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Complexity science and student teacher supervision ☆

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Abstract

To what extent might the practicum be regarded as a complex phenomenon? After introducing complexity science and its potential to illuminate educational practice, five characteristics are explored within the context of teacher education. Vignettes from a kindergarten classroom extend this exploration into the practicum setting. Five implications emerge for student teacher supervision: redefining the practicum, rethinking evaluation, surrendering certainty, acknowledging complicity, and allowing for improvisation.
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1. Introducing complexity science

Much has been written about complexity science, especially in recent times and across a range of disciplines including Education. For example, international scholars at the Santa Fe Institute, a renowned multidisciplinary research community, have been exploring the potential of complexity science in areas as diverse as neuroscience, meteorology, and economics (see www.santafe.edu). It would be impossible to do justice to the history and development of complexity science in the space available here. However, we will briefly sketch the central ideas of complexity science in an attempt to lay the groundwork for thinking about how this perspective might inform our understanding of practicum settings and student teacher supervision.[1]

Warren Weaver (1948),[2] one of the first to articulate the nature of complex phenomena provides an interesting starting point. Weaver was curious about phenomena, how they behaved, and how they lent themselves to investigation. Weaver worked at a time when scientists divided phenomena into two main categories for investigation:

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[1] We use the terms 'supervisor' and 'supervision' throughout this paper to situate our argument within the literature used to describe the work of classroom teachers who work with student teachers on practicum. We are not entirely comfortable with the connotations associated with these terms, particularly in contrast to the theoretical frame that we draw on in this paper (i.e., complexity science) but will save these concerns for another time.

[2] Weaver was director of the Division of Natural Sciences at the Rockefeller Foundation (1932–1955) and leading theorist in communication science and probability and statistics.

simple and complicated.[3] Paradigms and practices were devoted to developing investigative tools and interpretive frames for dealing with these two types of phenomena. The great comfort derived from these categorizations was that the phenomena under investigation displayed a linearity (and often a direct cause and effect relationship) that allowed phenomena to be broken down into their constituent parts, analyzed, and then reassembled unproblematically allowing predications to be made about the whole. For simple and complicated phenomena, the sum of the parts always constitutes the whole; no more, no less.

Simple phenomenon usually involve a couple of variables and their interactions, for example, the movement of a ball around a billiard table as it rebounds and finally comes to rest. With simple phenomena scientists are able to accurately predict every possible outcome. Complicated phenomena, in contrast, have many variables and it is difficult to specify exact outcomes in every instance. However, Weaver noted that if you observe and document the behavior of complicated phenomena over a long enough period of time, there is an overall regularity that can be discerned and therefore outcomes within acceptable limits can be predicted with considerable confidence. Weaver uses the life insurance industry of as an example of a complicated phenomenon. There are many variables that life insurance companies contend with, many of which are largely unknown in advance (the cause of death, a person's age at the time of death, pre-existing illnesses, occupational hazards, etc.). However, there is sufficient regularity associated with this phenomenon to allow the life insurance industry to operate successfully. While the insurance agents cannot say with certainly who will die this week, what will cause their death, and the nature of the financial obligations upon their death, etc., they can tell us with an extremely high degree of certainty how many people, for example, in British Columbia will die this week, how many next week, how many next month, how many this year, next year, etc. The exact details might be unknown in advance for each individual but there is a consistent regularity to the overall pattern that allows the industry to thrive and grow. For example, Canada's life and health insurance industry ranks third among the country's financial institutions (Canadian Government & Department of Finance, 2001). Further, a whole branch of mathematics—probability and statistics—has been generated to deal with this category of phenomena.

In addition to simplified and complex phenomena, Weaver believed that there was a third category of phenomena that scientists largely ignored. He was one of the first to speculate that treating all phenomena as either simple or complicated, as was the tendency by his colleagues of the day, was not only wrong headed but inappropriate. He argued that there was a large "middle ground" (Weaver, 1948, p. 3) that did not lend itself to the principles, practices, or canons of inquiry that scientists had established for simple and complicated phenomena. He called this group of phenomena "organized complexity" (Weaver, 1948, p. 3) or what we commonly refer to today as complex phenomena.

Complex phenomena, like complicated phenomena, have many variables but the outcomes are rarely predictable. However, Weaver observed that when the outcomes emerge, they are not random but display a unique pattern. Examples of complex phenomena include weather systems, monetary markets, and flu viruses. Each of these phenomena, unlike complicated phenomena, have an inherent unpredictability about them but at a critical point, referred to as "emergence" (Johnson, 2001), display a clearly discernable pattern. Take for example, youth fashion, which is highly unpredictable (Pais, 2000). Who would have guessed that the 'saggy low-riding crotch pant' phenomenon (known as *saggin*) would become a fashion trend among today's youth? This garment defies function, logic, safety, and, possibly even aesthetics! Nonetheless, *saggin* has had such an impact on youth fashion that large marketing chains, such as Wall Mart and Target, now produce copycat products for the youth market. It is interesting to note that a whole new industry, called 'pattern recognition,' has arisen to assist retailers in tracking emergent trends and rushing imitation products to the market place before their competitors (Gibson, 2003). In short, complex phenomena represent interactions of events, activities, and practices that coalesce in ways that are unpredictable but nonetheless highly patterned.

