Schools And Complexity

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As schools, districts, and the overall education system are complex entities, both the approaches taken to improve them and the methods used to study them must be similarly complex. Simple solutions imposed with no regard for schools' or districts' unique contexts hold little promise, while seemingly insignificant differences between those contexts affect in seemingly disproportionate ways the quality and success with which they implement the same programs. Context must be taken very much into account when initiatives are planned and implemented, as well as when their impacts are investigated.

Introduction

Anyone who has spent any appreciable time in American schools during the last two decades, whether as a classroom teacher, a parent volunteer, a central office administrator, a paraprofessional, or – like this writer – a school counselor and a school principal, can attest to schools' long history of changing "routinely and promiscuously," to borrow Elmore's (2004) colorful phrase (p. 219). Frustratingly, few of the initiatives in which schools have invested so much time, energy, and effort have yielded the desired results of improving instructional practices and, consequently, enhancing student learning.

Innumerable educational innovations have been attempted and they have: been found wanting (long before they could reasonably be expected to have had the desired impact, and conspicuously lacking the kind, quality, and duration of professional development and ongoing support that teachers would have required in order to institute those reforms effectively); been replaced by other initiatives; then, when the

latter have likewise shown themselves to be less successful than hoped, been revisited – with fashionable new names and little or no official acknowledgement of their earlier incarnations.

The variability with which they are implemented by different schools and districts has provided policymakers with one possible explanation for the historic failure of successions of reform efforts. Resulting mandates that curricula and instructional approaches be implemented 'with fidelity,' while unquestionably well-intended, are both simplistic and naïve – simplistic, because they presume that the variability of implementation stems from educators' differing willingness to follow directives, rather than from the very different contexts within which they teach; naïve, because they suppose that successful implementation in one district or school guarantees the same in all others.

In fact, what has taken years to hone in one school or district *cannot* be expected to have immediate success in another. As Hargreaves and Shirley (2009) explain, "It's the slowly built understanding of the development that makes much of the implementation effective" (p. 51). Likewise, as Elmore (2004) describes, "Improvement is a developmental process, not an act of compliance with policy. Schools 'get better' by engaging collectively in the acquisition of new knowledge and skills, not by figuring out what policymakers want and doing it" (p. 227).

Not only must teachers understand the intricacies of the specific curricula or instructional approaches that they are to implement, they must also – if those curricula or approaches are to prove effective – genuinely support the rationales behind their implementation, and be afforded sufficient opportunity to apply them in their own professional practice. Policymakers' and administrators' lip service to the importance of teacher 'buy-in' notwithstanding:

> Teacher support for reform is not merely an issue of politics and pragmatism. Research on the characteristics of effective professional development indicates that teachers must be active agents in analyzing their own practice in light of professional standards, and their students' progress in the light of standards for student learning…There should also be a strong commitment to sharing information, and to building trust and cooperation, as well as an explicit high-level commitment to the reform agenda from each partner…Teacher engagement also requires consistent, co-ordinate efforts to persuade those affected of the need for reform and, in particular, to communicate the costs of non-reform. (Organisation for Economic Cooperation and Development, 2011, p. 54)

Since all efforts at school improvement are only as effective as the commitment and support that they receive, policymakers and leaders at both the school and district level must be sure to invest in them sufficient human and material resources, provide teachers and other educators with ongoing opportunities to continue their professional learning and ample occasions to work together, and allow programs time enough to become institutionalized (Annenberg Institute for School Reform, 2004). What follows is an examination, through the lens of complexity, as to why such an approach is necessary.

The Complex Nature of Education

Identifying that philosophers as separated by space and time as Confucius, Plato, and John Stuart Mill had all appreciated and written in their own days about the complex nature of education, MacDonald and Shirley (2010) lament that only rarely is that complexity acknowledged, still less allowed to emerge, in schools. They join a growing number of scholars and practitioners who have come to understand – in many cases, after repeated false starts with prescriptive approaches to leadership and instruction, and still smarting from inflexible metrics ostensibly designed to enhance accountability – that there are no quick fixes or easy answers in endeavors as multifaceted as education reform or one-size-fits-all approaches to bettering organizations so uniquely intricate as schools and school districts (Harris & Rutledge, 2010; Fullan & Miles, 1992).

Writing "I used to think that policy was the solution. And now I think that policy is the problem," Elmore (2010) candidly discloses how his views about how to affect school reform have evolved over time. Coming to realize that policymakers would approve seemingly any proposal on the weight of its political support, and without regard for its educational merits or for how it did or did not square with previously approved initiatives, Elmore explains how he learned that changes from the top – no matter how well-conceived – are far less likely to impact schools for the better than are those that emerge from practicing educators, themselves. "For the future," Elmore proclaims, "I am putting my energy into building a stronger profession, not into trying to repair a desperately dysfunctional political system" (p. 8).

