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The Pasteurization of Education

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Abstract

In his book *Pasteur's Quadrant*, Donald Stokes (1997) argued that research projects can be described by their contributions to theoretical understanding and the solution of practical problems. Building on this model, scholars have suggested that educational research should focus more or less exclusively on what Stokes called “use-inspired basic research.” With this move has come a focus on projects with the potential to create systemic change—and the concurrent devaluation of naturalistic studies of learning in context and design research to develop innovative educational interventions. We argue that this current predilection is based on a fundamental misreading of the processes through which scientific investigation addresses practical problems, and (more important) is counter-productive for the field of educational technology. To make this case, we look more closely at the operationalization of Stokes’ *quadrant model* in the field of education, suggesting that its short-term focus on systemic change is based on a misunderstanding of history. We use Latour’s (1983) study of Pasteur to suggest an alternative *lever model* for the research-based transformation of educational practices through educational technologies. By way of illustration, we use a brief example of a research project in educational technology to ground a discussion of the broader implications of this alternative conceptualization of the process of education research.

The Pasteurization of Education

For decades educational technologists have struggled with the problem of how to transform school systems to meet the needs of post-industrial, knowledge-based economy and society. In recent years, reformers have looked to Donald Stokes' *Pasteur's Quadrant* (1997) as a framework for reorganizing research on educational technology in order to create more lasting impacts on the practice of education.

Stokes argues that research can be described by its contribution to theoretical understanding and contribution to the solution of practical problems. His model maps the landscape of inquiry into four "quadrants":

1. Bors' Quadrant of pure basic research: lots of theory but little practical application;
2. Edison's Quadrant of pure applied research: lots of practical application but little theoretical contribution;
3. Pasteur's Quadrant of use-inspired basic research: contributions to theory and practical applications;
4. and the ignominious, unnamed quadrant of research for its own sake: little contribution to anything at all.¹

¹ Although it is beyond the scope of this paper, we would suggest that the fourth quadrant might be more aptly thought of as Picasso's Quadrant: the realm of art, intended not to advance theory or to solve practical problems through scientific investigation, but to express the human condition.

Perhaps in response to those who suggest with thinly-veiled contempt that all of contemporary education research is in the unnamed, useless fourth quadrant, scholars in recent years have argued that studies should focus more on Pasteur's Quadrant of "use-inspired basic research" (Sabelli & Dede, 2001). With this move has come an emphasis on projects driven by "use-inspired" questions with the potential to create systemic changes, and a reliance on randomized controlled trials as the preeminent method of investigation—and a consequent devaluation of naturalistic studies of learning in context and design research developing innovative educational interventions, as well as the methods of inquiry that support them.

We argue that this current predilection is both counter-productive and based on a misreading of the processes through which scientific investigation addresses practical problems. To make this case, we look more closely at the operationalization of Stokes' *quadrant model* in the field of education, suggesting that its short-term focus on systemic change is based on a misunderstanding of history. Based on Latour's (1983) study of Pasteur, we then suggest an alternative *lever model* that emphasizes the transformation of educational practices through technological innovation. We argue that the renewed focus on use inspired research in education, while important, has placed undue emphasis on tinkering around the edges of existing educational systems without seriously reconsidering the fundamental values or organizing structures behind schooling. In short, it has led to a privileging of research programs that work within the current constraints of schooling rather than those that have the potential to change it.

Inhabiting Pasteur's Quadrant

Over the past decade, Pasteur's Quadrant has been taken up as a rallying cry for the reform of educational research, particularly among researchers in the learning sciences working

on developing innovative learning technologies (Sabelli & Dede, 2001). Stokes, who was a political scientist before his death in 1997, argued that policy makers have long held an oversimplified view of science. Too many people in the public and in policy making communities, he suggested, believe that innovation is simply the result of doing “basic” research, generating results, and then applying them outside the laboratory. In practice, Stokes pointed out, the distinction between “basic” and “applied” science is messy: each overlaps and informs the other. Writing for policy makers, Stokes argued that rather than exclusively funding “basic” research, the government (particularly the National Science Foundation) should also fund research projects driven by pragmatic questions, such as those faced by educators and educational technologists. He describes Pasteur’s work as a prototype for this kind of use-driven research, and the National Institutes of Health as a grant-giving agency that exemplifies this commitment to solving problems while furthering fundamental understandings (Sabelli & Dede, 2001; Stokes, 1997).

