

Conceptualizing the Work of the Information Infrastructure System

Our program of work involves a dynamic interaction of pragmatic design-engineering work on IIS tools and social practices with efforts to develop an empirically grounded theory of practice improvement mediated by these new technologies. This linking of a deep, direct engagement with practice improvement and theory building about such praxis is at the heart of our network's efforts to envision new and more productive forms of R and D in education.

An evolving theory of practice improvement, summarized below, (aka the "conceptual framework") both disciplines our design initiatives and guides inquiry into their effects. The conceptual framework seeks clinical validity for detailing the essential elements comprising specific school practices while also affording analytic traction for organizing research on improvement of these same practices. From a clinical perspective, the framework creates opportunities for new insights about school improvement and represents a useful tool for communication among school professionals and IIS team members. As an analytic device, it identifies the key factors to be considered, organizes a hypothesized set of relations among them, and guides the processes of developing measures for each of these factors and examines empirical relations among them.

Why a Grounded Theory of Practice Improvement is Essential in this Domain

It is fair to note that technology has failed to-date to deliver on the potential proclaimed by its proponents over the last two or three decades. We conjecture that there are at least two primary reasons for this. First, technology in schools has typically operated as some form of an "add-on" aimed primarily at students. For example, instructional designers have added visualization technology to science or added spreadsheet technology to mathematics curricula. While the designers' intent may have been expansive, in reality these technologies show up briefly in the instructional lives of children and teachers and just as quickly disappear.

From this perspective, technology has failed to become embedded in school life because it has not been viewed as an essential element in a larger systemic change effort. IIS initiatives, by contrast, focus specifically on adults and seek to bring to bear an integrated suite of technologies that aim to influence many, if not all, of the major aspects of their work. Such pervasive uses of technologies by adults will likely change schools in several, simultaneous, ways. Moreover, should these effects consolidate in a coherent fashion, IIS initiatives promise more profound organizational transformation than we have witnessed to date.

For this to happen in productive ways, however a second concern must also be addressed. Over the last several decades, efforts to introduce technologies into schools have been under-informed. It has often been the case that technologists have led with the technology, and its functions, as a way to catalyze school adoptions. They have often tried to retrofit or create new school practices around the constraints built into the technology itself. In addition, designers have tended to conceptualize a single person or

category of persons as target users, ignoring the functional interconnections among individuals within a school's social system.. For example, technologies aimed at students, have often under-articulated the role that teachers play in monitoring student use and understanding student progress. Similarly, technologies designed for teachers often specify in great detail how teachers are supposed to use them but typically under-specify how the pattern of interactions, with, and among, students might change as a result of the technology's introduction. In short, technologies are always social and will, if they are successful, have an impact on the overall fabric of an organization.

Taken together, these observations suggest that the effective introduction of new tools into schools must be anchored in:

- a deep understanding of specific school practices;
- a recognition of the different knowledge, skills and dispositions that school staff bring to these practices;
- an appreciation of how adult and student work in schools is shaped by local context and larger institutional features, and
- lastly, by a vision of how technology might better mediate specific work activities of the community in the future.

The IIS project aims to address these various shortcomings. An explicit goal of the IIS is to bring forth new form of theorizing about how technology might more effectively engage the work of schooling. Rather than starting with technology per se, we begin instead with the pressing problems of practice that people in schools face day-to-day. In addition, rather than narrowly grounding our efforts around one class of actors (e.g. the self-contained classroom teacher) we focus on the entire social system of a school-- looking to understand how collections of diverse actors with different backgrounds, working in distinctive school contexts, might use and adopt new technologies as a way to make progress on the problems of practice that they collectively face.

In sum, the IIS team has embraced the idea that technologies have failed to influence schools not because of the technologies per se, but because, as a field, we do not have good theories to discipline our work with these technologies. Our conjecture is that theories that start with practice and craft useful new tools based on practice, will lead first to a new generation of useful tools for schools; and second, will lead to a more robust set of understanding about the various factors shaping technology's impact in schools which will provide the basis for even more effective tool design in the future.

