change Laboratory serves as a microcosm in which potential new ways of working can be experienced and experimented with (Engeström, 1987, pp. 277–278).

A Change Laboratory is typically conducted in an activity system that is facing a major transformation. This is often a relatively independent pilot unit in a large organization. Working practitioners and managers of the unit, together with a small group of interventionist-researchers, conduct five to ten successive Change Laboratory sessions, often with follow-up sessions after some months. When feasible, customers or patients are invited to join Change Laboratory sessions, in which their particular cases are analyzed in detail. Change Laboratories are also conducted as boundary-crossing laboratories with representatives from two or more activity systems engaged in collaboration or partnership.

The Change Laboratory is built on ethnographic data from the activity setting in which it is conducted. Critical incidents, troubles, and problems in the work practice are recorded and brought into Change Laboratory sessions to serve as *first stimuli*. This "mirror material" is used to stimulate involvement, analysis, and collaborative design efforts among the participants.

To facilitate analysis and resolution of the problems, interventionists typically introduce conceptual tools such as the triangular models of activity systems (see Figure 1) as a *second stimulus*. Commonly the conceptual models offered by the interventionists are replaced or combined with mediating conceptualizations and models formulated by the participants.

The participants are challenged to use the mediating second stimulus as an instrument in the design of a *new concept* for the activity they are trying to transform. Implementation of the designed new solution is usually initiated while the Change Laboratory sessions are still running, in the form of pilot experiments. The implementation typically leads to a richer and more articulated concept.

In the analysis and design, the participants are asked to move between the past, the present, and the future. This means that historical origins of the current problems are dug up and modeled, and the ideas toward a future concept are played with in anticipatory simulations such as role play.

The laboratory sessions themselves are videotaped for analysis and used as stimuli for reflection. The procedure allows for the collection of rich longitudinal data on the actions and interactions involved in cycles of expansive learning (Engeström, 2001).

Recapturing the object in a hospital surgery unit

As I pointed out above, formative interventions differ from linear interventions (including design experiments) with regard to the starting point, the process, and the outcome. In the following, I will examine data from a recent Change Laboratory intervention in terms of these three aspects.

The Central Surgery Unit of the University Hospital of the City of Oulu in northern Finland invited my research team to work with their staff in the fall of 2006. The unit was in a near-crisis situation, suffering from shortages of qualified staff and excessive workloads which led to temporary closures of some of the operating theaters. This, in turn, led to longer waiting times and queues for patients, and to negative publicity. The pressures were intensified by the fact that new legislation required all hospitals in the near future to guarantee patients access to care with short waiting times, which meant that the hospitals would have to take determined administrative action to cut their queues. The management of the Central Surgery Unit were aware that their problems had a lengthy history and could probably not be eliminated by quick fixes. Our task was to conduct a collective process in which the problems would be diagnosed and a holistic long-term solution would be sought.

We conducted six 2-hour Change Laboratory sessions in the fall of 2006. The participants of the sessions were selected to represent the whole range of practitioners working in the unit, from the head doctor of the unit to surgeons, anesthesiologists, nurses, a porter, and a secretary. We videotaped the sessions and transcribed the discussions. We also conducted follow-up sessions in 2007 and 2008 and continued following the development by means of statistical reports and interviews in 2009.

In the first session, conducted on September 28, 2006, there were 21 participants: 4 surgeons, 4 anesthesiologists (one who served as the operations manager of the whole unit), 3 surgical nurses, 4 anesthesia nurses (including the head nurse of the unit), 1 administrator, 1 secretary, 1 porter, and 3 members of the research group.[3] In the 2-hour session, there were 402 conversational turns. In the following analysis, I will only use the transcript of the first session as data. I will scrutinize the data to characterize the starting point, the process, and the provisional outcome of the Change Laboratory intervention.

We started the first session by presenting a set of videotaped interviews in which practitioners expressed their concern with the shortages of staff, excessive workloads, long waiting lists, and closures of operating theaters. This "mirror material" triggered a rich discussion.