Building on Stokes’ argument, some scholars have suggested that “use-inspired” research—research in Pasteur’s Quadrant—might rescue the “awful” reputation of educational research by simultaneously creating successful interventions and developing fundamental understandings about educational practice (Kaestle, 1997). Sabelli and Dede (2001), for example, argue that “now that the causes underlying educational dysfunctions are better understood, practitioners and policy makers are asking researchers to focus on applied larger studies that improve practice in a sustainable, affordable, and scaleable manner” (p. 12). In suggesting this application of the concept of Pasteur’s Quadrant, educational researchers have often interpreted “use-driven research” as meaning *research that addresses the everyday questions of teachers and principals in typical—or more often, “problem”—schools*. Sabelli and

Dede explain: use-driven problems are problems “stemming from issues in curriculum, pedagogy, assessment, professional development, etc” (p. 4).

In this model, in other words, researchers should focus on what Sabelli and Dede call *scholarship of practice*: questions that speak to practitioners’ concerns—“curriculum, pedagogy, assessment, professional development, etc”—with an eye toward improving extant practices. One can only assume that conference sessions such as “Evidence-based motivation-related outcomes of mathematics improvement interventions: Collaborative adventures in Pasteur's quadrant” (a collection of papers at the 2005 American Educational Research Association annual meeting reporting on projects in the National Science Foundation Math and Science Partnership Program) would be part of such a scholarship of practice—asking use-inspired questions about programs or policies that work within the existing grammar of schooling (Tyack & Tobin, 1994).

The goal of such work is interventions that can be disseminated beyond specific research contexts. Fishman et al (2001), for example, describe the current conundrum facing educational researchers as one of developing innovations that “scale”. The problem with technological innovations, from this perspective, is that design experiments that show what might be accomplished with new learning technologies too often die off when they are taken out of the original research context and integrated into school settings. As Fishman et al (2001) suggest:

This form of research has been and will continue to be essential to developing both new technologies and refined understanding of the learning process. But it is insufficient for ensuring that the lessons learned about how to foster increased student learning find a foothold in everyday practice in classrooms that do not enjoy the same focused attention and support. The result is that the most valuable uses of technology are not achieving

meaningful *scale*, and more importantly, are not becoming a part of the everyday or *systemic* practices of schools or school reform. [Emphasis in the original.]

The metaphor of “scaling up” is core to this approach, which focuses on creating interventions that can be deployed beyond the context in which they are developed. The *quadrant model*, as interpreted by these researchers, is thus to answer use-inspired questions by developing scaleable, sustainable interventions that operate with the current assumptions and under the current conditions of schooling. And, of course, the way to evaluate such interventions, from this point of view, is with randomized controlled experiments which provide policy makers the data they need to decide which programs work best. As Feuer, Towne, and Shavelson (2002) explain: randomized, controlled experiments are “still the single best methodological route to ferreting out systematic relations between actions and outcomes” (p. 8)—and thus for deciding what interventions are worth bringing to scale and what programs are scaling successfully.

Inhabiting L'Ecole Normale Supérieure

Unfortunately, this view of educational reform as “scaling up research in Pasteur’s Quadrant through randomized, controlled experiments” is problematic, both practically and metaphorically, because it is based on a misreading of the processes of change and innovation. While Stokes accurately described Pasteur’s interest in basic research that addresses applied problems, his presentation of Pasteur’s work—and thus the image on which the quadrant model is built—did not describe the *mechanisms* by which Pasteur connected the two. A more careful analysis of how Pasteur’s “basic” research methods were “applied” to real-world problems

suggests that the metaphor of “scaling up” is not the only (and perhaps not the best) way to conceptualize technological innovation in education.