An Activity Theory Framework for Disciplining Design and Inquiry on Technology-Mediated School Practice¹

A work activity segment represents our primary unit of analysis. Each activity segment is rooted in a specific problem of practice embedded in some individual work roles (or interconnected set of work roles) within a school. IIS design efforts focus attention on how this work can be more effectively mediated by introducing new technologies and related social practices.

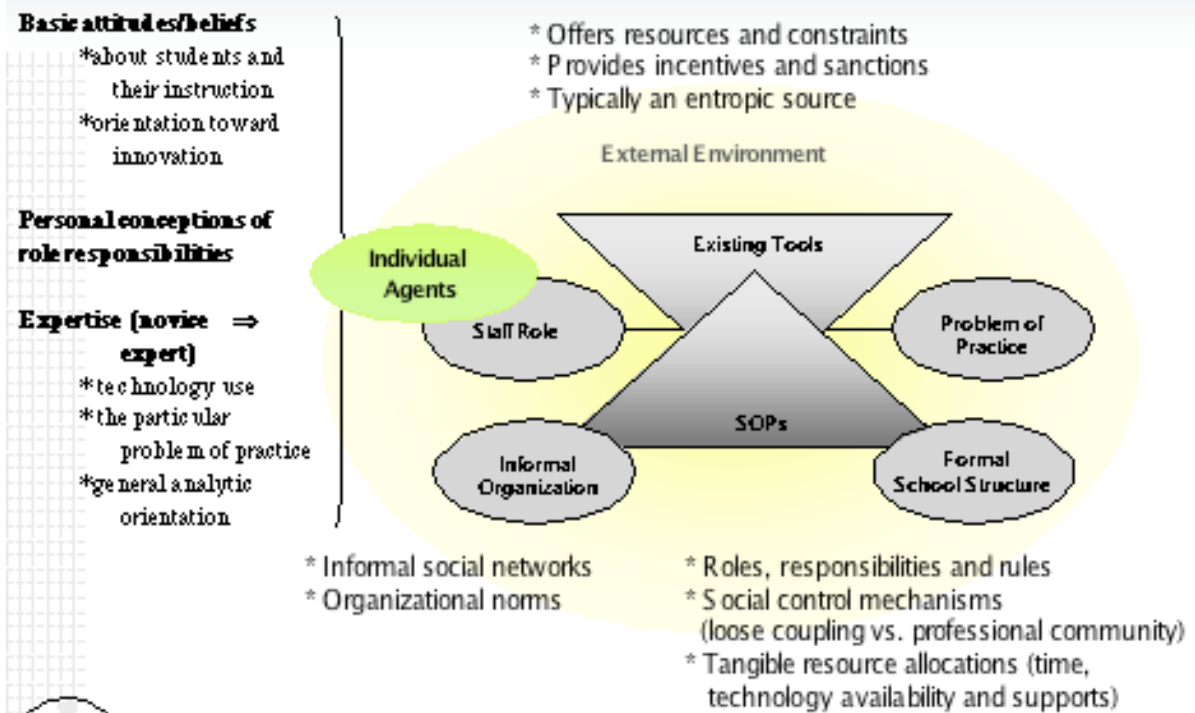
¹ This is a capsule summary from a separate working paper in progress.

We recognize that individual agents occupy these work roles and bring varied prior beliefs, role conceptions and level of expertise to their efforts. The perceived self interests and competencies of these individual agents influence how any new tool and/or social practice enters the school context and shapes whether and how an innovation adoption occurs.

These aspects of individual agency occur within a school context, consisting of a formal organizational structure and important informal socio-normative elements, which also shape the introduction of any innovation and its pattern of adaptation. Each school, in turn, exists within an external institutional environment, fashioned by district, state and federal policies that provide resources and constraints, and that offers incentives and sanctions which aim to define and control the proper forms of agent behavior. While current reforms seek to make this environment more coherent and ‘aligned’, this external environment still tends to exert a largely entropic effect on schools which remain highly open to its influences.

All of these elements, which taken together specify a work activity segment, stand in strong, dynamic interaction with one another. (See Figure 1.) At the most basic level, the identification of problems of practice is rooted both in the formal structure of schools (e.g. a commitment to balanced literacy) and their informal social organization. The base state SOPS (standard operating procedures) are shaped by both of these organizational features as well as by the collective perceived interests of school staff.