Starting point: Loss of the object. Much of the discussion in the first session circled around experiences of loss of meaning in the work. These experiences were expressed in different thematic streams. The first one focused on the vicious circle of necessary temporary closings of operating theaters and growing patient waiting lists.

> 048 *Researcher 1:* […] is it some kind of a problem, that they have to stay closed, the operating theaters?
> 049 *Anesthesiologist, operation manager:* It's a problem in the sense that there are patients in the waiting list who need the operations, and there is a lot of pressure on the other side that they must get treated. This can be seen in the public. So you are between a rock and a hard place all the time. Which gives you the feeling that here we are constantly failing, even though we work harder than ever, we are bad all the same because we cannot get the waiting list to move.

The formulation "between a rock and a hard place all the time" is a clearcut expression of what Bateson (1972) called a double bind: "we are bad all the same."

The second stream focused on the difficult or "bad" patient material in the Central Surgery Unit.

> 087 *Head anesthesia nurse:* If I can say on behalf of the anesthesia nurses, we really have three different anesthesia units. We have ours, the central clinic, and then short-term day surgery. If we compare the working conditions, patient material, working time, this is quite different. So we work three shifts, we have the emergency service duty. The patient material …
> 088 *Researcher 1:* […] please say that again, wind back.
> 089 *Head anesthesia nurse:* Well. The patient material is surely the worst of all. And the operations are the biggest, and the operations are the heaviest …
> […]
> 092 *Head anesthesia nurse:* Yes. And quite the same pay. And then the patient material, which I already mentioned. It is worse and it will remain worse because now the private sector combs out the easiest patients and operates on them there at a different time when we get all the worse patients. Then a big problem for us is postoperative care, immediate postoperative care, in other words the recovery room, which gets not only all our patients, but patients from the central clinic, and the emergency service, internal medicine patients, intensive-care patients …

Here the discourse shifted from "us" (the practitioners) to "them" (the patients): that is, from the subject to the object. But the talk about "bad patient material" displayed a reified object. Patients had become burdensome anonymous material. This was quickly countered by a surgeon, who took up the other side of patients.

111 *Surgeon 3:* I find it quite contradictory when you think about the people who leave and say it is because the job is so hard. I just feel that in this job, if you do the real work with the patient, however hard it may be, it is just that that is rewarding. On the other hand, you are ready to take on the challenge if you have the education for it. The leavings, they surely come from something other than that you have a difficult case in front of you, and that is what you battle with. So that when you leave to go home, you feel relieved, a nice feeling that I bloody did it! That you don't think this is so hard that I will leave this job.

112 *Researcher 1:* So here we have a comment that the fact that the patient material is becoming harder is not necessarily directly the reason.

113 *Senior anesthesiologist:* But it can be a reason if you experience the hardness and not the reward at all. Nobody ever thanks you, the work remains unfinished, you leave, and everything is unfinished, your shift ends and you leave; you never see the reward for the hard work, so that … Surely one thing that should be developed is that really you would feel that the work is rewarding. So that you would really feel that you do your job well and that the patients get well and stay alive. And in this way the whole image of the thing should get built.

The senior anesthesiologist (turn 113) actually opened up a third stream in the discussion: "You never see the reward for the hard work." This stream was continued and elaborated on later in the session. The point of this stream was the experience of loss of view and control over the object of one's work.

345 *Senior anesthesiologist:* […] You don't get to control your own work so that you would know what they have there. There we had it again, which I thought was a little bit like the chiefs in *Asterix* who are afraid of the sky falling down, that they don't know what will be coming in through the door. Why be afraid, why should you be afraid of that? When you have the best professionals, who can keep the person alive, you are afraid of what comes in through the door. But it surely doesn't depend on that, that you would be afraid that you cannot do something, but that you don't know in advance about the day, so that takes it away… That's how I see it anyway. Is it such a thing, there is the scare, that it is the unknown. When you have no idea at all who the patient is going to be. When if you saw on some sort of a list that there we have our orthopedic patients whom we are going to operate on today, these come in through our recovery part and these we are expecting. We will have a look at the monitor screen of how things will proceed, we know who is going to come next and then here again.