In his studies of the history of science, for example, Latour (1983) recounts in some detail the process by which Pasteur isolated the anthrax bacillus in his laboratory at L'Ecole Normale Supérieure and developed a vaccine for the disease that was endemic to French farms in the late 19th Century. Anthrax had already been the subject of much study, of course, but outbreaks did not appear to follow any regular pattern. Veterinarians had concluded that local conditions played a large role in determining when and where anthrax appeared, and were suspicious that the disease could be linked to any single organism.

Pasteur's approach to the challenge of anthrax was to take his laboratory apparatus into the field—to start working with the natural conditions in which the problem occurred, trying to isolate as precisely as possible the conditions under which outbreaks occurred. Pasteur's team systematically studied the natural history of the disease, and the life cycle of the organism they hypothesized as its cause.

Once a prospective organism was identified based on this naturalistic inquiry, Pasteur and his team returned to L'Ecole Normale Supérieure to grow the bacillus in culture. Under controlled conditions they were able to demonstrate that the organism was a critical agent in the spread of the disease. By designing systems for breeding the bacillus under a range of conditions, Pasteur was able to attenuate and strengthen strains of the organism, mimicking the variation observed in the disease in its natural setting. More important, by creating attenuated strains of the bacillus, Pasteur was able to produce, in his laboratory, the first ever artificial vaccine: a vaccination for anthrax. As Latour suggests, Pasteur was able to “do inside his laboratory what

everyone tries to do outside but, where everyone fails because the scale is too large, Pasteur succeeds because he works on a small scale” (p. 149).

Having developed a vaccination in his laboratory, Pasteur moved to a field trial at Pouilly le Fort. But moving the vaccine back into the applied setting did not mean adapting the vaccine for use in the more complex and less controlled setting of French agriculture. Rather, it meant extending the practices of Pasteur’s laboratory into the field. The conditions of the trial at Pouilly le Fort were carefully negotiated so as to recreate in a farm setting the conditions of Pasteur’s laboratory that were essential to the success of the vaccination. The success of the field trial appeared “miraculous” to the public because Pasteur was able to show that all the vaccinated animals survived and all the unvaccinated animals contracted the disease and died. But as Latour is quick to point out, the trial was really a “staged” experiment, repeating results Latour had already achieved in his laboratory, and the “dissemination” of the vaccine was not so much a process of scaling up as it was a transformation of farming practices to mimic the conditions of Pasteur’s research. As Latour explains, Pasteur’s achievement was that “on the condition that you respect a limited set of laboratory practices—disinfection, cleanliness, conservation, inoculation gesture, timing and recording—you can extend to every French farm a laboratory product made at Pasteur’s lab” (p. 152).

Latour describes Pasteur’s method as a series of “translations” between farm and laboratory: the initial naturalistic inquiry that isolates the bacillus for study in the laboratory; the subsequent designed strains of the bacillus and controlled “outbreaks” within the laboratory setting; the transformation of pathogen into vaccine; the recreation of the conditions of the laboratory in the field at Pouilly le Fort; and finally the reorganization of French agriculture to accommodate the scientific practices that make inoculation effective.

In 1881, when Pasteur developed the first artificial vaccine, it was possible for a single scientist to undertake this process of naturalistic inquiry, laboratory research, and transformation of practice. But as problems—and the social and technological systems in which they arise—become more complex, progress comes rather from researchers working at various stages in this process, with each research program gaining leverage on the problems it tackles by building on the work of those focusing on other stages: naturalistic investigations provide the basis for laboratory research, which in turn provide models for the transformation of practice. Pasteur’s own practice was, as Latour suggests, not merely “use-inspired basic research”; it was a series of levers by which problems and contexts were more deeply understood, tools and techniques were developed, and systems and practices were reorganized in light of the resulting process of inquiry.