Figure 1. A basic work activity segment

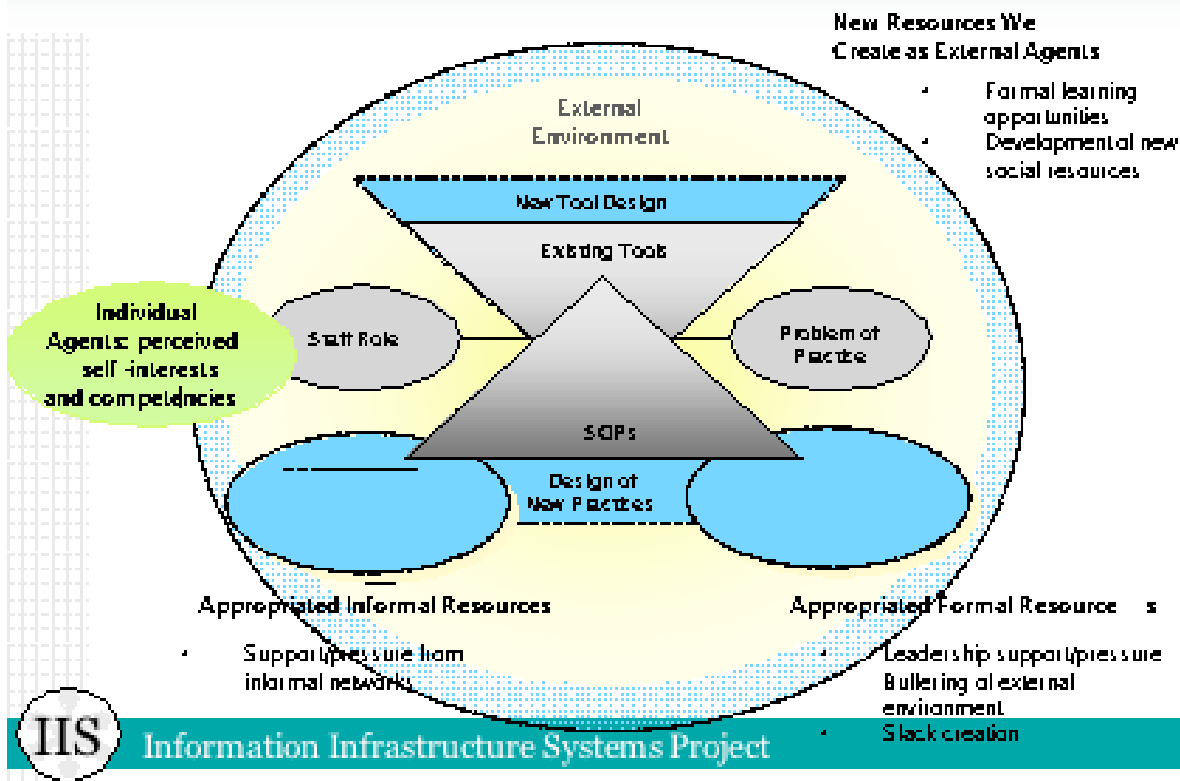


Similarly, our efforts to design new tools and social practices are anchored in, specific, work problems, which exist within a school organization with distinctive structural and socio-normative elements, and which are, in turn, subject to certain external sanctions and incentives. Each of the elements identified in Figure 1 represents a critical concern in our R and D work. To the point, an inadequate accounting for any one of these components could precipitate an overall system failure.

Filling out our design environment (see Figure 2), we also attend to: 1) the extant resources and mechanisms that can be appropriated within a school's ecology to support the introduction of innovations; and 2) any new resources which may need to be deliberately developed by the IIS team for this purpose. Together these focus us on:

- the formal and informal social organization of the school (e.g. formal and informal leaders who can exert pressure/support to engage the innovation, extant social resources that can be appropriated to assist in innovation diffusion),
- the interaction of the school and its external institutional environment (e.g. the use of formal authority by principals and officials in the external environment to buffer the innovation and create slack for agent experimentation and learning), and
- the interaction of any, or all, of these entities with members of our IIS group. We may design formal opportunities to support agent learning and draw on any social resources that we may have built with individual school actors to influence their "self interest calculus" about their possible engagements with our work.