346 *Senior surgical nurse:* Those we do know. But then the ones who come in through the central clinic or the ones that come from X-ray or who come in through the emergency room … Who come back from the ward when they cannot cope… Or when it is a patient back there for 3 days when he should be in the ICU [Intensive Care Unit] but they don't have the bed. And they won't take him in a corridor place in the in-patient ward and …

347 *Senior anesthesiologist:* So you have no control over your own work and you cannot plan it beforehand, and these are probably what cause the …

348 *Senior surgical nurse:* Yes, in a way they mess up our own operation.

The starting point of the Change Laboratory intervention in this case consisted of intense articulation of the experienced problem space, or spectrum of trouble. Through its three streams, this articulation transformed the initially given, publicly available problems (shortages of personnel, long waiting lists, closures of operating theaters) into a poorly understood contradictory object.

The first stream articulated the situation as a double bind. The second stream articulated patients as reified into anonymous "bad material" (or its flip side, "challenging material," as in turn 111). This kind of categorization, or empirical abstraction (Davydov, 1990), typically serves as "stabilization knowledge" that gives a name and a simple pseudo-explanation to a complex and bewildering problem (Engeström, 2007a). The third stream articulated the situation as fear of the unknown, as loss of control and overview of what kinds of patients one will encounter during the workday. Taken together, the three streams of this initial articulation may be characterized as *loss of object*.

Process: Alternative organization as second stimulus. One might assume that the intervention would have proceeded in a more or less straightforward manner to regain and re-identify the lost object. However, no such linear fix was available. A second stimulus was needed to open up an indirect avenue toward regaining the object.

In this case, the second stimulus was generated by the participants already in the first session, before we researchers had a chance to suggest our own conceptual tools for the task. This reminds us of Vygotsky's (1999) statement quoted earlier: "[W]e do not necessarily have to present to the subject a prepared external means with which we might solve the proposed problem" (p. 60); we may "wait while he spontaneously applies the auxiliary device and involves some auxiliary system of symbols in the operation" (p. 60).

In this case, the second stimulus, or the mediating conceptual instrument, began to take shape first in relatively vague terms, as complaints about the large size of the unit.

097   *Senior anesthesia nurse:* […] And the number of staff is large, and really as I said the area of responsibility is big.
098   *Researcher 1:* What's the disadvantage in having large numbers of staff?
099   *Senior anesthesia nurse:* Management is hard and communicating is very difficult, getting the group together is really hard, motivating is hard. And what else should I think? Knowledge management is hard.

The issue was further developed as a need for smaller sub-units.

138   *Head nurse:* […] If we want to make this education and familiarization easier we should absolutely divide the people into smaller pools, or specialities, or whatever you call it. Like the surgeons have. In that case it would be easier to take care of.

The actual formulation of the second stimulus was initiated by a surgeon.

193   *Surgeon 1:* Yes. As T [senior anesthesia nurse] said, the Central Surgery Unit is terribly big, and therefore hard to control, what if we divided it into parts. Orthopedics would get their own department, as would soft tissue surgery,

cardio-thoracic surgery, and vascular surgery. Into three parts so that each would have their own nurses, their own doctors there, so that we would have smaller units, easier to manage, better to build their own identity for everyone and easier to recruit new people. Would that be more functional?

194 *Researcher 1:* Have you seen similar models in Finland?
195 *Surgeon 1:* Yes in Tampere.
196 *Researcher 1:* Does it work?
197 *Surgeon 1:* It works very well.

The idea of dividing the unit into three or four smaller independent sub-units was received with both enthusiasm and reservations. The new organizational model evoked considerations of complications. However, these were taken as issues to be resolved by joint design efforts.