We thus argue that this *lever model* of Pasteur’s work is a more appropriate “translation” of Pasteur’s methods to education research than the quadrant model described above. The lever model suggests that we need to support systematic naturalistic inquiries into the mechanisms by which learning takes place, in both exemplary and problematic situations. We need to support systematic experimental and design research into understanding these mechanisms more deeply and developing “ideal” practices and contexts which show how students can learn effectively. And we need to reconceptualize the process of “dissemination” as one of “transformation,” in which practices developed in controlled settings become images that drive the reorganization of schooling in fundamental ways.

In the next section we describe an example of this process, showing how the lever model implies a different and powerful way of thinking about both education research and educational reform.

The lever model in action

One hundred and twenty three years after Pasteur used the new science of microbiology to defeat anthrax at Pouilly le Fort, ten middle schools students in Madison, Wisconsin were writing about cutting-edge research to cure Alzheimer's disease using stem cells. These students were participating in *Science.Net*, a role-playing game in which they became science journalists, reporting on scientific developments and discoveries and their impact for an online science newsmagazine.

As in a real newsroom, these cub reporters attended news meetings where they pitched stories for the health and medicine, technology, and environment sections of the magazine. Working with desk editors for each section, the cub reporters interviewed sources, submitted stories for copyediting, and copyedited each other's work. To produce finished stories they learned to write leads and headlines, to use the neutral journalistic "voice of the newspaper," to source their stories using AP style, to include art and captions, to format their work for distribution on the web, and to prioritize copy on the section front. In a three week summer outreach program at the University of Wisconsin-Madison, these students collectively reported and produced some 50 news articles about science and technology.

Along the way, not surprisingly, students who play a game like *Science.Net* learn a lot about journalism. In a shorter pilot version of the study² in which we interviewed students before and after the role-playing game, students use of journalism terms went up by 188% (mean before=3.5, after=10, $p<.01$), and more than twice as many students (9/12 compared to 4/12) said

² As of the writing of this chapter, we are still collecting and analyzing data from *Science.Net*. Data presented here are from an earlier, shorter design experiment using the same tools and practices as *Science.Net*.

they thought journalism is about informing the public. For example, before playing the game one student said: “A journalist is someone who would write because they want to but they get paid to do it, so [journalists] bring stories that they’re interested in and write something about it.” After the game, the same student said: “To be a journalist [is] to inform people about current events by writing them.”

Also not surprisingly, these students learned a lot about science. To be sure, they learned scientific facts and theories related to their stories, whether about nanotechnology (“Small Technology Goes to War”), ecology (“Study: Phosphorus Threatens Mendota”), or information technology (“Can games really help children?”). Perhaps more significant, writing about science and learning about science in the context of science journalism—and thus in the context of informing the public about events that impact their lives—helped expand these students’ understanding of what science is and why it matters. Before playing the game one student said:

I think science is... things that include electricity or the human body or... I just, like, do science... I don’t really think about what science is.

After role-playing as a science journalist, the same student explained:

I think science can be a lot of different things. Science can be technology, environment, health and medicine. Football fields can be considered science. Someone had to like help like make things up, inventing things. How to grow the grass... Like how long the yards are going to be... I didn’t know science could be health and medicine. Things like environment... before I just thought they were what they were... [but I think about them

differently after] picking the articles and finding stories about them and writing about them.

Overall, as shown in Figure 1, students came to describe science less in terms of school subjects and topics (“electricity or the human body”) and more in terms of the impact of science on society. (The changes in both categories of the graph are significant with $p < 0.05$.)