Since Weaver's (1948) commentary, practitioners and researchers in a variety of fields have explored the potential of complexity science, in particular, in settings where simple or complicated analyses seem to provide little illumination of the phenomena

[3]The latter being the current term for what Weaver refers to as 'disorganized complexity.'

under study. Education has been a late entry among those fields exploring the potential of complexity science to illuminate their endeavors. For example, the 'Chaos and Complexity' special interest group (SIG) at North America's largest education conference, the American Association Educational Research Association (AERA), met for the first time in 1995 under the guidance of Bill Doll, author of one of the earliest papers to explore a systems approach within an educational context (Doll, 1993). However, the impact of these forays within Education remains minimal and the extent of engagement is still at the periphery of discourses about educational theory and practice.

2. Complexity science and education?

Few educators would consider teaching and learning to be a simple activity. In contrast, however, Weaver's second category reminds us how often educational researchers have cast teaching and learning as a complicated activity. Davis (2003), points to a recent research report as evidence that this approach is still very much a part of educational research:

> While browsing the abstract of a recent issue of Educational Evaluation and Policy Analysis, a journal of the American Educational Research Association, I came across a report in which statistical methods were used to "control for" such "confounding variables" as "teachers, schools, and classrooms" (Pong & Pallas, 2001). I had to read the abstract a few times, a little stunned by the fact that there still exists educational researchers who regard teachers, classrooms, and schools in such terms (p. 39).

While not dismissing the value of statistical methods or their use in educational research, Davis highlights the danger of widespread and uncritical use of such methods (Davis & Sumara, 2005). A number of reasons could be suggested as to why researchers in education have become so enamored with a complicated view of the world. For some educators, it is an attempt to apply some order and control on what seems to be an unruly phenomenon. For others, the temptation to adopt the methods of inquiry that secured the natural scientists their lofty position in the academy is too great, especially at the time when teacher education made the shift from Normal Schools to Universities in the latter half of the 20th Century (Clarke, 2001).

However, even the most ardent advocate of a complicated view of education is likely to admit that aspects of the phenomena they are studying defy the tidy sort of explanation that a complicated rendering purports to offer. For example, Porter (2001) in an invited commentary for the National Centre for Educational Statistics in the US, notes that while policy makers would like to render instructional practice as a statistical construct, "that there are significant challenges to producing high-quality indicators" (p. 14) that could capture the complexity inherent in such a construct.

By the beginning of the new millennium it seemed to be common practice for educators of all persuasions (simple, complicated, or other) to use the modifier 'complex' to describe educational practices. For example, the editor of the Journal of Teacher Education, writes about "The unforgiving complexity of teaching: Avoiding simplicity in the age of accountability" (Cochran-Smith, 2003, p. 3). Florio-Ruane (2002), in the same journal, published a paper entitled 'An argument for complexity in studies of teaching and teacher education' (p. 205). Neither of these authors refer to complexity science in their papers. However, we argue that authors, such as these, use the modifier 'complex' to signal the inadequacy and difficulty of current conceptions of educational practice to fully account for the unanticipated and unpredictable nature of teaching and learning that are an inherently a part of the daily practice of schools and schooling.

The move away from simple or complicated renderings of education has been increasingly prevalent as researchers have sought alternative ways of thinking about teaching and learning. For example, the increasing use of arts-based inquiry within education is one such move. The value of such an approach was recognized by Frijof Capra (2004), one of the foremost proponents of complexity science today as a way of understanding natural and social phenomena. He argues that the study of pattern (an essential element of an artistic rendering of phenomena) as opposed to the study of substance (a fixation of the sciences) is a more productive way of thinking about and inquiring into complex phenomena:

> … the study of pattern was always there, and at various times it came to the forefront, but most times it was neglected, suppressed, or sidelined by the study of substance. As I said, when you study

> pattern, you need to map the pattern, whereas the study of substance is the study of quantities that can be measured. The study of pattern, or of form, is the study of quality, which requires visualizing and mapping. Form and pattern must be visualized. This is a very important aspect of studying patterns, and it is the reason why, every time the study of pattern was in the forefront, artists contributed significantly to the advancement of science. Perhaps the two most famous examples are Leonardo da Vinci, whose scientific life was a study of pattern, and the German poet Goethe in the eighteenth century, who made significant contributions to biology through his study of pattern (Capra, 1994, p. 4).

A turn towards complexity science within education is consistent with these renderings. But first, to appreciate the significance of this turn, an understanding of some of the characteristics of complex systems is necessary. In particular, the following characteristics are important to this discussion: networks, feedback loops, self-organization, disequilibrium, and the nested nature of complex systems.