204 *Senior anesthesia nurse*: And then such a thing works in surgery and instruments and it is good that there are doctors who are responsible in each area of expertise. But then this is kind of general, the specializing doctors and anesthesia nurses, for them the rotation is absolutely vital because we have emergency duty and such. So in a way on the anesthesia side you have to have flexibility in building the system.
205 *Researcher 1:* If it would be three separate units, then you should be able to move across them.
206 *Senior anesthesia nurse:* Yes.
207 *Researcher 1:* Exactly. That brings along its own difficulties right from the start.
208 *Operations manager:* And it also leads to the fact that emergency duty should be partly made separate, which we already have in the plans, on the other hand, we will have soft tissue and hard tissue emergency services.
209 *Researcher 1:* Do you mean that in a way there would be a fourth unit, the emergency service unit?
210 *Operations manager:* No, I mean that if we were to be divided into these smaller units, in a way the units would take care of their own emergency service. In any case we have three to four teams there, but they would represent the knowledge in the different areas of expertise.

The construction of the second stimulus, namely the alternative organizational structure based on smaller sub-units, was a long and laborious process. It went on practically all through the six Change Laboratory sessions, resulting in a detailed new organization chart. This new chart was subsequently implemented in the Central Surgery Unit.

The relevance of double stimulation in long-term processes was not alien to Vygotsky. He pointed out that the principle applies even to "a continuing real-life problem that ends only at death and whose resolution may be interrupted thousands of times" (Vygotsky, 1997b, p. 213).

But where did the idea for the second stimulus come from? An exchange between four physicians indicates that the idea had been around for quite a while.

216   *Surgeon 2:* I feel that we are mixing things a little bit. The things that V [surgeon 1] said about Tampere, they are organizationally different units. And I think that what you said about dividing the functions is nothing but regrouping the functions here.

217   *Operations manager:* They could have their own organizations, we don't …

218   *Surgeon 1:* This is a step into that direction.

219   *Surgeon 2:* So it is a really long step. They would have to have their own ward. They would have their own financial management, their own management …

220   *Surgeon 1:* We have talked about this for a long time.

221   *Surgeon 3:* It is just like V said, and at least I am warmly in favor of and vote for V even in the council elections [*laughter*]. This is a work policy issue. The knowledge base in surgery is so huge. In addition I know that this has been talked about in several meetings and talks. It is exactly anesthesiologists, anesthesia nurses and instrument nurses who bring this up a lot; they do so much that the control of all this should be, it is an impossible goal. It is a fact that going through all the theaters is not enough to take control of them. You have to take realism by the hand and do your own specializations.

Vygotsky talked about the second stimulus as a "neutral stimulus" which is filled with significance. In the simple examples of tying a knot or using the position of the hands of the clock as a prompt, the second stimuli indeed look neutral. But no object is neutral. By virtue of being recognized as an object, it already is invested with a meaning and certain affordances which have a history. In this sense, the notion of "neutral" is unfortunate and should be replaced with "ambiguous." The initially ambiguous artifact—in our case, the alternative organization chart—is gradually filled with specific contents and demands for action. The crucial issue is that the second stimulus is a mediating artifact, not the solution in itself. Adopting a new organization chart is not an automatic solution to the the loss of the object. It has to be implemented as an instrument to solve the problem, which in turn means that the new solution, the new concept, only emerges as the second stimulus is put into action.

Outcome: New concept of responsibility? From its very inception, the mediating second stimulus (the alternative organizational model) was inherently ambiguous in that it implied two possible and partly conflicting outcomes. The first one was specialization.

228   *Surgeon 4:* [...] the central operating ward it is a big ward, and a large part of it, apparently all procedures, especially on the instrument side, they go around the whole system all the time. And this leads to the fact the we have these specializations, where, e.g., on the instrument side on the table you are given five containers of nuts and bolts, and it always takes about 2–3 months to learn all those nuts and bolts. And the training restarts every half year or a year, and the first 2–3 months slow down the operations and efficiency. And then when we get to the point where it starts to run smoothly, we start the same round again. It is continuing learning which affects the normal operations, it is inefficient. It always slows down the action and it is not rational due to the fact that when the

person has been there for 6 months or a year s/he then goes elsewhere and comes back again after 5 years, s/he has had time to forget everything several times over. In addition it is completely useless. And not everybody needs to know all of these things.
[…]

235   *Surgery nurse 1:* We could also say that on the contrary when you have an experienced nurse s/he sometimes oversees the inexperienced surgeon that s/he does things right. But about the emergency service time, I find it contradictory that we have doctors in all the specialties, our own doctors who do the emergency duty—as back-up—but we don't have in the specialty in question a back-up emergency nurse who knows all the work in the area exactly, who we could ask at least by telephone. And then we do there, we sort of sail through from one day to the next.

