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The Ingenuity Gap, Revisited

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> Collective intelligence involves a transformation in the way we think about human capability. It suggests that all are capable rather than a few; that intelligence is multiple rather than a matter of solving puzzles with only one right answer; and that our human qualities for imagination and emotional engagement are as important as our ability to become technical experts.

—Philip Brown and Hugh Lauder, *Capitalism and Social Progress*[1]

Who would *not* want their young child to be in a Science-Lab afterschool program with Dr. Heike Schettler and her colleagues? The vision offered is a compelling one that we crave for all children—a program that sparks deep curiosity in the natural world through the encouragement of skilled teachers, cheered on by a chorus of engaged parents. The flourishing of Science-Lab over a short number of years testifies to the original designers' alchemy, converting the zeitgeist of anxiety around globalization and its consequences into a positive force for educational change on a potentially broad scale within and beyond Germany. The effort is earnest and the response enthusiastic, converting skeptical educators, inspiring anxious parents, and attracting a swath of support from teachers and corporate sponsors.

Of greatest interest to me is what this case says about building knowledge for educational change. My comments elaborate three spheres of such knowledge-building. The first is the most obvious and has to do with what Dr. Schettler portrays as Science-Lab's "recipe for success." The ingredients of that recipe comprise what Richard Elmore, a scholar of school reform, has called the "core" of teaching and learning: the reciprocal relationships among student, teacher, and subject matter.[2] The second sphere embraces this core, but adds an encompassing shell—the relationship between the innovation's designers and those who would carry forward their design. This comes in two parts with Science-Lab: the relationship with the parents who started the Science-Lab afterschool activities, and that with the teachers in state primary schools with whom Science-Lab sought to work to reach more diverse students. The third sphere is yet more encompassing, enveloping the first two. It concerns knowledge-building around change in the broader system of schooling, touching on the recent engagement Science-Lab has had with state decision-makers and corporate sponsors.

The Knowledge-Building "Planet"

The image of a planet captures the three spheres of knowledge-building and their interdependent relationships. Imagine the fiery core of teaching and learning, contained by a fertile and breathing mantle, which in turn is encompassed within a sustaining atmosphere. Of course the opposite image also holds: of a spent core, a desolate mantle devoid of life, and a thin or poisoned enveloping atmosphere. As with living systems, the three spheres are interdependent; what happens within one affects all. These three spheres of knowledge-building are not unique to Science-Lab; they pertain to any intervention that aims to have broad and enduring influence on the core of teaching and learning. Studies of educational innovations that have sought to shift the dynamics within that core make clear the mutually dependent relationships among core, mantle, and atmosphere.[3]

These relationships of mutual influence and effect point toward a fundamental question about the rationale for Science-Lab and the purpose of knowledge-building. To provide a shorthand answer, I turn to political scientist Thomas Homer-Dixon, whose notion of an "ingenuity gap" seems well-tuned to one aspect of what knowledge-building at the broadest level needs to address.[4] The ingenuity gap refers to the critical distance between what makes us smarter and what makes us wiser, both as individuals and as a society. The readers of this publication know all too well that despite cascades of information, solutions to the ill-structured problems that beset us, such as climate change and persistent poverty, elude our grasp. The well-structured disciplinary domains of our inheritance are necessary but not adequate. The knowledge that we acquire from the past is but the prelude to new and useful forms of practical, technical, and social knowledge that are urgently needed.

I want to add another dimension to ingenuity that goes back to the early roots of the word in English. “Ingenuity” in the 16th century meant the quality of being in*genious*, of having a capacity for invention, but it also could mean being in*genuous*, open and frank.[5] And the latter meaning was not just a personal characteristic; it was an indicator of social status, of being “free-born” and having full access to all that society might offer. This lost meaning of ingenuity as being open to all is a leitmotiv throughout the following. It is what I mean by “social franchise,” in contrast with Dr. Schettler’s use of the term as an innovative solution to a vexing contractual issue.

