

Application of Complexity theory to Educational decision-making process: A model for democratic school change*

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ABSTRACT

This paper attempts to apply the Complexity Theory as nonlinear dynamics system to educational decision-making process as a metaphor. Different from conventional form of linear and static approaches, the chaotic characters of the Complexity Theory provide nonlinear, dynamic, and creative ways of decision-making process. For the application, this paper adopted three major variables from the Complexity Theory: attractors, bifurcations, and the fractal structure. Based on the three concepts, this paper applied the theoretical implications of the Complexity Theory to a school's case, La Escuela Fratney school, and developed a model for democratic school change. Finally, the implications of this modeling and the application are discussed. This suggested model could broaden the horizon of schools' policy-making practices in more democratic ways, facilitated by diverse, open, and self-regulative movements, rather than linear, directive, and hierarchical processes.

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I. Introduction

Schools face an incessant series of agenda that needs to be decided for their administration, curriculum, teaching/learning, and personnel affairs. The way these decisions are made is important because school is not a simple institution comprising teachers and students who teach and learn, but a very complex and comprehensive organization, which is open to various arguments, contentions, and even contradictions arising from the diverse needs and expectations of those involved (Davis & Sumara, 2006). For this reason, schools are places where most decisions are complicated and disputable at every moment.

No matter how we describe the process of schools' decision making, i.e., Educational Decision-making Process (henceforth, EDP), in terms of "Conflict theory" (the theory of power relationships) or "Communication theory" among administrators, teachers, parents, and even students, it is too complex to explicate the process with a single outline (Simon, 1986). Schools are supposed to undergo this similar process in their tasks, but the forces driven by needs, expectations, and goals from diverse members of the school make the EDP ambiguous, conflicting, and fluctuating (Davies, 2004; Bolman & Deal, 2017). Thus, it is necessary to take a stance on how to interpret this EDP phenomenon, understand its complexity, and determine what it is supposed to be.

To provide an alternative approach to understand the complicated nature of EDP, this paper borrows the major concepts of Non-linear Dynamic System (henceforth, NDS) theory, an overarching term that embraces Chaos theory, Complexity theory, and Catastrophe theory (Guastello, 1995), which are considered metaphoric explanation of the phenomenon, EDP (Barratt, 1994). Standing on this theoretical basis, this paper ventures to explore three major research questions as follow: first, how can the NDS theories be applied to the decision-making process in educational policy? If they can, what principles and variables can be extracted from the NDS theories for highlighting the nature of EDP? Second, what is the suggested procedure ruled by the principles and variables of NDS theory to explain an EDP? Third, what is an actual example of EDP delineated by the NDS framework, which is suggested by this paper? Building on these research questions, this paper suggests a "Complexity model for EDP," comprising three major theoretical components of NDS theory: attractors, bifurcations, and fractal structure.

The body of this paper embraces the following three components as its line of reasoning: Literature review, Development of a complexity model of EDP, and Case analysis an application. In the literature review, this paper provides conceptual orientation of this paper's project and discusses how NDS theory could applied to EDP and how the

application benefits the field of educational policy and leadership regarding democratic decision-making in school. In the development section, this paper pinpoints three seminal parameters for EDP —attractors, bifurcations, and fractal structure—, and variables related to each parameter, extracted from the NDS theories. On top of these parameters and variables, this paper suggests a model of EDP, which shows how an EDP is made throughout such complicated parameters and variables are involved. This model is depicted in a flow chart as a concept map to illustrate the procedure. Finally, in the application section, this paper epitomizes the processes of reform of a local school and discusses six lessons obtained from the analysis of the school's case. The process of reform and the lessons obtained from it can serve as a model for democratic school change by an EDP, which is the major goal of this paper.

This paper's theoretical review and application of the chaos model as a metaphor may serve as practical guidelines for teachers or school administrators who want to make a decision for changing their school policies with more democratic way.