Figure 2. The Design Environment



Finally, we expect our innovations will culminate in three forms of outcomes: **activity level outcomes** relevant to each specific work problem which we seek to mediate with new tools and social practices; **individual level outcomes** where the aspects of individual agents, which form their initial engagements with an innovation, may in turn be reshaped as these activity cycles proceed over time; and **organizational level outcomes** which represent the primary aims of our work--the transformation of schools from a loose coupling toward a more tightly coupled professional environment characterized by a shared common language about the technical core, enhanced communication across the organization, and greater reliance and use of information in the reflective practice of individual staff and in the internal accountabilities across the school organization.

Deepening the Framework, Developing the Warrant through Research

Developing the initial conceptual framework has been a collective priority for the IIS team. A detailed working paper elaborating these ideas is in progress and will be completed soon. Now we are working to deepen this conceptualization and to develop its empirical warrant through a combination of participatory observations during design processes and structured field studies as new tools and social practices are introduced into school sites.

Different Questions and Methods for Alpha Versus Beta R and D Phases

During the alpha phase, we typically engage in multiple cycles of co-design and redesign with school staff. From a research and evaluation perspective, our key focus during alpha stage work is to thoroughly document the rationale for why specific tools and social practices have been designed as they are. This includes considering: the ways the tools and social practices bring into focus and support practitioners in addressing problems of practice; the ways the tools and social practices meet the differing needs and levels of expertise of tool users; and the influences of features of the organization on the design of the tools and social practices.

As is our customary research methodology during the alpha phase where we are actively working in a small number of schools, we rely heavily on the observing participant field notes from our design research staff. We also engage in some limited additional data collection such as interviews and field observations, and where appropriate, think aloud protocols to guide our alpha testing. In addition, we track and analyze how (if) teachers and students actually use the new tools provided and whether this use appears to result in any changes in efficiency or productivity (see discussion of activity-level outcomes below). Taken together, this evidence allows us to develop detailed principle-based accounts of each technology and its use. These accounts are an essential support for our subsequent efforts to take IIS initiatives to a larger scale.² They create affordances for others to learn about the “why” as well as the “how” of an innovation and offer a source of guidance for successful tool and process adaptation to other local contexts.

In contrast, beta field trials for new IIS tools and social practices will typically occur in a larger number of school sites which may spread over a wider geographic area. From a design perspective, our attention shifts more toward concerns about the possible adaptations required for effective IIS use in different kinds of school contexts. Developing a better understanding of this context specificity, along with a stronger evidence base about project efficacy, represent the primary research and evaluation objectives for this project phase.

For these beta investigations, we expect to employ a more structured field design, similar to the IES study of PDS2 that we have initiated. We will likely use some combination of structured interviews, surveys, work logs and/or observation protocols, use-data generated by IIS tools, along with sociometric information to assess student and teacher use, context conditions affecting this use, and how core features of context may in turn be transformed (see discussion below on organizational-level outcomes) as a result of our initiatives. This would also be accompanied by either a quasi-experimental value-added design, or possibly a randomized trial where sensible and feasible, to examine the

² This work promises to advance a theory of travel for complex innovations of the type being sought by the IIS. Principled accounts of technology and its use represent one key resource for travel along with: the tools, materials and procedures we design; the expert human resources developed through this work in alpha and beta phase school sites who can in turn help others learn how to engage in similar work; and a social infrastructure of academic, clinical and commercial expertise that can sustain social learning around these endeavors into the future.

changing impact over time on teachers' beliefs and practice (see discussion of individual-level outcomes below) and student learning.³

An Integrated Focus on School Work and the Context in Which It Occurs

During both the alpha and beta phases, our activity theory framework suggests inquiries from two distinct perspectives. First, we consider the specific school “problems of practice” which new tools and social practices are being designed to mediate. The “problems of practice” perspective focuses our attention on the introduction of each new tool and any new social practice immediately connected to that tool. We look for possible changes in work activity and individual-level outcomes and explore why (or why not) these changes are occurring.