With the connotation of ingenuity as social franchise in mind, I want to take a closer look at the Programme for International Student Assessment, or PISA, the assessment sponsored by the Organization for Economic Cooperation and Development (OECD) that initially inspired Dr. Schettler and her colleague Sonja Stuchtey to launch Science-Lab. PISA provides a basis for cross-national comparisons of education systems in economically developed countries, based on data collected every three years from a random sample of 15-year-olds within a representative selection of schools. PISA has several characteristics that distinguish it from other kinds of large-scale summative assessments of students’ capabilities. Foremost is that sampled students complete performance assessments in reading, mathematics, and problem-solving as well as in science. In the terms I have used above, performance assessments are meant to provide some indication of the capacity for Homer-Dixon’s notion of ingenuity, in that they require students to use what they know, not just to demonstrate the knowledge they have acquired. In addition to measuring students' performance, PISA collects a wide range of sociological data about socioeconomic status, family structure, and the organization of schooling.

A recent working paper analyzing 2006 PISA results for Germany, the administration of the assessment most recently analyzed, showed achievement in science above the OECD average, placing Germany eighth highest among OECD countries.[6] On that scale, Germany appears to be doing well on its prospects for addressing at least the original definition of the ingenuity gap, just ahead of the United Kingdom (9th) and far ahead of the United States (21st).

This hardly means that Science-Lab should pack up its kits and head home. Parsing these results reveals wide variation within the country. Students with immigrant parents have much lower science scores than students with at least one parent born in Germany. The disparity in achievement between students who are the children of immigrants and those with German roots is among the largest across the OECD countries. Moreover, the analysis shows the gap widening for more recent immigrants who, unlike the post-1989 wave of immigrants from countries in the former Eastern Bloc, are not exposed to German at home from older family members likely to be fluent. The children of more recent immigrants, largely from Turkey, enter a radically different linguistic and cultural environment at school than what they are accustomed to at home. Moreover, these students and their families confront greater social and economic disparities than earlier immigrants.[7] Thus, the achievement gap revealed in assessment results reveals an equity gap when analyzed in more detail. The combination of gaps in achievement and equity are what I mean to evoke with the term "ingenuity gap" in its fullest sense.

Early childhood education is crucial for redressing the ingenuity gap, a point highlighted in the recent OECD report and a vital premise of the work of Science-Lab. While the details of waves of immigration may be unique to Germany, disparities in achievement and equity and the role of early childhood education are certainly not. A wide range of studies from the United States and other countries shows how early achievement gaps in science have consequences for enrolment in science courses, decisions about college majors, and pursuit of career choices.[8] Achievement and equity are inextricable aspects of ingenuity. Initiatives like Science-Lab are of increasing importance, but they also risk privileging the already privileged unless keenly attentive to those for whom full social franchise has yet to be attained.

The Core

Up to this point, I have been talking about the ingenuity gap at its broadest sweep. Now I want to zoom in on where building knowledge to redress that gap first takes shape. In the core of teaching and learning, knowledge-building has to do with the everyday interactions of teacher, student, and subject matter. Just as at the broadest level, knowledge-building about such interactions concerns both the social and the substantive. We often take for granted the social and underestimate the substantive. Children, even very young children, do not lack the ability to reason; they lack knowledge and experience. Developing the ability to assemble and examine evidence and to test propositions is central to the eight factors that comprise Science-Lab's "recipe for success." The ingredients of that recipe comprise knowledge-seeking inquiry—an approach to teaching and learning science that has gained broad acceptance as best practice. One scholar characterizes the shift in a manner reminiscent of the "ingenious" side of the ingenuity gap. The shift toward inquiry is a movement from the traditional approach that asks "what do we want students to know?" to one that asks "what do we want students to be able to do and what do they need to do it?"[9] The National Research Council's National Scientific Education Standards and the Benchmarks for Science Literacy of the American Association for the Advancement of

Science have been lauded as vision statements for promoting broad shifts in the "core" toward inquiry in the United States.[10] Articulation of exemplary science education in many countries has taken similar aim.[11] The National Research Council summarizes the main tenets:[12]

- Learner engages in scientifically oriented questions
- Learner gives priority to evidence in responding to questions
- Learner formulates explanations from evidence
- Learner connects explanations to scientific knowledge
- Learner communicates and justifies explanations