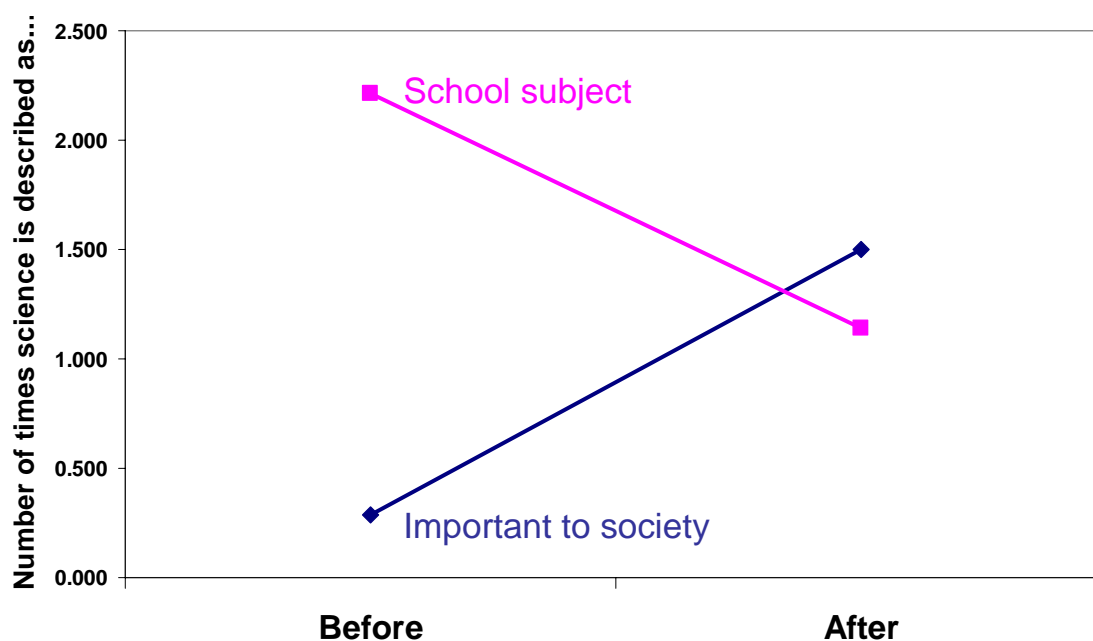


Figure 1: Change in students’ description of science before and after role playing as science journalists. Points represent the mean number of times students refer to science as a school subject or topic and as something important to society. Both changes are statistically significant with $p < 0.05$.

Our research on *Science.Net* suggests that what makes this role-playing game effective is that students are participating in an authentic recreation of the practices of journalists—or, more

precisely, a recreation of the professional practicum through which journalists are trained (Shaffer, 2004). That is, students are learning about science by learning to work as—and thus think like—reporters. A role-playing game like *Science.Net* is thus based on the practices by which journalists are trained, and creating *Science.Net* meant conducting careful ethnographic observations of journalists in training—naturalistic study of the context in which reporters learn to think like journalists.

Elsewhere we have described this kind of game based on the practices of real-world professionals as an *epistemic game* (Shaffer, in press-a, in press-b; Shaffer, Squire, Halverson, & Gee, in press). We raise the example here to ask: Where does an intervention such as this fit in our understanding of technology-based educational reform? Is this better conceived as a point in (or out) of Pasteur’s Quadrant, or as an example of Pasteur’s Lever?

Quadrant v Lever

Is *Science.Net* in Pasteur’s Quadrant as interpreted by educational researchers? It certainly addresses a real, persistent, and continuing educational problem: getting students deeply engaged in scientific issues, and in this sense might qualify as “use-inspired research” similar to Pasteur’s laboratory study of the anthrax bacillus. However, *Science.Net* is not focused on scientific thinking in the context of schools as currently constituted. Indeed, we deliberately work *outside* of school settings because the structures of school—mandated curricula and assessments, 50-minute periods, permissions for field trips, and large class sizes—make it difficult to simulate the conditions of journalistic practice. *Science.Net* is not driven by issues of “curriculum, pedagogy, assessment, professional development, etc.” as currently constituted within our schools; rather, it is a deliberate attempt to reconsider such issues in light of the

affordances of new technologies. As such, it is not a *scholarship of practice* as described by Sabelli and Dede (2001) but quite deliberately *scholarship of the possible*.