3. Complex systems

First, complex systems exhibit networked rather than hierarchical structures. Rather than vertical lines of control, they have multiple braches extending in many directions (Senge, 1990). Stock markets, the World Wide Web, and flu viruses represent multi-branched or non-linear complex systems. This means that complex systems are difficult to control or constrain. While development within these systems occurs, the exact direction is unknown prior to its emergence. The extraordinary tech boom in the 1990s, the demise of Dan Rather (one of America's most influential television commentators over the last 25 years) at the hands of weblogs in 2004, and the current threat of an Avian Flu epidemic all represent non-linear systems at work.

Networks allow for the rise of a second important characteristic: feedback loops:

> The first thing you see when you draw a network is that it is nonlinear; it goes in all directions … . Because of this nonlinearity, an influence or message may travel around a cyclical path and come back to its origin (Capra, 1994, p. 6).

These loops provide the opportunity for 'learning' at the local level, that is, new knowledge returning to and being taken up at the point of origin. This feedback process means that control and organization, order and direction, do not emanate from a single point or location (i.e., the sense that learning is dependent on a hierarchical structure is absent) but from many points simultaneously. Multiple branching combined with feedback loops means that information can be communicated quickly within a complex system and there exists the possibility for learning at local levels without a single master plan directing what and how and when it is learned.

This leads to a third characteristic of complex systems in that they have the capacity for self-organization or self-regulation.

> Self-organization refers to patterned behaviour arising from agents interacting locally according to their own principles, or "intention," in absence of an overall blueprint for the systems (Stacey et al., 2000, p. 106).

Complex systems have the capacity to change and alter based on information sent and received at the local level independent of an authorizing or directing agent. Therefore, we can never fully know or control a complex system. This means that at the outset, we must accept that there is an element of indeterminacy. Local effects can have system-wide implications. For example, a storm in the Caribbean can turn into a hurricane with devastating consequences upon landfall or turn back out to sea and dissipate quietly. At best we might confidently predict its path up to 24 h but beyond that it is difficult to determine its direction (Hayden, 2006). The challenge presented by the complex systems, such as hurricanes, is reflected in the widely varying path predications generated by the sophisticated computer modeling programs used by the US National Hurricane Centre (www.nhc.noaa.gov).

A fourth characteristic of complex systems is disequilibrium. This concept runs counter to traditional renderings of successful systems that suggest that a state of equilibrium is both a prized and essential characteristic. llya Prigogine (1977) argued that while stability is important for closed systems, the generative potential of open or complex systems, is the degree of disequilibrium inherent in the systems themselves (his theory of 'dissipative structures' won him the Nobel Prize in 1977):

> Prigogine discovered that the dissipative activity of loss was necessary to create new order.

> Dissipation didn't lead to the death of a system. It was part of the process by which the system let go of its present form so that it could reorganize in a form better suited to the demands of its changed environment (Wheatley, 1999, p. 21).

Vibrant and robust systems must be not only be able to tolerate but need to embrace an element of chaos where uncertainty is a source of spontaneity, creativity, and growth (Lorenz-Shulman, 1997). Wheatley (1999), in her analysis of large institutions as complex systems, notes that organizational equilibrium is "a sure path to institutional death." (p. 76). Optimum conditions for complex systems require that they have a capacity for change, are alert to alternatives, sensitive to difference, and open to experiment. The interplay of these factors lies somewhere between the flexibility necessary for growth and the consistency necessary for consolidation. There is always an element of disequilibrium:

> …"often called the edge of chaos—where the components of a systems never quite lock into place and yet never quite dissolve into turbulence either (Waldrop, 1992, p. 12).

Disequilibrium is regarded as a creative tension—the generative capacity of the system—and not a dysfunctional characteristic that should be eliminated (Collins, 2004).

A fifth characteristic of complex systems is their nested nature. Davis and Sumara (2005) note that complex systems are systems within systems and that upon closer inspection "things do not get simpler as you zoom in or zoom out" (p. 313). They draw on fractal geometry to illustrate this point. For example, the edge of snowflake, when magnified, bears a resemblance to the whole, the similarity continuing as the magnification increases or decreases (the concept of self-similarity). Complex systems are not comprised of discrete parts, distinct and separate from each other, that can be easily dissembled. Rather any complex system is a collective of similarly complex systems and is a part of a larger complex system:

> … a complex phenomena is irreducible. It transcends its parts, and so cannot be studied strictly in term of a compilation of those parts. It must be studied at the level of emergence (Davis, 2003, p. 43).

Taken together, the characteristics of complex phenomena—networks, feedback loops, self-organization, disequilibrium, and their nested nature—represent dynamic interactions that cannot be accounted for by simple or complicated renderings. Haggis (2005) notes that if there are a sufficient number of these interactions, and if they take place over a sufficiently long period of time, specific forms of order, or organization, will periodically emerge from within the system" (p. 4). While there are a number of other characteristics that could be included here, these five are regarded by most authors as critical. Our attention to these characteristics has been to assist in distinguishing complex phenomena from simple or complicated phenomena. It should be noted that it is possible for all these characteristics to exist but there is no guarantee that complexity will emerge. Other elements or forces can act upon systems to distort or inhibit the emergence of complexity. Monetary markets can be stifled by over regulation, ecosystems compromised by loss of habitat, and student learning constrained by lockstep programming.