Another, still more public, conversion was that of education historian Diane Ravitch, who moved from being a *No Child Left Behind* devotee to serving as one of that policy's most ardent critics. Ravitch (2010) now acknowledges that – as schools are complex systems, not clockworks – effective school reform is far more difficult to achieve – and even more challenging to sustain – than it would appear.

> Reformers imagine that it is easy to create a successful school, but it is not. They imagine that the lessons of a successful school are obvious and can be easily transferred to other schools, just as one might take an industrial process or a piece of new machinery and install it in a new plant without error. But a school is successful for many reasons, including the personalities of its leader and teachers; the social interactions among them; the culture of the school; the students and their families; the way the school implements policies and programs dictated by the district, the state, and the federal government; the quality of the school's curriculum and instruction; the resources of the school and community; and many other factors.

> When a school is successful, it is hard to know which factor was the most important or if it was a combination of factors. Even the principal and teachers may not know for sure…Certainly schools can improve and learn from one another, but school improvements – if they are real – occur incrementally, as a result of sustained effort over years. (p. 137)

Writing specifically about the role of professional development in school improvement efforts, Guskey (2009) highlights "the powerful and unique influence of context" (p.

229). He argues that, as school contexts vary widely, it is unrealistic to expect what works in one locale to work equally well in another without adaptations specific to the latter setting.

> The particular educators involved, the characteristics of students with whom they work, and aspects of the community can all affect results…The most powerful content will make no difference if shared in a context unprepared to receive it and use it. Similarly, a powerful professional development activity poorly suited to a particular context will likely fail miserably. (p. 229)

The importance of local contexts reflects a key concept in complexity, 'sensitive dependence on initial conditions,' about which McQuillan (2008) explains, "Similar reform initiatives can produce different outcomes in different contexts, dependent on the history and nature of those contexts, the initial conditions" (p. 1784).

By the nature of how they are organized, of the work in which they are engaged, and the fact that they are populated by, and exist to serve, human beings, schools – like the overall system of education of which they are a part – are complex systems (Drago-Severson, 2012; Lareau & Walters, 2010; MacDonald & Shirley, 2010; McQuillan, 2008; Clarke & Collins, 2007; Fullan & Miles, 1992; Lortie, 1975). Consequently, those who make education policy, and anyone who is interested in genuine school improvement, would do well to recognize that, far from being predictable or amenable to readymade solutions, "Knowledge is born in chaotic processes that take time" (Wheatley, 2005, p. 153).

Too few school reform efforts are afforded anywhere near the kind of time required for them to take hold or to yield results, let alone to foster breakthroughs. "It takes time for…new practices to mature and become part of the working repertoire of teachers and administrators. Schools that are improving recognize and allow for this time and don't switch gears if they don't see immediate results on state tests" (Elmore & City, 2007, p. 2). Regrettably, rather than thoughtfully selecting and painstakingly implementing contextually appropriate programs and reforms, policymakers at all levels lurch from one initiative to the next, impatient for results, and quick to move on to some other initiative when improvement is slow in coming. In their haste, they fail genuinely to comprehend – let alone to promote teachers' understanding of – what the programs or approaches actually do or do not promise. The zeal with which school reform measures are undertaken is, too often, their very undoing.

Citing *A Nation at Risk* – the work of a presidential commission on excellence in education – as "a precursor of the standards movement," Ravitch (2010) hastens to add that the report made no mention of school restructuring, state takeovers of schools and districts, or other such mechanisms by which to promote accountability. Rather, Ravitch (2010) explains, *A Nation at Risk* identified the need for improvements in the quality of curriculum, materials, and teacher preparation, and "recognized that what students learn is of great importance in education and cannot be left to chance" (p. 29). Ravitch (2010) recounts how, following a long, unsuccessful attempt at the creation of national history standards, the movement to establish such nationwide standards fell apart, only to be superseded by *No Child Left Behind* legislation that was "not closely related" to the

ideas set forth in *A Nation at Risk*. Rather than satisfying *A Nation at Risk*'s call for improving education largely through enhancing the quality of the curriculum in which all students were engaged, *No Child Left Behind* "sidestepped the need for any standards," instead mandating test-based accountability (p. 30).

The oversimplification of policies and programs occurs at the local level, as well as at the national one, with results that are fed back into – and felt throughout – the entire education system. Half-baked implementation not only fails to yield the intended results, but also perpetuates such falsely dichotomous debates as the math wars and the contests between partisans of phonics instruction and proponents of a whole language approach to teaching literacy (West, 2009).