The other possible outcome of the new organizational model was characterized as a new kind of shared responsibility.

202   *Senior surgery nurse:* I feel that taking the responsibility would perhaps be—or should I say, that there would be more people taking responsibility if we had a smaller system. Now it is easy to throw everything to P [the operations manager] and maybe a little goes to T [senior anesthesia nurse], too.
[…]

266   *Operations manager:* We're living at the point of whether we drown or not. Each model or thing that we do puts more water into the boat. And then if we were divided into smaller units, then perhaps the ability to see the whole would grow among this group. Sometimes I feel that everyone just thinks that they aren't interested, I do exactly what I have been told to do and I don't care how this thing gets done as a whole. And seeing the whole is then left to the small group in the control room who try to fight the big current.

In a way, specialization and shared responsibility were opposite images of the outcome. Specialization implies focusing on a *narrower* field, with more depth. The new responsibility called for in turns 202 and 266 envisioned collective focus on a *wider* field: "to see the whole." The need for such a wider or more holistic perspective was formulated in terms of the patient's "whole chain of care."

354   *Head nurse:* And if you think of the whole chain of care, then we have a big bucket into which everyone pours, and out of the bucket comes a thin hose which leads to the operating ward, and from there in turn to the in-patient wards. There are a number of narrow passages and at the end there is a plug. This is because of the fact that for several reasons the patients cannot go home or to further care. And the ward capacity for in-patients is not enough for these kinds of patient numbers. And there too, when we talked this is a kind of a spiral that in my mind in this patient flow is such that when the patients wait for days, even 4 days, for their emergency operations in the ward, they cannot get into the

operating theater, and therefore the patients who have already been operated on and are in the recovery ward cannot get into the in-patient wards. This is if you think in caricature. Or then when the patient leaves the ward to go to the operating theatre, and, e.g., it has been planned that there will be 1–2 days in the intensive care unit, then his or her place in the in-patient ward will be filled not with a patient who will be there for the 1 or 2 days that the patient is away, but similar kinds of patients who need long-term care. So when we want to transfer the patient from either the recovery ward or the ICU to the ward, then the ward announces that we cannot take him or her as we have no places as we took in ten new patients today. Emergencies, or elective patients too.

As I restrict this paper's data analysis to the first session of the intervention, it will be the task of future analyses to find out to which extent and in which ways this new, more holistic responsibility for the patient's chain of care has actually been worked out and conceptualized as an outcome of the formative intervention in this case.

The layered character of formative intervention

The analysis presented above may be summarized with the help of Figure 3. The diagram shows the layered character of the formative intervention.

As the intervention progresses from the starting point to the construction of the second stimulus, the first stimuli (the problems to be solved) also gain a new layer, appearing as complications engendered by the second stimulus itself. Similarly, as the intervention moves to the phase of implementing the second stimulus in practice and thus generating a new concept, the second stimulus as well as the first stimuli also gain
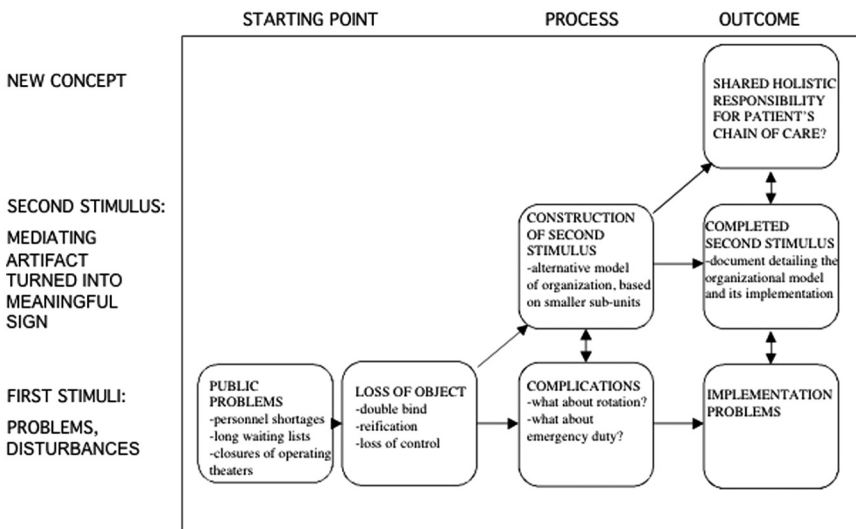