II. Literature Review

A. Conceptual orientation

There are two rationales for the inception of this paper. One rationale of this paper's approach is taking a different perspective on the meaning of 'orderliness' in an organizational decision-making process. Orderliness presumes itself as a righteous thing or a desirable status in matters of school and society, while *Chaos*, its opposite, is considered to be what must be avoided. Thus, the conventional educational theorists may believe that education is responsible for transmitting the 'social order' of current society to children and adolescents. In this case, *Order* is nothing but an ideology that is trying to maintain the legitimacy of the current system. In this paper, it is argued that order is not always preferable, especially in the practice of EDP, because it may restrict the nature of variable, creative, and democratic ways of EDP. As an alternative approach, this paper argues that the concepts from NDS theories (e.g. Complexity or Chaos theory) can provide meaningful insights in dealing with the issues of EDP, because of the fundamentally different perspectives in interpretation of social and institutional phenomena, as well as its use in explaining natural phenomena. This is one reason why the application of Complexity theory in EDP is significant.

This being said, Geyer & Rihani (2000: 8) provides clear distinction between the

notions of order and chaos as shown in the following <Table 1>.

<Table 1> Comparison of the traits of order and complexity

Order (Linear)	Complexity (Nonlinear)	Disorder (Anti-linear)
Complete rationality	Bounded rationality	Complete irrationality
Total Certainty	Limited certainty	Uncertain
Predictability	Limited predictability	Unpredictable
Linked causes and effects	Causality is indeterminate	Causality is meaningless
Determinism	Evolutionary change	Chaos

Geyer & Rihani (2000: 16) argues that, from a non-linear perspective, a vision of consensus and uniformity could lead to stultifying order as opposed to “healthy creative” complexity. It means that EDP, with the scheme of NDS, can be flexible, changeable, and emergent, rather not be restricted by determinism; it is also different from vague uncertainty, irresponsibility, and irrationality.

Another significance of this paper’s approach resides in its democratic consideration in school practices. Order in school usually comes from the agency with power: the principals, the bureaucrats, teachers rather than students or community members. The exercise of order produces a kind of power imbalance between administrators and teachers, teachers and students, or teachers and parents (Maxcy, 1995). Accordingly, this one-sided power exercise might cause a fundamental and serious problem in achieving a pedagogical goal and making school democratic. Bruner (1973) articulated it as a self-organizing process that order must originate from inside. This paper argues that the concept of ‘chaos’ needs to be interpreted as the “self-organizing process,” or Kauffman’s (1995) notion of *Order for free*, not ‘disorder.’ For example, this *order for free* might look like *Chaos* the same way that diverse and unpredictable behaviors of students look to parents, teachers, and school administrators. Without understanding this chaos in students’ minds, or their inner system of order, teachers or teachers’ leadership (Morrison, 2002) will fail to reach their pedagogical goal. Even though it looks like chaos, students’ inner system of order is clearly rule-governed and self-organized with their own regulation system.

In short, democratic decision making is a rule-governed and self-organized process, though the process looks uncertain, unpredictable, and even *chaos* (Escobar, 2017). As this principle is investigated in many educational settings, they are the natures of social relationship, especially in such cases as democratic school reform (Armstrong, 2005; Kayuni, 2010; Normore, 2004).

B. Application of NDS theory to EDP

Cambell (1993) argued that complexity can occur in social structures, such as our behavior in making plans, purchasing goods, or selecting one among multiple choices, etc. NDS theory is one way of studying an institution where such complexity exists in its system. According to Cambell, complexity of a system can be defined by several traits: e.g. number and diversity of components, the degree of freedom, the influence of environment, etc. By considering these traits, it is important to determine whether the system is conservative, an equilibrium, a static stage or stable, or it is dissipative, non-equilibrium, phase stage, or unstable. The former traits are for a closed system that is considered to be less complex, and the latter traits are for an open system that yields more complexity.

Furthermore, to apply NDS theory to EDP, the following three points need to be considered: i) whether EDP belongs to an open system; ii) what conditions EDP has; and iii) how we can deal with the complex or chaotic situations. Let me briefly explain these three points.

For the first point, Merry (1995) argued that decision-making in human affairs becomes more complex as a result of the mounting number of driving forces, such as increasing populations, new technologies, and rising human expectations. As Cambell (1993) acknowledged that socioeconomic institution is a typical example that allows fluxes of goods, services, people, and information, school is an institution with an open system in such dynamic circumstances. Every decision school makes is under the influence of such ecology in which school resides, and many factors, agents, and interests are closely related to the decisions. At all times, the openness in the school's EDP is quite requisite and significant, for it yields democratic and creative optimism in all agenda that school confronts.