4. The practicum as a complex system

There is consensus, both within and beyond the complexity science community, that many social systems exhibit the characteristics of complex phenomena (Epstein & Axtell, 1996). The examples cited earlier include a variety of social systems: stock markets, the fashion industry, and weblogs. Fullen (1993), an expert in educational reform, among others (Barnhardt, 2005; Reigeluth, 2004), argues that school systems represent complex phenomena. This assertion raises the question: Does the practicum represent a complex system and, if so, what are the implications for student teacher supervision?

At first glance, the above elaboration of the characteristics of complex systems seems relatively commonsensical; complex systems display a network pattern, have feedback loops, are self-regulatory, etc. However as the conversation shifts to thinking about the practicum as a complex system, some of our long-held notions about teaching and learning are challenged. We regard this challenge as an opportunity to think differently, perhaps more expansively, about the practicum.

First, does the practicum exhibit a *network* structure? This question addresses the non-linear nature of complex systems suggesting a branching rather than a hierarchical structure. We believe that many teacher education programs have a tendency

towards linearity (particularly when large numbers of students are enrolled in a B.Ed. program). It is not difficult to imagine a flowchart with the university at the top followed by (with directional arrows pointing downward) the faculty advisor, the school, the cooperating teacher, the student teacher, and if they are featured at all, the pupils at the very bottom of the diagram. While this might represent a vision of institutional efficiency and authority (where higher levels have the ability to reward or sanction lower levels) we suggest that it does not represent, at least in our experience, the practicum as it unfolds in school settings.

To begin with, once removed from the physical setting of the university, the various players in the practicum have a degree of freedom that is not accounted for in the above flowchart. For example, the faculty and cooperating teachers constantly engage in and refer to one another for guidance, advice, and direction. Student teachers, in most instances, become increasingly involved in these interactions, and the possibilities for mutual learning is ever-present (for example, cooperating teachers often comment on learning new ideas that their student teachers bring to the practicum from their course work). Also, the learning that occurs within the classroom is itself multi-directional and includes pupils, the student teacher, and both cooperating teachers and faculty advisors. For example, as faculty advisors, we never ceased to be amazed by what we learn from visits to practicum schools and classrooms (including what we learn from our interaction with the children in these classrooms).

This network structure is best illustrated with reference to one of our regular practicum supervisors, Nadene, and her kindergarten classroom.[4] Nadene is a highly experienced kindergarten teacher. Over the past 8 years we have visited Nadene's classroom on no less than 60 occasions. We have observed, videotaped, and engaged in conversations and activities with Nadene, her student teachers, and her pupils. Nadene's desk, often overflowing with papers, is off to the left-hand side of the room; a small island that children can easily approach and walk around without obstruction. Also, there are some chairs at Nadene's desk for the children to sit and talk with her. Around the room, there are small-group tables, a carpeted area near the blackboard, a couch and lounge chairs, a painting area, a sink and 'wet' area, a microwave, a cloak room, etc. The student teacher has a desk off to one side. Nadene's classroom has the feel and look of a family room in a home or is akin to the central hub in a community center.

While there is a structure to the day, and unquestionably Nadene is 'in charge,' unless one looks very closely, it is hard to discern where the authority emanates from within the classroom. Nadene works hard in the first couple of weeks of the school year to establish clear guidelines for the children as they work with each other and the various adults in the room (teacher, student teacher, classroom aides, and parents). However, after the first month of school, we often have to look around the room to find Nadene because she is rarely at the front of the room directing activities. The students are very much involved in the unfolding of the school day, from the introductory activities at the beginning to the sharing of resources, etc. For example, there is a deliberate attempt not to have class sets of every item in the room to ensure that students take turns and share items with each other. In short, Nadene is in the background and her pupils and their activities in the foreground. Sometimes, 10 or 15 min can go by as we watch the children busily engaged in activities before we suddenly realize that we have absolutely no idea where Nadene is. The same can be said for Nadene's interaction with her student teacher. Direction is provided early in the practicum but quickly the student teacher becomes a fully participating member of the classroom. There is a network like structure to the way the classroom is organized or web-like pattern that encompass a range of possibilities for interaction (e.g., peer group interaction, buddy teaching, teacher directed instruction, team-teaching, parent helpers). Responsibility and authority are shared, slowly at first but increasingly as the term and the practicum progresses. Nadene expects her young charges and her student teacher to play a very significant and active role in how their learning unfolds. The elements of a participatory democracy (Collins, 2004) are established early and continue throughout the year. The student teacher joins this network and influences the classroom system and is influenced by that system. The class (pupils, teachers, and assistants) and the environment co-evolve together.