Figure 3. The layered character of a formative intervention

a new layer. The second stimulus took the shape of a sizeable document, entirely written by the practitioners themselves, that detailed the new organizational model and guidelines for its implementation. The first stimuli took the shape of pressing practical problems engendered by the implementation of the new organizational model.

The layered character of formative interventions means that the stimuli do not remain the same through the intervention process. Both the first stimulus (the problem to be tackled) and the second stimulus (the mediating artifact) typically go through multiple reformulations in the course of the intervention. These shifts demand careful attention from the analyst.

The notion of second stimulus is of crucial importance in the design, implementation, and analysis of formative interventions. As pointed out above, Vygotsky's term "neutral stimulus" needs to be replaced with "ambiguous stimulus." But this is hardly a sufficient characterization of the second stimulus. The Change Laboratory data analyzed in this paper suggest the following characteristics of an effective second stimulus.

First of all, an effective second stimulus is actively constructed by the participants of the intervention. This does not mean that the second stimulus cannot be initially suggested or presented by the interventionist. In Change Laboratories the interventionists commonly suggest that the participants use the triangular model of an activity system (see Figure 1) as a template for analysis and design. However, while the participants may indeed use the offered template, they sooner or later switch to a model or instrument of their own, or at least modify and fill the template with their own contents. In the Central Surgery Unit, the participants focused almost from the very beginning on constructing their alternative organization chart and eventually an elaborate organizational model as the second stimulus.

Secondly, the construction of the second stimulus requires that an ambiguous and often quite skeletal or sketchy artifact is step-by-step filled with increasingly rich meaning. In our case, the new organization chart was initially presented as a one-page diagram. The chart was modified several times, and its different elements were elaborated in oral discussions and with the help of written texts. Eventually this led to the collective formulation of a 10-page document detailing the new organization and its implications. In a way, the initial ambiguity was replaced with increasing precision. However, the organizational model was never fully fixed and stabilized. The participants were conscious of the experimental and open-ended character of their model and have continued to modify and develop it further for at least 3 years after the end of the Change Laboratory sessions.

Thirdly, even though the second stimulus retains its open-endedness and modifiability, it also has to take the shape of a relatively stable material representation that can serve as an "anchoring" device (Hutchins, 2005) in the lengthy and discontinuous process of collective concept formation. In our case, the diagram of the organization chart and subsequently the paper document detailing the organizational model have served as such material anchors.

Fourthly, the second stimulus is constructed for the purpose of dealing with the challenge of the contradictions manifested by the first stimulus. In other words, the effectiveness of the second stimulus is revealed when it is used. Again, the implementation of the new organizational model has been a process that we have now followed for

3 years. The near-crisis situation of the unit has been overcome: sick leaves have gone down significantly, patient queues and waiting times have been reduced, and there have been no recent closures of operating theaters.

It is not sufficient to analyze the shifting layers of the stimuli. The crucial third element is the new concept that emerges out of the interplay between the stimuli. In formative interventions, this new concept is to a large extent an unknown factor to begin with. For the analyst this means that indications of concept formation need to be followed with great care. Concept formation includes naming and modeling efforts; in other words, attempts at stabilization. However, as the case analyzed above demonstrates, it is important to separate the modeling of the second stimulus (e.g., an organization chart) and the modeling of the new concept. The organization chart designed and effectively used by the practitioners was a means for generating a new kind of practice. The articulation of the quality of this new practice as a new concept has been much slower and more difficult than the formulation of the new organizational model.