The consequences of policymakers' failure fully to appreciate what they are mandating – and of practitioners' incomplete understanding of what they are being directed to implement – are far-reaching. Lagemann (2000) writes compellingly, for example, about the use that was made of the so-called 'Coleman Study,' the *Equality of Educational Opportunity Study* (1966):

> Coming at a time when the courts were seeking to define remedies for segregation, judge after judge referred to the study in mandating the busing of children. Although Coleman had found that the achievement of black children improved if they were enrolled in a majority white school, the study was taken as supporting desegregation generally. This dismayed Coleman, who claimed in a 1972 interview that 'judges have…used the results more strongly than the results warrant.' Three years later he published a study indicating that busing contributed to so-called white flight. Sorry that the study had been misused in this way, Coleman was also disappointed that it had been 'underutilized' by legislators. (p. 199)

Not simply a cautionary tale about what can happen when matters of enormous public import are decided according to decision makers' superficial understandings of social science research, Lagemann's (2000) narrative also illustrates that the impact of social policy is anything but linear:

> As Coleman became increasingly aware, it is difficult to control the trajectory of ideas, and it is especially difficult to do so in a domain of policy like education, where the authority to make decisions and implement policy is extremely diffuse. (Lagemann, 2000, p. 199)

Complexity

The evolution and communication of ideas, the de facto implementation of policies and programs, and the fallout from decisions in such fields as education, government, and economics are difficult to predict, precisely because of the complexity that characterizes those disciplines. Byrne (1998) points out that, in this, the social sciences share a great deal in common with the life sciences:

> In the social world, and in much of reality including biological reality, causation is complex. Outcomes are determined not by single causes but by multiple causes, and these causes may, and usually do, interact in a non-additive fashion. In other words, the

combined effect is not necessarily the sum of the separate effects. It may be greater or less, because factors can reinforce or cancel out each other in non-linear ways. (p. 20)

The notion of a field of science that would attend specifically to such complex systems and phenomena was introduced by scientist-mathematician Warren Weaver in the late 1940s. In an article titled "Science and Complexity," Weaver (1948) surveys the range of problems that science has endeavored to understand since the seventeenth century, and establishes three categories according to which those problems could be classified: problems of simplicity, problems of disorganized complexity, and problems of organized complexity.

The seventeenth, eighteenth, and nineteenth centuries, according to Weaver (1948), were a period during which the physical sciences "learned variables," and developed quantitative methods with which to predict and analyze the impact of adjusting one or another variable in problems involving very small numbers of variables. Weaver explains that many of the innovations that begat the industrial revolution were themselves conceived at this time, when science learned to understand such 'problems of simplicity.'

Toward the latter part of this same period, Weaver (1948) continues, physical scientists and mathematicians began to devise statistical methods by which to understand situations involving tremendously large numbers of variables, each of which "has a behavior which is individually erratic, or perhaps totally unknown" (p. 3). Although he terms these problems ones of 'disorganized complexity,' Weaver makes clear, "in spite of this helter-skelter, or unknown, behavior of all of the individual variables, the system as a whole possesses certain orderly and analyzable average properties" (p. 4). The insurance industry, as Weaver points out, capitalizes on the science of disorganized complexity by basing policies, not on perfect information about the trajectory of an individual policyholder's health or life, but on reliable statistical knowledge about the average health histories and life spans of groups of similarly situated individuals. Problems of disorganized complexity, Weaver (1948) summarizes, are ones "to which statistical methods hold the key" (p. 5).

The third class of scientific problems, the category for whose better understanding Weaver (1948) advocates, and which he calls 'problems of organized complexity,' are distinguished from the other two classes, not so much by the quantity of variables involved, but by the fact that the relationships between those variables "show the essential feature of organization" (p. 4). While the number of variables in problems of organized complexity – the kinds of problems studied in the life sciences and many of the social sciences – more closely approximates those found in problems of disorganized complexity than in ones of simplicity, those variables are recognized as forming "a most complexly organized whole" (p. 4), and, therefore, cannot be understood using the statistical techniques that have proven so helpful in understanding problems of disorganized complexity.

Weaver's (1948) call for science to make "a third great advance," and to learn how to investigate the problems of organized complexity that are encountered in biology, medicine, psychology, ecology, government, economics, and – it is increasingly

acknowledged – education, contributed to the creation of complexity, also referred to as complexity theory.

Complexity "offers the possibility of an engaged science not founded in pride, in the assertion of an absolute knowledge as the basis for social programmes, but rather in a humility about the complexity of the world coupled with a hopeful belief in the potential of human beings for doing something about it" (Byrne, 1998, p. 45). Not assuming "predictable and linear interactions among discrete elements," complexity instead "draws attention to the evolving interrelationships among system elements at various levels of the system" (McQuillan, 2008, p. 1773). In keeping with its etymology ('complex' stems from the Latin for 'that which is interwoven'), complexity "offers a means to analyze emerging patterns and trends to illuminate how the disparate system parts are, or are not, working together" (McQuillan, 2008, p. 1773). Complexity, in short, defies the criticism that Goethe – through the voice of Mephistopheles – levels against what passed for scientific scholarship at the time he penned *Faust*:

> *…The web of thought has no… creases*
> *And is more like a weaver's masterpieces:*
> *One step, a thousand threads arise,*
> *Hither and thither shoots each shuttle,*
> *The threads flow on, unseen and subtle,*
> *Each blow effects a thousand ties.*
> *The philosopher comes with analysis*
> *And proves it had to be like this:*
> *The first was so, the second so,*
> *And hence the third and fourth was so,*
> *And were not the first and the second here,*
> *Then the third and fourth could never appear.*
> *That is what all the students believe,*
> *But they have never learned to weave.*
> *Who would study and describe the living, starts*
> *By driving the spirit out of the parts:*
> *In the palm of his hand he holds all the sections,*
> *Lacks nothing, except the spirit's connections.*
> Encheirisis naturae *the chemists baptize it,*
> *Mock themselves and don't realize it.* (1832/1961, p. 199)

Complexity emphasizes that complex systems should be regarded, not as the sums of their constituent parts, but as networked wholes wherein cause and effect relationships – the "spirit's connections" about which Goethe (1832/1961) writes – are neither linear nor random, and are anything but inconsequential. Complexity also teaches that, rather than remaining at equilibrium, complex systems continually evolve. Whereas closed systems take strength from stability, complex systems are sustained by – and derive "generative potential" from – disequilibrium (Clarke & Collins, 2007, p. 163). Complex systems' sensitive dependence upon initial conditions provide elements of instability that are countered by the constraints provided by negative feedback, and by complex systems' own abilities to self-organize. Neither static, nor entirely disordered, complex systems

exist at the edge of chaos. "Life," as Prigogine (1996) rather poetically explains, "is possible only in a nonequilibrium universe" (p. 27).

Leadership: Emergence, not Management

While one cannot control the process of emergence within complex systems, complexity explains that it is possible for one to influence it (McQuillan, 2008; Reigeluth, 2004). By refraining from imposing control upon the elements of complex systems, one can foster – and can capitalize on – novelty at the points where it is likely to emerge. Similarly, by attending to, and – where necessary/appropriate – adjusting, control parameters, one can "shape interactions so identifiable patterns and routines emerge and lend a measure of predictability to an ultimately unpredictable system" (McQuillan, 2008, p. 1778). Complexity reminds anyone seeking to influence emergence within the complex systems of schools or school districts that the task is an ongoing one, and that (s)he "must constantly adjust and adapt the process to the emerging, ever-changing reality of a particular educational system and its environment" (Reigeluth, 2004, p. 8).

McQuillan (2008) provides an explanation as to why reform does not result inexorably from a school or district's introduction of one or another initiative:

> To change the outcomes produced by any system, complex or otherwise, you must alter the interaction among system elements…Some perturbation must unsettle the system so it does not return to its prior state…Although this may seem self-evident, piecemeal reforms often occur in isolation from other elements of the school 'system' …So even though reforms are implemented, no one does anything of significance differently. (p. 1781)

The change efforts that schools and districts undertake seldom engage faculty members in anything more than superficial ways. These initiatives, which are usually selected by administrators in isolation from, and with very little consultation with, teachers, do cause some disruption to – and quite a bit of grumbling amongst – faculty members (for example, by requiring them to attend lectures or to participate in workshops), but they seldom impact those faculty members' day-to-day instructional practices. Likewise, these initiatives regularly meet with skepticism from local school boards, which – even after they have approved initial funding – are unlikely to maintain support for change efforts that do not immediately yield obvious, positive results. Consequently, after only short amounts of time, these initiatives are abandoned for having failed to achieve their goals, and their respective schools or districts return to their prior states, where they remain until such time as some other initiatives are introduced.

Sustained change in complex systems, by contrast, is iterative; perturbations cause system elements to change their behavior, and are in turn sustained by the changed behavior of those elements. Genuine change in schools requires that educators – administrators and teachers, alike – are prompted by reform efforts to work ever more closely with one another around issues of improved instruction, constantly learning from and continually providing feedback to one another, until ongoing reflection upon

and refinement of new instructional practices replace the systems' former patterns of behavior.

The nonlinear, networked nature of complex systems allows for information and energy, not only to flow from one part of the network to another, but also to be fed back to its origin, and to foster collective learning. The greater the rate of information flow through a system, the greater the likelihood that the system will adapt to changing conditions.

The amount and quality of connections between system elements likewise impact a system's ability to adapt. Complex systems whose elements are isolated from one another are both slower to adapt and less likely to achieve genuine learning; those whose elements regularly engage with one another are far more apt to learn and thrive.

Diversity amongst and between the autonomous agents that comprise complex systems further contributes to the health of those systems, especially when the power differentials between those agents are kept at a critical level. This arrangement does render complex systems – not least, those in which humans are involved – harder to govern from the top-down, but it also permits new order to be generated within them from the bottom-up in ways not possible in more centralized, mechanistic systems. While such distributed control can give complex systems the appearance of being rather less disciplined or efficient than hierarchical systems, without it, the former would be as devoid of novelty as the latter very often are.