Second, to what extent are *feedback loops* evident in practicum settings? There is little question in our

[4]Nadene Carline is a teacher in British Columbia and has given permission for her identity to be revealed in this paper.

minds that the information and meaning constructed, negotiated, and mediated across multiple levels within the classroom often goes unnoticed. Our assessment practices, be it for the children, the student teacher, or the periodic appraisals that Nadene undergoes from the school administrator, capture only a fraction of the feedback that is generated over the course of the day; ripples of learning reverberate throughout the room and bounce back altered, changed and sometimes amplified. As faculty advisors, we complete formal weekly anecdotal comment sheets and periodic checklists on our student teachers' performance. However, there is a constant undercurrent of activity that is almost invisible but occasionally surfaces in surprising ways to remind us of the circles of influence and opportunities for learning (as the result of feedback loops) that emanate from unlikely sources.

For example, one day a pupil in Nadene's classroom asked Tony "Are you going to the beach?" A puzzling question until the pupil points out that Tony is wearing sandals, shorts, and is carrying a camera. This interaction is noticed by other students in the room who giggle and begin to join in the conversation. They test out a number of ideas among themselves. Nadene is conscious of the discussion but as it does not impede the children's work (a centres-activity with children working in various parts of the room) she does not intervene. She lets the conversation flow, ideas to be taken up or dismissed, scenarios developed, and problem setting and solving to emerge (Schön, 1987). Some think that Tony is a classroom assistant (the students are familiar with other adults in the room taking notes). Some guess, correctly, that he is the student teacher's teacher. Some think he might be the student teacher's husband. Some think that he is just another visitor and that is enough to satisfy their curiosity. At times the circles of conversation widen. Nadene enters by prompting a student who is struggling to find a word to express an idea (and later makes note of the child's progress on his language assessment sheet). The student teacher joins in with one or two probing questions to see if another child can articulate his reasons for a particular contribution and learns that the child has rarely been to the beach or swum in the ocean. This strikes the student teacher as odd but begins to explain some confusion that this child had with a earlier activity about 'the seashore.' Ideas circulate, develop, and are refined. Arriving at the correct answer is not an immediate preoccupation. There is a game like quality to the discussion and enjoyment in playing with ideas as they are offered, shared, and modified, only to be taken up anew again by the initiator or others in the group. These are examples of feedback loops that arise within the practicum setting, in this case unprompted, that serve a purpose and then disappear. Such events occur frequently within and across the course of the school day in Nadene's classroom. Within the context of the practicum environment such loops are an illustration, to us, of the ways in which learning across a range of levels (pupils, student teachers, teachers, advisors, etc.) is informed and enriched.

Is *self-organization* a characteristic of the practicum setting? This is perhaps one of the most difficult characteristics to conceptualize within the practicum setting, and one that requires the greatest shift from traditional ways of thinking about supervisory practices. Self-organization asks us to believe that if we allow sufficient freedom for interactions among and between people then generative, fruitful, and productive outcomes will emerge.

A contra-example is useful here. We invite you to visit Eve's classroom, the room directly above Nadene's classroom.[5] The first thing you notice about Eve's classroom is that it is very well organized, one might even be tempted to use term 'highly routinized.' For example, if you were to visit this classroom today and then return a year later, in all likelihood you would find the same lesson being taught, the same artifacts being generated, and the same activities taking place. Eve's classroom runs like clockwork. For all intents and purposes, Eve's pupils meet or exceed the Ministry guidelines and score well on all Provincial-wide assessment tasks. Eve regards the student teacher as a component that can be slotted in (and taken out) unproblematically without altering the teaching or learning in her classroom to any significant degree. The student teacher is expected to conform to the Eve's practices. Any difficulties in this regard are viewed by Eve as a failure on the university's part to adequately prepare her student teacher for the practicum. Student teachers in these types of classrooms quickly begin to mimic their cooperating teachers, adopting their values, mannerisms, and

[5]The character, Eve, although fictitious is representative of some teachers and their classrooms that we and our student teachers have witnesses over the years.

practices for the duration of the practicum. Some student teachers even begin to sound like their cooperating teachers! In short, there is very little autonomy on the part of the pupils or the student teacher with respect to their learning in Eve's classroom.