Back to the grammar

The first tenet of the argumentative grammar presented above requires that formative interventions are embedded and contextualized in the participants' meaningful life activity. In the case of the Central Surgery Unit, the intervention was focused on making sense of and redesigning the participants' work activity. The intervention sessions took place during work hours in the unit's own premises.

The second tenet of the suggested grammar requires that formative interventions respond to and build on the energy of contradictions in the affected activity systems. In the case of the Central Surgery Unit, the intervention was a response to a near-crisis situation in the work activity. The contradictions of the activity system may be summarized with the help of Figure 4. The two-headed lightning-shaped arrows indicate that the aggravated contradictions were located between the object and the division of labor, on the one hand, and between the object and the instruments, on the other hand. These contradictions generated a strong "warrant" for the intervention, to use the terminology of Schwartz, Chang, and Martin (2008).

It is nice to know that the practitioners' new organization model led to the overcoming of the crisis. However, if that were the sole concern of the methodology, we would be dealing with a rather technical intervention approach, again reproducing the quest for closure. The two remaining tenets of the suggested argumentative grammar open up the landscape toward the unknown and unpredictable.

The third tenet requires participants' agentic actions to be recorded and analyzed as an important outcome of a formative intervention. In Change Laboratory interventions, we have identified five main forms of participants' emerging agency which seem to be quite specific and characteristic to this type of interventions. I will briefly discuss these five forms and their appearance in the Central Surgery Unit.

Resisting the interventionist or the management. This may take the shape of criticism, questioning, opposition, or rejection (see Kindred, 1999; Sannino, 2010). In the Change
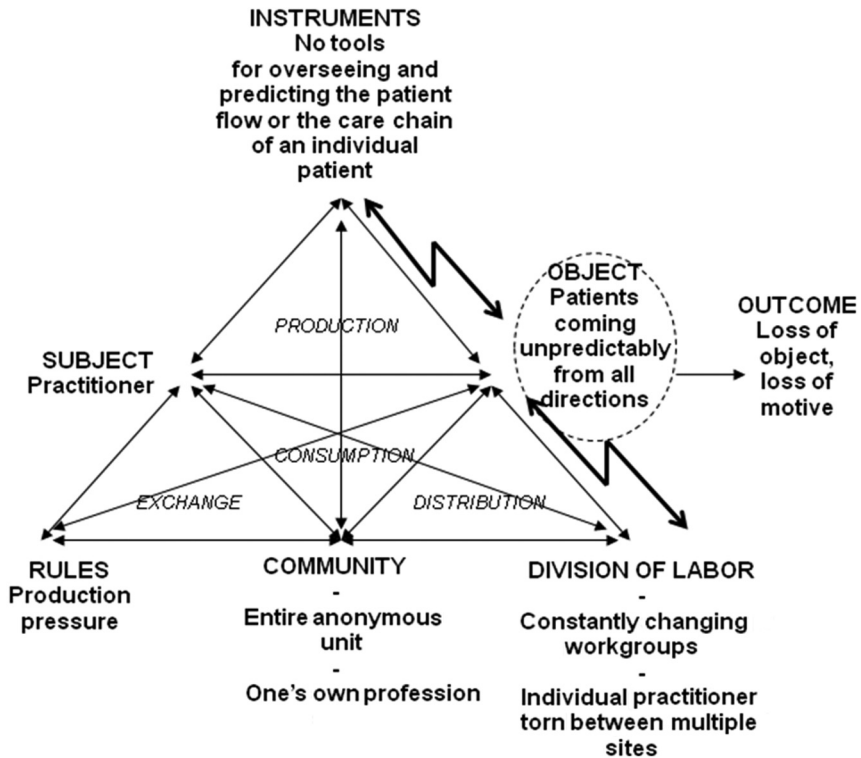
Figure 4. Contradictions of the activity system of the Central Surgery Unit

Laboratory session of the hospital surgical unit analyzed above, resisting appeared as rather indirect criticism of the management.

> 113 *Senior anesthesiologist:* But it can be a reason if you experience the hardness
> and not the reward at all. Nobody ever thanks you, the work remains unfinished,
> you leave, and everything is unfinished, your shift ends and you leave; you
> never see the reward for the hard work […]

In particular, the formulation "Nobody ever thanks you" is a fairly explicit comment toward the management.