On the other hand, *Science.Net* is an excellent example of the lever model applied to education. In *Science.Net*, naturalistic study of a context in which learning takes place is the basis for a design experiment in a controlled setting. Methods from the naturalistic study are refined through successive iterations under “laboratory” conditions until an effective curricular model is developed. *Science.Net* is surely not yet as refined as Pasteur’s final anthrax vaccine—and whether it will ever be is an open empirical question. However, the basic processes are similar: studying a real world context, simulating its essential elements within a laboratory setting, and developing a potentially powerful intervention through design and experimental research.

The reason that it matters whether we think of *Science.Net* as a good example of Pasteur’s Lever or a poor exemplar of research in Pasteur’s Quadrant is that each of these models has a different implication for the question: What next?

In the quadrant model, *Science.Net* would need to “scale up”—to be implemented in a large number of classrooms and compared to traditional instruction in randomized controlled trials. To make that possible, it would have to be re-adapted to the existing conditions of practice—rescaled to the class sizes, periods, content, and assessments of middle school science instruction. We haven’t done those experiments, but even without empirical data, it is easy to see that reworking an intervention based on the authentic simulation of real world practices to fit the existing structures of school would be about as likely to succeed as handing Pasteur’s vaccine to a 19th Century farmer and asking him to inject it into his cows without changing anything else about the organization of his farm.

But, of course, that is precisely *not* what Pasteur did. Latour's point is that successful implementation of the vaccination Pasteur developed at L'Ecole Normale Supérieure meant adapting the conditions of practice to recreate the features of the laboratory essential to the success of the intervention. The *quadrant model* for educational research argue that design experiments under laboratory conditions are not useful because they “are not becoming part of the everyday or systemic practices of schools or school reform” (Fishman et al., 2001). But the point of the *lever model* is that the role of such experiments is not to adapt to existing practices but rather to provide guidelines for the transformation of practice. Following the lever model, the pathway would be to develop more and larger contexts that can accommodate Science.Net and other epistemic games of its kind—thus providing an engine for improving schools in fundamental ways rather than tinkering within the constraints of what is clearly a complex and very stable system.

Conclusion

We argue, then, that the Stokes' concept of Pasteur's Quadrant may not be the most productive metaphor for thinking about educational reform in the context of new technologies. A more careful reading of the practices by which Pasteur used the new technologies of microbiology and experimental science to transform 19th Century animal husbandry suggests that educational research needs to abandon the notion that successful “scaling up” in the rough-and-tumble world of extant schools is the only meaningful test of an intervention. There is, of course, a place for research that directly addresses the needs of practitioners. But not all research can or should be conceived in that way, particularly research with and about new technologies, which have the potential to transform practice in more radical ways.

Rather, we should conceive of the role of research on educational technology as also being about finding ways to reorganize schools in more fundamental ways. To this end, we suggest adopting the concept of Pasteur's Lever. In the lever model, naturalistic study of extant contexts provides the foundation for design-based laboratory research. This design research leads to new and powerful interventions that serve as models for large-scale transformation of schooling. That is, we suggest that rather than focusing on "scaling up" an intervention by adapting it more broadly to the conditions of practice, we emphasize "scaling up" the transformation of schools by adapting them more broadly to the conditions under which meaningful learning takes place. We suggest that in an age of technologies that have the power to expand the limits of our pedagogical imagination, we provide conceptual space for research that looks broadly at the possible future rather than narrowly at the here-and-now—scholarship that focuses deliberately on the ideal rather than doggedly on the practical.

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