The shorthand list above masks a crucial ingredient of classroom inquiry that Science-Lab's "recipe" highlights. Science-Lab's recipe is written in the first-person *plural,* an important acknowledgement of the role that peers and adults have in the process of learning. The relationship with adults in particular is where the social and substantive come together, at least initially. As John Bransford and colleagues write in their synthesis of contemporary research, *How People Learn,* "Children's curiosity and persistence are supported by adults who direct their attention, structure their experiences, support their learning attempts, and regulate the complexity and difficulty levels of information for them."[13] Such systematic inquiry facilitated by knowledgeable adults, referred to as guided inquiry, is well-established through research and in policy as best practice for sustaining interest in science and cultivating deep and flexible understanding.

David Perkins, a respected scholar of teaching and learning, uses the extended metaphor of "playing the whole game" to help convey the complex interplay of social and substantive that the best environments for learning entail, for adults as well as children. Playing the whole game does not mean getting thrown onto the varsity squad from the start; it means engaging an "accessible version of the whole game early and often."[14] Creating conditions through which the whole game can be accessible is the role for professional players and coaches (i.e., teachers and other adults in school and pre-school settings) with their deep knowledge and experience. What results, according to Perkins, is a "threshold experience, a learning experience that gets us past initial disorientation and into the game. From there it's easier to move forward in a meaningful, motivated way."[15] Important to highlight here is that the "whole game" is not just about being child-centered or solely attentive to the social. It is about creating experiences that engage conceptual relations through social interaction. Moreover, that mutual engagement aims at producing knowledge—playing the whole game—not simply reproducing solitary parts of it—batting practice.[16]

Science-Lab appears to be a good bet for the kind of "whole game" learning that Perkins describes. The core of inquiry teaching and learning it espouses aligns solidly with best practice in both the social and substantive aspects of inquiry by offering a carefully tailored, accessible version of the whole game of science for young children.

What about the social franchise side of the "ingenuity gap"? Research tells us that the linguistic, social, and cultural classroom environments of economically developed countries are most closely aligned with the home environment of professional, middle-class, non-immigrant parents.[17] It is no wonder that just these kinds of parents were the ones who responded so enthusiastically when Science-Lab first got underway. The same research also implies that igniting and keeping alive the fiery core of inquiry for children who experience great disparity between their home and school environments requires approaches that might not fall neatly into a single "recipe" and might entail considerable adaptation to particular circumstances, all of which hinges on knowledge-building to bridge the ingenuity gap at the next level up.

The Mantle

Knowledge-building in this sphere has to do with the dynamics of scaling-up, taking an innovation such as the Science-Lab afterschool program out of the hothouse (or the backyard and kitchen, in this case) in which it was developed and training others in its use. To do so requires enveloping a solid "core" with a vibrant mantle. Dr. Schettler describes a two-stage process for Science-Lab in this realm. The first had to do with developing a network of science and engineering professionals who, like Dr. Schettler and her colleague, were committed to active engagement with their children's education. When Dr. Schettler discovered that Science-Lab was not reaching out to all, she and her colleague adapted the original design and began working with teachers in state primary schools to ignite their interest in science.

Scaling-up educational innovation entails a fundamental contradiction between fidelity and adaptability. Fidelity requires the articulation of essence; however, essence does not appear on command, like a genie from a lamp. Essential elements emerge as the innovation comes into contact with the real world. Joseph P. McDonald, an acclaimed scholar of innovative educational change, and his colleagues point to the importance of clarifying "distinguishers" in their study of a groundbreaking effort to re-envision schooling through social entrepreneurship known as Big Picture Learning.[18] Distinguishers are what the staff of Big Picture Learning came to see as aspects that set their initiative apart from all others. Science-Lab has clarified its distinguishers in relation to the core—a focus on early childhood, close attention to inquiry. At the mantle, the program appears to be in the midst of identifying its distinguishers.