In contrast, Nadene constantly seeks pupil and student teacher engagement in setting the agenda for their own learning. She encourages her pupils to think about, choose, and carry out activities they see as being related to their learning. Choice and decision-making are vital and essential components of the learning environment that is created in her classroom. As with all activities, Nadene supports the children in these process asking regularly, "Is that a good choice?" and "Why?" She first models what it means to make a good decision and she then has some of her pupils model and talk about how they made their decisions, etc. As the children become increasingly able to take responsibility for their own learning, they are given greater freedom to choose among activities and to monitor their own progress. Nadene works alongside, rather than in front of her pupils. Nadene's practice is not predicated on a naïve discovery-learning approach. Rather, Nadene has a clear pedagogical intent for the class but the way in which that intent is fulfilled is negotiated through the interactions brought forth, acknowledged, and responded to by the various members of the classroom community throughout the day. There is a shared consciousness and a valuing of alternatives (Collins, 2004). Organization from within the collective is valued as much as organization by the teacher. The same openness characterizes Nadene's supervisory relationship with her the student teachers. Nadene recognizes that the practicum setting is always going to be different or altered by the presence of the student teacher. The student teacher is not a cog that can be inserted and removed unproblematically, but is recognized by Nadene as being integral to the agenda that will form, shape, and give meaning to the learning experiences in the classroom for both the children, the student teacher, and Nadene herself.

Fourth, to what extent is *disequilibrium* a characteristic of practicum settings? We again contrast Eve's classroom with Nadene's classroom to highlight this characteristic. For Eve, it is important to fix or lock each and every element of teaching and learning in place. Eve places great value on stability as a marker of success. Hence, routinization is not only an aid to organization but also a mainstay of the teaching and learning environment in her classroom. Repetition and drill, consistency and order, are very much evident. Deviations on the part of the pupils or the student teacher from Eve's plans and expectations are treated as 'noise' and regarded as irrelevant or inconsequential to the curriculum that Eve has charted for the class and the student teacher (i.e., what she wants done, and how and when she wants it done). There are no surprises. There is a predictability about everything that occurs.

On the other hand, we get a very different sense when we visit Nadene's classroom. The pedagogical practices that unfold in the course of the school day take into account the unexpected, the unusual, and the unanticipated. Never nearing chaos or confusion, Nadene's classroom is directed as much by what the participants (parents, aids, student teachers, etc.) bring to it as what she brings to it. Throughout the day, one can trace the splicing and blending of the pedagogical intent that Nadene is working towards with the contributions from the various participants: a conversation with the class about pupils who leave their raincoats on the cloakroom floor instead of on the hooks, an unexpected visit by a child's grandmother from China, or the goldfish that is discovered floating belly up in the fish tank. All these events become part of the purposeful discourse in the school day. These impromptu events, along with those planned by Nadene in advance, are interwoven and become part of her pedagogy. At times it is hard to discern what is planned and what is emerging 'in the moment' (Brookfield, 2000). Strict timelines, timetables, and timepieces do not bind Nadene to particular courses of action, be it for her pupils or her student teachers. There are always spaces for new directions, sudden changes, and alternative ideas to be taken up and engaged in throughout the course of the day.

Student teachers, more so that most of us, can relate to experiencing a sense of disequilibrium during practicum. This is often due to unpredicted events, as mentioned above, which occur while the student teacher is intensely focused on their lesson and unit plans and try to implement those plans according to anticipated outcomes. Flexible students are able to embrace disequilibrium, regarding the unfolding process as an opportunity for experimentation, innovation, and risk taking. They recognize opportunities for learning within a supportive framework.

And finally, in what ways might the practicum be regarded as a *nested* phenomenon? As we zoom in or out, does the practicum, reveal similarly complex systems regardless of the level of magnification? Davis and Sumara (2001) note that complexity science, at its essence, is the study of learning and learning systems:

> … a learning system is any complex form that can adapt itself to changing circumstances. Examples include a stock market as it adjusts to unexpected economic news, an ecosystem as it establishes a new balance through climate change, a child who accommodates to the demands of a new classroom, and a workplace community that adjusts to flow with the expectations within the larger social context. For the most part, such systems are dynamic and robusts, able to change and adapt efficiently (Davis & Sumara, 2001, p. 88).

In this paper, our focus has been on the practicum as a complex system. What do we see if we zoom out? The practicum is embedded in a classroom setting, which we would argue is another instance of a learning or complex system, albeit somewhat larger. The classroom is embedded in a school setting, which we would again argue is another instance of a learning or complex system. What if we go the other way, if we 'zoom' in? We encounter the child. Davis and Sumara (2001), as illustrated above, regard the child as a learning or complex system. As you zoom in further, complexity theorists argue that our biological selves constitute further complex systems, for example, organs and cells (Davis & Sumara, 1997, p. 118). Thus, for our purposes, we contend that the practicum setting does indeed represent a nested phenomenon; it is itself a complex system, is part of a larger complex system, and is comprised of similarly complex systems. As complex systems are open systems, influences from one system on another can and do occur. Student teachers are themselves nested within various communities: their practicum peers, their cooperating teacher/faculty advisor/student teacher triad, their student teacher cohort, their university, and so on.

5. Implications for student teacher supervision

We argue that the practicum, to the degree that we have illustrated above, is potentially an example of a complex system or phenomenon. From a supervision perspective this presents a number of challenges to conventional ways of thinking about supervision. At various points we have indicated the ways in which supervisory practices are rendered differently when the practicum is regarded as a complex system. In concluding this paper, we draw back from specifics to explore five broader aspects of supervision that a complexity science sensibility suggests: redefining the practicum, rethinking evaluation, surrendering certainty, acknowledging complicity, and allowing for improvisation.