Complexity acknowledges "that society unfolds from and is enfolded in individuals" (Davis & Sumara, 2005, p. 317) and that the members of any social collective "might cohere into a unit of cognition whose capacities exceed those of the individuals on their own" (p. 317). Classrooms and schools, then, are more than mere collections of learners; they are learners, themselves. Educational practice is not a policy to be enacted or a series of procedures to be followed, but an emergent phenomenon in which "someone acts or makes a move in relation to someone or something else" (Spillane, 2009, p. 204). McQuillan (2008) elaborates:

> Complex systems should be understood at their points of emergence, when system elements self-organize into discernible patterns – when the system is doing what the system does (Davis, 2003)…In the complex adaptive system of schools and schooling, complexity theory focuses one's attention onto the relationships among students, teachers, and administrators to see what emerges from their collective interaction. (McQuillan, 2008, p. 1780)

Consonant with complexity's appreciation of whole systems as learners, Reeves (2010) cautions against "toxic hierarchy" in education. Acknowledging their necessity in schools and other organizations, Reeves does not call for hierarchies to be dismantled, but to be "supplemented with effective networks" (p. 77). Reminding that complex systems exist at the 'edge of chaos,' which he describes as a "'just right' balance," McQuillan (2008), likewise, calls for the careful formulation of freedom and control within schools: "Distributed control…should promote individual autonomy and enrich communication while not being so centralized that the system stagnates for lack of common direction" (p. 1792). Describing what they had actually encountered during

their studies of big city high schools engaged in multi-year improvement efforts, Miles & Louis (1990) acknowledge the hesitancy of some school leaders to distribute leadership, while illustrating the practical utility of just that approach: "Central office people often worry that empowering schools will just lead to chaos (read 'central office powerlessness'). There is often a zero-sum view (more for them means less for us), but real empowerment usually expands the pie, with more coherent control on everyone's part" (p. 57).

Elmore (2004) succinctly summarizes the central tenets of the distributed leadership espoused by Reeves (2010), McQuillan (2008), and Miles & Louis (1990):

> Distributed leadership does not mean that no one is responsible for the overall performance of the organization. It means, rather, that the job of administrative leaders is primarily about enhancing the skills and knowledge of people in the organization, creating a common culture of expectations around the use of those skills and knowledge, holding the various pieces of the organization together in a productive relationship with each other, and holding individuals accountable for their contributions to the collective result. (p. 59)

Given the interrelationships between the actions of the multiple individuals across whom school leadership is distributed, and consonant with the priority that complexity places on the whole, rather than on the component parts, Spillane, Halverson and Diamond (2004) posit that the school – not the bearer of any one title – should be the unit of analysis in examinations of school leadership.

Those who hold formal positions of authority within their schools, and who seek to lead them to sustainable improvement, are advised not to stop at allowing leadership to be distributed amongst multiple individuals, but also to refrain from imposing needless homogeny or inflexible plans upon their faculties. Drawing from their investigation of large urban high schools engaged in years-long reform initiatives, Miles & Louis (1990) report, "We saw repeatedly that the leadership and management of change was a matter of dealing with uncertainty, complexity, turbulence, and the cussedness of many different people. Narrow blueprints or 'rules for change' did not work" (p. 57). Hargreaves & Fink (2004) add, "Standardization is the enemy of sustainability. Sustainable leadership recognizes and cultivates many kinds of excellence in learning, teaching, and leading, and it provides the networks for sharing these different kinds of excellence in cross-fertilizing processes of improvements" (p. 12). Reeves (2008) summarizes,

> Leaders who want to create effective and sustainable change initiatives can either continue to engage in the fantasy that their colleagues will conform to hierarchical expectations, or find their islands of excellence and leverage the enormous potential that they hold (p. 65).

Faulting the education system for being largely insensitive to the fact that people "work best in a climate that creates high expectations but mitigates against personal threat," Schmoker (1999) argues, "If we want better results, we need to look beyond the isolated point or moment or result and into the system that affects the impact we can have" (p. 33). Fullan (2005), similarly, calls for all who work in schools to engage in 'systems

thinking,' a habit of mind that requires people to consider the entire system when making choices about their individual parts of it, in order that the whole system may be changed sustainably and for the better.

Nearly half a century ago – about two decades before the release of *A Nation at Risk*, and almost forty years in advance of the passage of *No Child Left Behind*, Miles (1965) appreciated the importance to school improvement of focusing upon the education system as a whole.

> Any particular planned change effort is deeply conditioned by the state of the system in which it takes place…To use an image from Gestalt psychology, specific planned change attempts have most typically been 'in figure,' occupying the focus of attention, while the organization itself has remained the 'ground'. (p. 11)

Taking issue with the approach by which organizational change had long been conceived, Miles (1965) asserts, "It is time for us to recognize that successful efforts at planned change must take as a primary target the improvement of *organizational health* – the school system's ability not only to function effectively, but to develop and grow into a more fully-functioning system" (p. 11). Miles (1965) continues by explaining that, in much of the literature on innovation, the individual innovator and the innovation itself are emphasized, but the organizational setting into which the innovation is introduced is largely ignored; "the local system itself [is treated] as a kind of unmodifiable ground against which the innovation shows up in stark figure" (p. 12). In the language of complexity, by underestimating their schools' and districts' sensitive dependence upon initial conditions, many who have sought to reform or otherwise improve their schools have undermined their own efforts.