The key to clarifying distinguishers at the level of the mantle lies in organizational knowledge building around teacher learning. This entails both developing an approach to teacher development that remains true to the distinguishers of the core and continuously learning from teachers' efforts to implement desired change. Research into teacher learning in the midst of their work broadly points to the components of substance, process, and context as fundamental to ensuring fidelity and nurturing adaptability. Science-Lab appears to have solid foundations in the first two areas. Its work with teachers integrates two important areas of content—the substance of science and the substance of teaching science. Teachers learn science as they learn to teach it. The process of teacher learning models the same inquiry process teachers are expected to carry out in their classrooms.

In relation to the three aspects of content, process, and context, Science-Lab does not yet appear to have tackled context, and this aspect is the key to adaptability. Studies of sustained change in teaching practice point to the need to develop supports for innovative practice within and across schools, and to provide ongoing feedback around teacher and student learning over long periods of time. Shifts in individual teaching practice may entail years of trial and error. Success is far more likely when school leaders and staff are involved and most of the learning takes place in the midst of ongoing work, building local capacity to sustain systemwide improvement.[19] The kind of workshops that Dr. Schettler describes may well energize and engage teachers initially, but, at least based on others' experiences, workshops organized externally have had only limited long-term success.

In the United States, research into teacher learning and the enactment of inquiry has a long history. The comments of education researcher Fouad Abd-El-Khalick in an international review of inquiry science education tersely sum up what has been learned:

> The history of science education reforms in the United States has taught us that when envisioned conceptions of inquiry meet the reality of schools and classroom teaching, and the associated social, political, economic, and cultural spheres, these more philosophical conceptions [of inquiry] are often transformed into incommensurate (practical) curricula and then translated into incongruent enactments or classroom practices.[20]

Both fidelity and adaptability are crucial to the vitality of the mantle, the organizational knowledge required to flourish. For Science-Lab, adaptability may require reexamining assumptions about its distinguishers, especially as it becomes more entwined with the existing system of schooling, which it must necessarily do. Building knowledge about mutually beneficial adaptation will come from the experiences of the teachers who try to put into practice the distinguishers that Science-Lab preaches, which may require change. Such cycles of refinement and adaptation are particularly needed to create learning conditions for students who face large disparities between their school and home environments. Igniting teachers' enthusiasm for science and science teaching is an important place to start, but on its own it will not reveal effective approaches that engage all students, especially those on the social margins.

The Atmosphere

As intimated above, larger forces are at play that are well beyond the control of individual teachers, their schools, or Science-Lab as an organization. The researchers who studied the scaling-up of Big Picture Learning in the United States point to an overarching challenge that brings us to the outermost layers of our spheres of knowledge-building for educational innovation. This is what they call "the mindset challenge," which consists of confronting our built-in assumptions about schools and schooling.[21] Science-Lab has confronted the mindset challenge through decision-makers in state education ministries who have rebuffed their approach because of its lack of alignment with the existing system. On the other hand, Science-Lab has made inroads in one German state, gaining influence that has begun to shift that alignment.

I set out two dimensions to the ingenuity gap at the start, that of creativity built atop deep understanding, and that of expanding the social franchise by opening up what society has to offer to those excluded. If the full dimensions of the ingenuity gap are to be grasped, Science-Lab and innovations like it that are attempting to improve teaching and learning need to confront the mindset challenge. Avoiding the challenge risks becoming either an outlier, a “boutique” program that privileges those already privileged, or an insider absorbed by the very system the innovation sought to change. Franchise must come to mean more than just an entrepreneurial arrangement among the like-minded. In the words of Ciaran Sugrue, in summing up an account of the future of educational change, the search for true social franchise entails “new forms of engagement that are populated by ‘coalitions of the willing’ rather than the serried phalanx of the coerced.”[22]

Science-Lab has had a remarkable run over the past several years, assembling “coalitions of the willing” through the network of professionals it has built as a part of its expanding afterschool activities and through the pre-school and primary years teachers it has trained. What may be required now as it begins to engage the third sphere of knowledge-building around systems of schooling is to clarify its own vision for education in a technologically advanced, globalizing, and increasingly diverse society. Is it one of individual achievement toward technical expertise, or is it one that sets a broader compass, pointing toward what sociologists Philip Brown and Hugh Lauder, in the quote that began these comments, call “collective intelligence”?