6. Redefining 'the practicum'

Often, when we think about the practicum, we find ourselves focusing our attention on the student teacher to the exclusion of all other participants and practices. However, if we regard the practicum as a complex system then we are forced to shift our attention away from a focus on the individual considerations of the student teacher to the practicum as a whole. In other words, in contrast to more traditional renderings of the practicum that quickly zero in on the student teacher and his or her activities, a complexity science sensibility requires us to view the practicum as a system of relationships and engagements. A singular focus on the student teacher can only provide a part of the picture. Indeed, we believe that many current school and faculty advisors do not focus solely on the student teacher as they make sense of the practicum experience but we suspect that for many this approach is likely to be more intuitive or tacit than an explicit act on their part. Making it explicit, that is, recognizing that the practicum encompasses a range of participants and practices, demands a systems approach to 'learning to teach.' So, the practicum is much more than just the student teacher and the 13-weeks[6] they spend in a classroom. Redefining the practicum this way has far reaching consequences and forces us to reconsider many aspects of our supervisory practices, for example, the evaluation of student teachers during the practicum.

7. Rethinking evaluation

Our attention solely on the student teacher, while undeniably important, distorts how we apprehend

[6]Thirteen weeks is the length of UBC's extended practicum experience.

the learning that occurs and how it is represented in the practicum, and by implication, how we make judgments about that learning, be it from the children's, student teacher's, or advisor's perspective. As Davis and Sumara (2001) remind us: "Any event of individual learning affects the collective character, and so on. There is no simple, isolated, or consequence-free event in a complex world" (p. 89). From a complexity science perspective, the success of the practicum can only be appreciated by including in our evaluation what is happening to the system as a whole rather than a singular focus on the student teacher within the system. Therefore, in making any assessment about student teacher learning, our attention should be focused on the ways in which the practicum setting has changed during the time that the student teacher has been a part of that setting. It is not just about how the student teacher has changed during his or her time as an individual in the setting but the quality of the collective interactions. Indeed, complexity science suggests that attending to changes to the collective as a whole is likely to tell us more about the individuals that make up the collective, than a singular focus on individuals themselves. An important indicator of a successful practicum, then, would be the transformation that has taken place in the practicum setting as a whole.

We are not arguing for wholesale dismissal of current practices in evaluating student teachers on practicum. For example, there is a place for the current use of checklists as a component of student teacher assessment. Rather, we suggest that such approaches should be recognized as attempts to reduce the complexity of the practicum and only partially capture the learning that has occurred. A broader understanding and appreciation of the system as a whole and how it has changed and responded to the student teacher's participation is likely to be more informative. Therefore, any evaluation of the student teacher should include an evaluation of how the system has changed or altered during the course of the practicum.

8. Surrendering certainty

A complexity science sensibility also warns us of the inevitability of change in the practicum setting as a student teacher enters the classroom. Cooperating teachers must be ready for and anticipate such change. Attempts to hold or fix the classroom as a constant during the practicum are impossible. Efforts to do so indicate a perspective on learning that assumes learning can be isolated, separated, and controlled from the milieu in which it is embedded. A complexity science sensibility suggests that this is impossible:

> Both the cognizing agent and everything with which it is associated are in constant flux, each adapting to the others in the same way that the environment evolves simultaneously with the species that inhabit it. In simplest terms, ecological thinking understands that the boundaries we perceived between different objects and different events are mere heuristic conveniences. Everything is inextricably intertwined with everything else (Davis & Sumara, 1997, p.111).

Perhaps an uncomfortable but necessary outcome is for practicum supervisors to be prepared and allow for the unanticipated and unexpected. From a complexity science perspective we need to accept that which we cannot determine completely in advance. However, indeterminate does not mean that anything goes, or that we abandon our curriculum, plans, and expectations for student teachers. Rather, it is an acknowledgement that expecting our students to conform neatly to a predetermined set of practices and at the same time maximize their learning is highly improbable. If we do, we will greatly constrain the possibilities for the emergence of complexity in all its forms as described earlier. Where complexity is allowed to emerge, student teacher learning will be shot through with a myriad of influences. Therefore what one student teacher learns in one setting will be necessarily different from what another student teacher learns in different setting. There are likely to be as many differences as there are commonalities between the various practicum experiences of the students. This may seem odd at first glance. However, current evaluation practices that focus our attention on commonalities (e.g., many teacher education programs have checklists which provide a finite list of indicators of successful student performance on practicum) often ignore difference between settings and deviations from the norm. As practicum supervisors (both school and faculty) we need to broaden our conception of student teacher evaluation to include the system as a whole. Therefore, student teacher evaluation would include, among other things: a consideration of the pupils and their response to the student teacher's participation in the community; a consideration of the classroom

environment and how it has changed as a result of the student teacher's presence; and, a consideration of the learning that the student teacher's presence has occasioned with respect to the cooperating teacher. That is, the classroom is always evolving and is never constant.