Explicating new possibilities or potentials in the activity. This may take the shape of relating past positive experiences as evidence of unacknowledged potentials (Sannino, 2008), or more generally characterizing the problematic object as a source of new possibilities (Engeström, 2007a; Engeström, Engeström, & Suntio, 2002) and exciting challenges. In the Change Laboratory session of the hospital surgical unit, this was exemplified in an utterance by Surgeon 3.

111   *Surgeon 3:* [...] I just feel that in this job, if you do the real work with the patient, however hard it may be, it is just that that is rewarding. On the other hand, you are ready to take on the challenge if you have the education for it. [...] So that when you leave to go home, you feel relieved, a nice feeling that I bloody did it!

Envisioning new patterns or models of the activity. This may range from preliminary partial suggestions (e.g., Teräs, 2007, pp. 111–136) to the presentation and examination of comprehensive models for the future. In the Change Laboratory session of the hospital surgical unit, Surgeon 1's formulation of the new model was first tentative, hedged with conditionals and an open question at the end.

193   *Surgeon 1:* […] what if we divided it into parts. Orthopedics would get their own department, as would soft tissue surgery, cardio-thoracic surgery, and vascular surgery. Into three parts so that each would have their own nurses, their own doctors there, so that we would have smaller units, easier to manage, better to build their own identity for everyone and easier to recruit new people. Would that be more functional?

Committing to concrete actions aimed at changing the activity.   This typically takes the shape of commissive speech acts. "This is, by definition, agentive talk: The speaker expresses his or her intention to act in a specified way" (Sannino, 2008, p. 247). In the Central Surgery Unit, this form of agency emerged increasingly strongly in the later sessions of the Change Laboratory.

Taking consequential actions to change the activity. Occasionally in formative intervention sessions the participants go beyond talk and simulation and actually perform consequential change actions, for example redefine the diagnosis and treatment of a specific patient. Of particular interest are occasions in which such specific consequential actions merge with broader envisioning and modeling of the future activity (Engeström, Engeström, & Kerosuo, 2003). In Change Laboratory processes, the consequential change actions are mostly taken *in vivo,* after and in between the laboratory sessions. To record and reflect on such actions, various kinds of follow-up data are collected and specific follow-up sessions are included in the longitudinal intervention process. Recently we have traced back and analyzed consequences of formative interventions over time periods of 10 or more years (Engeström, Kerosuo, & Kajamaa, 2007).

Finally, the fourth tenet of the suggested argumentative grammar requires the analyst to trace steps of expansive concept formation, from early unstable attempts and suggestions to stabilization steps such as naming and modeling. As summarized in Figure 3, initial, albeit weak and ambivalent, steps toward the formation of a new concept for the activity were found already in the first Change Laboratory session. The fledgling new concept seems to take shape around the redefinition of responsibility in patient care. At this point, this finding remains a working hypothesis for forthcoming analyses.

All this leaves us with a longitudinal intervention methodology that yields no quick closures. Especially the capture and analysis of the emergence and stabilization of new forms of agency and consequential concepts are still in their infancy. Yet there is no

doubt that Vygotsky's principle of double stimulation has found a new life in the emerging methodology of formative interventions.

Notes

1. This obsession is of course the core of a whole field of intervention research, called "fidelity of implementation" (O'Donnell, 2008).
2. There may be design experiment studies that overcome one or more of the limitations described in the four points of contrast. This paper is not meant to be a comprehensive assessment of work done within the paradigm of design experiments. Thus, my critique is necessarily somewhat simplified and treats design research as a totality without much nuance.
3. The research group consisted of Yrjö Engeström (PI), Hannele Kerosuo, and Anu Kajamaa. Also Philippe Lorino and Annalisa Sannino participated in data analysis of the transcript of the first Change Laboratory session. I am grateful for their insights. However, I am alone responsible for the interpretations included in the preliminary analysis presented in this paper. This analysis is very much a work in progress.

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