None who work in schools – least of all, those who seek to contribute to their sustainable improvement – do those schools (or, indeed, the education system overall) any great service by attending only to those parts for which they have titular responsibility. Rather, they need to maintain a dual focus on the organization as a whole, and the portion of it within which they function. This is not merely to forestall any linear breakdowns or to reinforce the proverbial 'weak links,' but to acknowledge that, in complex systems, the constituent parts are best understood as microcosms.

As explained above, similar patterns repeat themselves at both higher and lower scales within complex systems; "they do not get simpler as you zoom in or zoom out" (Davis & Sumara, 2005, p. 313). 'Scale independence' and 'self-similarity' are often described, in complexity, using the now clichéd example of measuring the coast of England: Each magnification of any one feature of the coastline reveals that same feature repeated many more times in miniature; as smaller and smaller units of measurement are employed, one is able to measure with still greater precision, thereby obtaining a greater length. Johnson (2008) explains, "This is a standard pattern in the history of science: when tools for measuring increase their precision by orders of magnitude, new paradigms often emerge, because the new-found accuracy reveals anomalies that had gone undetected" (p. 76).

Gleick (1987) explains how the creation of fractal geometry – so called, because of its introduction of fractional, or noninteger, dimensions with which to measure objects with

irregular shapes – both permitted scientists to measure natural objects and phenomena in finer and finer detail, and – in the process – to recognize the recursive quality of the patterns that they saw:

> It is hard to break the habit of thinking of things in terms of how big they are and how long they last. But the claim of fractal geometry is that, for some elements of nature, looking for a characteristic scale becomes a distraction. *Hurricane*. By definition, it is a storm of a certain size. But the definition is imposed by people on nature. In reality, atmospheric scientists are realizing that tumult in the air forms a continuum, from the gusty swirling of litter on a city street corner to the vast cyclonic systems visible from space. Categories mislead. *The ends of the continuum are of a piece with the middle.* (Gleick, 1987, p. 107 – emphasis added)

The notion that the whole system may at least begin to be understood by looking at one component of it is in no way new to education. Making the case for deep-reaching education reform, Elmore (2004) explains, "The problems of the education system are the problems of the smallest units in that system, and each unit faces a different version of the overall problem of the system. If the overall problem of the system is student performance on higher order cognitive tasks…this problem will be present in very different forms in every classroom where it occurs" (p. 56).

Likewise, and even more poignant, students in teacher- and administrator-preparation programs during the past decade have been assigned to read Mano Singham's (1998) insightful article "The Canary in the Coal Mine," which takes its title from coal miners' historic practice of bringing with them into each mine a canary to serve as a means of detecting the presence of noxious gases. If the canary – whose much smaller size rendered it more susceptible – died, the coal miners knew that the area of the mine in which they were working posed a threat, and that they needed to take protective action. Singham suggests, "The educational performance of the black community is like the canary, and the coal mine is the education system" (p. 15). He explains, "What the academic achievement gap may really be telling us is that, while the symptoms of the education system's ills are more clearly visible in the black community than in the white, there are fundamental problems with the way education is delivered to *all* students" (Singham, 1998, p. 15).

It is not insignificant, for example, that the very aspects of professional development about which teachers express dissatisfaction – that it is decided for them without their input; that it is undifferentiated for those with greater or lesser experience or expertise; that it is presented through formats, such as lectures, which afford them little if any opportunity to engage with the material; that it is seldom clear how what is being presented applies to their day-to-day lives – are the very complaints that students quite rightly voice about their own school experiences. Neither is it purely coincidental that the very complaints that building-level administrators voice about district-level ones – that, lacking day-to-day exposure to and responsibility for students, the bureaucratic demands that they impose are unreasonable; that they are inadequately supportive when conflicts or controversies with families and/or the wider community arise – sound

strikingly like the charges that teachers occasionally level against building-level administrators.

Were educators at all levels of the education system to bear self-similarity and scale independence in mind, were they to appreciate that the demands on, and decisions made by, those at other levels of the system are roughly analogous to those that they themselves experience each day, they would likely engage with each other more harmoniously and sympathetically, and – still more important – provide better service to the students who are their collective charge.

MacDonald and Shirley (2010) provide an example of just this sort of thing. They explain that, after hearing two former administrators voice their own job-related frustrations, teachers participating in a seminar grew less critical of administrators.