9. Acknowledging complicity

Sally, in a Charles Schulz's (1999) comic strip, upon receiving a 'C' for her coat-hanger sculpture asked her teacher: "… Are you willing to share my 'C'?" (p. 91) (see Fig. 1).

From a complexity science perspective, Sally's observation is quite astute. As supervisors, we are implicated in the practicum, whether we acknowledge it or not. As school and faculty advisors we cannot refer to the practicum as something that 'the student teacher does,' but rather it is something that we are all complicit in. The practicum, as a complex system, is constituted by a series of interactions, relationships, and engagements and cannot be distinct or set apart from those. Even if we try to be inconspicuous during our classroom visits or neutral in our pre- and post-lesson discussions, our presence has an impact on the system. A complexity science sensibility encourages us, if nothing else, to recognize that we, as supervisors, are part of the dynamic system known as the practicum. Acknowledging our complicity requires us to pause and reflect upon how we both influence and are influenced by the practicum. Put another way, acknowledging complicity is a call to a consciousness of self within the practice setting (Clarke & Erickson, 2004).

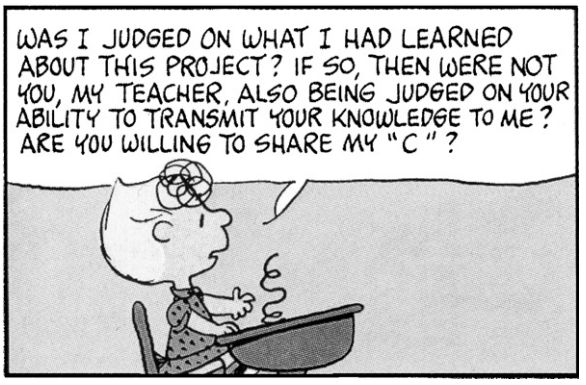

Fig. 1. Are you willing to share my 'C'?
Peanuts: © United Features Syndicate, Inc.

10. Allowing for improvisation

All living, adaptive systems need to be innovative and creative in order to survive the changes that arise in their environment. A complexity science sensibility calls our attention to the need to allow for improvisation; a readiness to genuinely entertain new ideas and alternative approaches. Too often student teachers willingly submit to being told what to do. They happily forgo inquiry and mindlessly mimic their supervisors. However, this is not the sort of learning that we would expect from professionals, and should not be the sort of learning we accept from our student teachers. If inquiry is a defining feature of professional practice (Clarke & Erickson, 2003), then the generative space created by improvisation is essential for the emergence of complexity:

> Improvisation … is often used to help solve problems where conventional thinking particularly within a creative context is not working. It is also used to develop new ways of working that can be spontaneous and innovative. Through improvisation we create relationships with other improvisers that utilize our imagination and explore the differences that exist in relating that leads to creative emergence (Naidoo, 2004, p. 10).

Improvisation relies on interaction, communication, and a willingness to explore. Improvisation during the practicum is not a solitary act but requires the participation of others (including supervisors). Improvisation is a willingness to hold in abeyance patterned responses and allow for the possibility of something new to emerge. The journey that a beginning teacher is about to embark upon may well have been traveled in similar ways by previous student teachers but is both unknown and unexplored by the beginner. Improvisation moves beyond surrendering uncertainty to allow student teachers and their supervisors to engage in thought experiments (Sorensen, 1992) and action possibilities (Roth & Barton, 2004) within mutually agreed upon boundaries. We need to recognize the potential in the question that was asked of Tony ("Are you going to the beach?") and the possibilities it invites *in the moment*. As Beairsto (2001) notes:

> A [learning] curriculum is "constructed" on the basis of required content and student needs, rather than simply "delivered" in a standard

way. From this perspective the notion of "lesson planning," which either ignores or presupposes learner response, is replaced by "lesson preparation," which provides a clear framework of intents but assumes that actual classroom activities must be adapted or even initiated on the fly according to student responses, both individual and collective (p. 9).

We need to recognize the potential of a student teacher wondering out loud about trying something very different to what we, as supervisors, might have planned, as he or she thinks about her lesson and the possibilities for learning that it invites for the future.

11. Conclusion

Taken together, the implications for student teacher supervision arising from our engagement with complexity science throughout this paper and in this final section—redefining the practicum, rethinking evaluation, surrendering certainty, acknowledging complicity, and allowing for improvisation—suggest an alternative way of thinking about the practicum. If 'learning to teach' is regarded as a complex phenomenon, then the initial insights shared here have ramifications for the practicum and for teacher education more broadly conceived. As noted at the outset, this paper represents an initial foray into a theoretical rendering of the practicum that currently lies at the periphery of teacher education discourses. However, following Davis and Sumara (2005) we contend learning systems represent complex phenomena. Therefore, by extension, the practicum, as a learning system, warrants a continued exploration of the sort presented above.

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