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[1] Phillip Brown and Hugh Lauder, *Capitalism and Social Progress: The Future of Society in a Global Economy* (New York: Palgrave, 2001), 8.

[2] Richard F. Elmore, Penelope L. Peterson, and Sarah J. McCarthey, *Restructuring in the Classroom: Teaching, Learning, and School Organization*, 1st ed. (San Francisco: Jossey-Bass, 1996).

[3] Some examples include Lea Hubbard, Hugh Mehan, and Mary Kay Stein, *Reform as Learning: School Reform, Organizational Culture, and Community Politics in San Diego* (New York: Routledge, 2006); Joseph P. McDonald, Emily J. Klein, and Meg Riordan, *Going to Scale with New School Designs: Reinventing High School* (New York: Teachers College Press, 2009); Mike Wallace and Keith Pocklington, *Managing Complex Educational Change: Large-Scale Reorganisation of Schools* (London: RoutledgeFalmer, 2002).

[4] Thomas F. Homer-Dixon, *The Ingenuity Gap* (New York: Knopf, 2000).

[5] "Ingenuity," in *The Oxford English Dictionary,* 2nd ed., OED Online (Oxford: Oxford University Press, 1989). 2 Sep. 2009 http://dictionary.oed.com/cgi/display/50116722

[6] David Carey, "Improving Education Outcomes in Germany," in *Economics Department Working Paper No. 611* (Paris: OECD, 2008).

[7] Ibid., 6.

[8] Susan T. Hill and Jean M. Johnson, *Science and Engineering Degrees, by Race/Ethnicity of Recipients: 1992-2001* (Arlington, VA: National Science Foundation, 2004).

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[11] Fouad Abd-El-Khalick et al., "Inquiry in Science Education: International Perspectives," *Science Education* 88, no. 3 (2004).

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[13] National Research Council, *How People Learn: Brain, Mind, Experience, and School* (Washington, DC: National Academies Press, 2000), 112.

[14] David N. Perkins, *Making Learning Whole: How Seven Principles of Teaching Can Transform Education* (San Francisco: Jossey-Bass, 2009), 9.

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[15] Ibid.

[16] See also Seth Chaiklin, "A Developmental Teaching Approach to Schooling," in *Learning for Life in the 21st Century*, ed. Gordon Wells and Guy Claxton (Malden, MA: Blackwell Publishers, 2002); Carl Bereiter, "Liberal Education in a Knowledge Society," in *Liberal Education in a Knowledge Society*, ed. Barry Smith and Carl Bereiter (Chicago: Open Court, 2002).

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[18] McDonald, Klein, and Riordan, *Going to Scale with New School Designs.*

[19] Richard F. Elmore, "Bridging the Gap between Standards and Achievement: The Imperative for Professional Development in Education," Albert Shanker Institute, http://www.ashankerinst.org/Downloads/Bridging_Gap.pdf; Philip Adey, *The Professional Development of Teachers: Practice and Theory* (Boston: Kluwer Academic, 2004); Laura Desimone et al., "Improving Teachers' In-Service Professional Development in Mathematics and Science: The Role of Postsecondary Institutions," *Educational Policy* 17, no. 5 (2003); Eleanor Drago-Severson, "Helping Teachers Learn: Principals as Professional Development Leaders," *Teachers College Record* 107, no. 1 (2007); David Eddy Spicer, *Collective Inquiry in the Context of School-Wide Reform: Exploring Science Curriculum and Instruction through Team-Based Professional Development*, unpublished doctoral dissertation, Harvard University, 2006; Thomas R. Guskey, "Professional Development and Teacher Change," *Teachers and Teaching: Theory and Practice* 8, nos. 3/4 (2002); Ann Lieberman and Lynne Miller, eds., *Teachers Caught in the Action: Professional Development That Matters*, The Series on School Reform (New York: Teachers College Press, 2001).

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[21] McDonald, Klein, and Riordan, *Going to Scale with New School Designs*, 94-119.

[22] Ciaran Sugrue, *The Future of Educational Change: International Perspectives* (New York: Routledge, 2008), 223.