Second, we consider the broader school context in which this work activity is embedded and which also represent a primary change objective for the IIS project. The organizational context studies begin with an analysis of the base state of the school organization; how its general features may influence the design and “take up” of new tools and social practices; and how our multiple innovations may consolidate over time to affect how individuals’ perceive and conduct their work and to reshape fundamental features of the school’s organization.

In this research tandem, we are in essence examining the school’s activity system, both from the “top down” of tool-level design and intervention, and from the “bottom up” of a school’s social practices and the organizational context in which the IIS designs are embedded.

A Multi-level Outcome Framework

This conceptualization naturally leads us to organize our work around three broad categories of outcomes:

- Work activity changes as a result of introducing new tools and social practices;
- Individual-level outcomes where the beliefs, perceived self-interests and competencies of school staff may be reshaped over time through multiple IIS initiatives; and
- Organizational-level outcomes that represent the broader aims of our work.

The discussion below derives directly from the conceptual framework. All of our work to date has focused on how technology might advance instructional improvement through mediating the work of adults.

Activity-level outcomes. This class of outcomes is directly tied to the specific work problems that we seek to assist with new tools and social practices. For each work activity in which we intervene, a common set of question can be asked:

³ We have just begun to develop our first data collection protocol of this sort for a 20 school randomized efficacy trial of the PDS2 system to begin in 2005. As we engage in the subsequent beta trials, proposed here, we will look to employ common data protocols, wherever appropriate, across these multiple trials.

Information Infrastructure System
December 2006

- Is there any evidence that our new tools and social practices are being used?
- Have any efficiencies been introduced into these tasks?
- Has new activity been introduced that previously did not exist?
- Is there any evidence that individuals in the corresponding staff role are now more reflective in addressing this particular problem of practice?⁴

From a research perspective, each of these represents a relevant question about a possible direct causal effect of a planned intervention into a specific activity segment. By maintaining a common outcome specification across our “tool-oriented” research studies, we also afford possibilities for post-hoc “meta-analyses” of why changes may occur in some situations but not others.

Individual-level outcomes. The IIS consists of multiple interventions into a school’s activity system. Collectively, these interventions may effect changes in teachers, including their:

- Attitudes and beliefs about students’ academic capabilities and appropriate aims for instruction, and orientation toward innovation especially the utility of adding new technologies to their practice;
- Conceptions of their role responsibilities including: attitudes and beliefs about the appropriate social organization of their work, the development of norms about professional responsibilities for continuous learning, maintenance of a shared professional practice, and personal accountability for students’ academic progress; and
- Professional expertise in technology use, in the specific aspects of instruction being mediated by new IIS technologies, and more generally in their analytic capacity to use data on student learning to reflect, plan and evaluate instruction.

We note that this class of outcomes is germane for both the tool-oriented and organization-oriented inquires discussed above.

Organizational-level outcomes. Achieving more ambitious instruction for every student entails fundamental changes in the organization and operation of schools. Specifically, the IIS project seeks to promote the following organizational outcomes:

- A shared professional language for describing students intellectual development (e.g. as emergent readers and writers) and for guiding instructional decision making aimed at advancing this learning;
- Enhanced communication and work coordination across the school context;
- Increased internal accountability for the overall progress of students and more informed decisions about how to accelerate this progress; and

⁴ It seems plausible that individuals might become more reflective as a cumulative result of the various innovations introduced into their schools. It is also plausible, in fact quite likely, that they may become more reflective about certain problems of practice (e.g. those that we are intentionally mediating), while remaining unreflective in other regards. This suggests that we examine, at least initially, the changing reflectivity that may be occurring at the activity/task level, leaving open the question as to whether this eventually generalizes to a broader individual-level change in disposition toward one’s work.

- Emergence of a school-based professional community where both critical dialogue about programmatic improvement and social support/pressure for expertise development is normative.

Contact information:

Anthony Bryk at Stanford University: abryk@stanford.edu

Louis Gomez at Northwestern University: l-gomez@northwestern.edu

Website: www.iisrd.org