> They came to appreciate that administrators, too, were exasperated at working in an underfunded school system with many bureaucratic guidelines in place that were a disservice to pupils. The duality of 'us against them' began to be replaced by a more complex understanding of a whole range of forces that lead to depersonalization and dehumanization, with no obvious single force or factor available to play the role of villain. (p. 43)

The kinds of inter-role discourse and understanding that MacDonald and Shirley (2010) describe, and the 'systems thinking' in which Fullan (2005) recommends that all members of the school community engage, will seem foreign to those who inhabit the education system – not because teachers are incapable of such activity, but because, across the years, they have grown accustomed to being managed, and to being required to implement programs prescriptively and 'with fidelity.' Additionally, ignoring Miles' (1965) characteristically prescient counsel against "a recrudescence of the unfortunate enthusiasm of schoolmen for Taylorism and 'scientific management'" (p. 22), schools and districts have constructed ever larger and increasingly hierarchical structures by which to govern the work of educators. While on paper they appear orderly, even sophisticated, such organizational structures ignore the humanity of the individuals who people them, as Pink (2009) cogently explains:

> We forget sometimes that 'management' does not emanate from nature. It's not like a tree or a river. It's like a television or a bicycle. It's something that humans invented… Its central ethic remains control; its chief tools remain extrinsic motivators. That leaves it largely out of sync with the nonroutine, right-brain abilities on which many of the world's economies now depend. But could its most glaring weakness run deeper? Is management, as it's currently constituted, out of sync with human nature itself?...The idea of management…is built on certain assumptions about the basic natures of those being managed. It presumes that to take action or move forward, we need a prod – that absent a reward or punishment, we'd remain happily and inertly in place. It also presumes that once people do get moving, they need direction – that without a firm and reliable guide, they'd wander…But is that really our fundamental nature? Or, to use [a] computer metaphor, is that our 'default setting'? When we enter the world, are we wired to be passive and inert? Or are we wired to be active and engaged? I am convinced it's the latter – that our basic nature is to be curious and self-directed…That's how we are out of the box. If, at age fourteen or forty-three, we're passive and inert, that's not

because it's our nature. It's because something flipped our default setting… That something could well be management – not merely how bosses treat us at work, but also how the broader ethos has leeched into schools, families, and many other aspects of our lives. Perhaps management isn't *responding* to our supposedly natural state of passive inertia. Perhaps management is one of the forces that's switching our default setting and *producing* that state. (p. 89)

While seldom permitted – still less, invited – to do so as part of their work lives, human beings are entirely capable of recognizing, appreciating, and responding to patterns that emerge organically within such complex systems as their back yards, their families, or their chosen fields of employment. While such patterns invariably fail to comport with organizational flowcharts, and while they certainly present as far-less-tidy than procedures outlined in official protocols, they are accurate representations of real life.

Leonardo da Vinci's appreciation of nature's recurring patterns is famous. Conceiving of the Earth and all life upon it as an organism, Leonardo identified that nature followed 'laws of necessity' – laws that, while simple, are adhered to and repeated time and again, at scales both large and small (Capra, 2007). No less affected by nature's organized complexity, novelist and memoirist Osbert Sitwell (1946) writes reverentially of the recursive beauty that he encountered during childhood strolls through the greenhouses of his ancestral home. Randal Keynes (2001) cites the work of John Herschel, nineteenth century polymath and author of the *Preliminary Discourse on the Study of Natural Philosophy*.

Herschel wrote of man as a 'speculative being' who 'walks in the midst of wonders,' intrigued by the hints of underlying patterns in the infinite variety of the living world and searching for grand principles to explain them…Herschel claimed that the laws of nature were 'not only permanent, but consistent, intelligible and discoverable.' The way forward was to embark on an inductive inquiry into natural phenomena, searching for the underlying patterns and inferring the grand causes. (Keynes, 2001, p. 25)

Being keenly observant, able to recognize emergent patterns, and creative and flexible enough to adjust to changing circumstances, are increasingly recognized as essential in the modern workplace. There is more-than-a-little irony in the fact that the habits that business and industry now exhort schools to cultivate in students are the very ones whose suppression they had for so long sought in the names of consistency and efficiency…and which, as a consequence, had come to be regarded as the exclusive province of Renaissance men (literal and figurative) and men of letters.

The sustainable improvement of the overall education system requires – and scholars and policymakers increasingly acknowledge – that teachers must thoughtfully, mindfully experiment within those parts of that system which they occupy, and that they must attend to and engage with actors from the wider system.

We are working explicitly with an understanding of teaching that acknowledges (and yes, even cherishes) its tentative, experimental, iterative nature…Accepting this open-endedness of education allows us to view teachers' professional decision making not as a problem to be avoided through impulsive overreaction to test scores or uncritical

compliance with mandates, but rather as *an intellectual field in and of itself*. (MacDonald & Shirley, 2010, p. 27)

Where countless approaches to school improvement have sought to train teachers in the faithful utilization of prescriptive materials and instructional approaches, Elmore (2004, 2010), MacDonald and Shirley (2010), Reeves (2010), and Hall and Simeral (2008) promote teachers' thoughtful education about appropriate instructional practices, and their active engagement with ideas. Explaining, "The word *education* is built of the Latin prefix *ex* plus the verb *ducere* ('to lead') and suggests a 'leading out from'," Kegan (1994) asserts, "While *training* increases the fund of knowledge, *education* leads us out of or liberates us from one construction or organization of mind in favor of a larger one" (p. 164).

Hall and Simeral (2008) write of the significance of teachers' engagement in such activities as "diagnosing problems, researching solutions, and creating action plans to develop competence and discernment" (p. 87). Reeves (2010), likewise, advises that teachers be encouraged to pursue "disciplines related to expertise" – namely, "focus, repetition, and effective practice" (p. 51). Fullan (2005) explains how teachers' pursuit of such activities contributes to the improvement of the education system overall: "We know…that experts expend less energy in dealing with complex matters because they more easily and subconsciously recognize patterns and intuit effective responses…They become more efficient and more effective because of their…experiences" (p. 34).

Teachers would likely be glad to be relieved of the 'alienated teaching' under which so many of them have labored during the now decades-old era of school reform. "Alienated teaching," which MacDonald and Shirley (2010) describe as endemic in schools across the United States, "is a kind of teaching that teachers perform when they feel that they *must* comply with external conditions that they have not chosen and from which they inwardly dissent because they feel that new reforms do not serve their children well" (p. 2).

With greater liberty to think about, plan for, and implement their own professional practice, though, many teachers would likely also experience new tensions. In addition to feeling still greater accountability for student outcomes, now that their instructional practice would be based more on their own professional judgments than on administrative dicta, larger numbers of teachers would also increasingly recognize their responsibility for the education system as a whole, not just for their individual classroom or even school.

The vast majority of teachers could be expected to approach their work more mindfully and confidently if policymakers, administrators, and they, themselves, felt greater comfort with complexity. Acknowledging that life is colored by the full spectrum, not just by the black and white used to render organizational charts and statistical tables, teachers would discern hitherto unrecognized patterns, and appreciate analogous phenomena in seemingly dissimilar contexts.

Reading across the social and life sciences, rather than limiting themselves to the education literature, is one way by which teachers could get into the habit of thinking differently about complex systems. Likewise, as "the *specific* order of complexity

demanded in the workplace is precisely that which is demanded in the home and family," teachers and others would do well "to violate the existing custom and bring the literatures of love and work together" (Kegan, 1994, p. 152); they would do well to recognize the similarities between the relationships and negotiations that they enjoy at home and those in which they engage at school. Above all, teachers would be more likely to embrace uncertainty and to take the risks necessary to improve the quality of their practices if they trusted that administrators not only permitted, but would support them through, such professional experimentation, and if they observed, were observed by, and engaged in candid, ongoing conversations about practice with knowledgeable fellow educators.

Conclusion

In order for complex systems to change sustainably, agents at various levels of those systems must interact with each other, and control must be distributed in such a way as to "promote individual autonomy and enrich communication" amongst the systems' various levels (McQuillan, 2008, p. 1792). The practical implication of this is that each school system implementing an effort at instructional improvement must establish and maintain a common direction while also allowing individual actors – principals, teachers, and other educators – to make decisions that are appropriate for them and their local constituencies.

Ravitch's (2010) treatment of curriculum frameworks in her book *The Death and Life of the Great American School System*, provides one example of such a balance:

> The curriculum is a starting point for other reforms. It informs teachers, students, parents, teacher educators, assessment developers, textbook publishers, technology providers, and others about the goals of instruction. It provides direction, clarity, and focus around worthy ends, without interfering with teachers' decisions about how to teach. (p. 231)

Writing that instruction would be far more likely to improve if the powers that be refrained from requiring "pedagogical conformity and recognized that there are many ways to be a successful teacher" (p. 191), Ravitch (2010) echoes the worldview of Jane Jacobs, the title of whose book she appropriates in homage. Jacobs (1961) – who employed Weaver's (1948) then-novel notion of 'problems of organized complexity' to investigate cities and city planning – points-out in *The Death and Life of Great American Cities* that, while certain domains of city governance ought by right to be structured horizontally ("The importance of locality coordination is little recognized or acknowledged in city administrative theory," p. 418), other functions are better-managed centrally ("Doctrinaire reorganization of government into pure horizontal administration would be as fatally simple and as chaotically unworkable as the present messes," p. 421).

Applied to education, complexity requires that agents – at the policymaking, district, school, and classroom levels – approach reform efforts thoughtfully, not formulaically; that they permit those efforts genuinely to emerge within, not hastily to

be imposed upon, individual schools and districts; and that they afford educators the "ingenious blend of support and challenge" (Kegan, 1994, p. 42) that they require if the change that they undertake is actually to yield improved educational outcomes for students.

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