For the second point, we have to designate what conditions exist in school's EDP. It is important to define the conditions of school—factors of influence or parameters of variances—that might affect the EDP in the school because, for successful leadership or a decision-making, there is a certain amount of time and preparation needed (Shapiro & Stefkovich, 2016). For instance, when a school needs to decide whether it introduces a new program for 'underrepresented' minority students, the school has to predict probable resistance, pitfalls, and turnarounds as a consequence of the introduction. For EDP in school, such variables are regarded as parameters. In this sense, this paper proposes exemplary parameters from the NDS theory, i.e. attractors, bifurcations, and fractal systems, which explicate the model process of EDP in the school as an open system.

For the third point, 'chaos' means, in NDS theory, the existence of unpredictable or random aspects in dynamic matters (Poincare, 1952); nonetheless, there is still possibility

of getting ‘order out of chaos’ (Prigogine, 1984) since the system is not static, but dynamic. As Poincare had opened our eyes to this chaotic aspect of nature, Macchia (1994) claims that NDS theory may help to explain and resolve the stagnant situation in which the dilemma of educational decision making finds itself.

To brief, educational systems are nonlinear systems that tend to operate chaotically, although there are hidden patterns and/or attractors that keep them within bounds. It is normal and natural to have such varieties, but it is still important to identify the structure of school system, the hidden patterns (i.e., attractors or bifurcations), and the boundaries of decision making. Thus, this paper argues that, by analyzing these chaotic features in educational phenomena, more predictable reactions can be dealt with more efficiently and effectively for necessary and timely educational decisions.

C. Democratic decision-making in education

Most educators agree that schools are a crucial locus for training children to become democratic citizens. In this sense, Hochschild & Scovronick (2000: 212-213) emphasize that schools are supposed to provide common core of knowledge and set of values, to model to deal with diverse others, to teach democratic practices, and to provide broad social goal of equal opportunity. NDS theory can be a useful conceptual framework for democratic policy-making initiatives for school. There are studies that applied Chaos theory to educational policy-making for democratic school changes (Ball, 2016, Bowe, Ball, & Gold, 2017) or problem solving in school administration (Dimmock, 2013). Also, a plenty of researches investigated the practices of democratic EDP and suggested various democratic policy-making strategies, such as, leaders’ collaborative decision making (Furman & Starratt, 2002; Schoenfeld, 2010) or strategies for making democratic community (Henderson & Kesson, 2004). In the same vein, O’Hair, McLaughlin, & Reitzug (2000) suggested the concept IDEALS, which introduces some characteristics of democratic decision making: inquiry, discourse, equity, authenticity, leadership and service.

To implement democratic decision-making practices into education, it is important to see that school is a very complex organization comprises various stakeholders. Brazer & Keller (2006) emphasizes that multiple stakeholders typically involve in school’s decision-making process: national and regional associations, superintendent, parents and community members, national and local governments: i.e., each stakeholder’s involvement is also a variant, as they argue “likely enter and exit the web as their interests change over time and as decision foci change” (Brazer & Keller, 2006: 5). Each of the multiple stakeholders intervenes in the process of decision-making by imposing different

levels and sources of power, legitimacy, and urgency (Pettigrew, 2014; Winn & Keller, 2001). In this sense, democratic policy-making tends to be very complex, multi-variant, and time-consuming process, in nature. However, the complexity in schools itself can be a condition for more creative and evolving democratic schools in the future (Davies, 2004).

III. Developing a complexity model of EDP

In this chapter, this paper develops a complexity model for EDP by adopting three parameters for the suggested decision making process.

A. Parameters for educational decision-making

1. Attractors: initial phase parameter

In NDS theory, there are mainly three types of attractors: *fixed-point attractor*, *limit cycle attractor*, and *repellor*, which determine whether the system is conservative or dissipative and whether it is chaotic or not. We need to pay attention to what such chaotic attractors induce to EDP and how they influence the decision-making procedure. What we choose for initial conditions will decide what we will experience. One of the important characteristics of Complexity theory is that obstacles are generated from inside, not induced from outside. For example, Fairman & Mackenzie (2015) investigated a high school's decision for student-tracking policy which had to be balanced between teachers' professional leadership and parents' demand. The obstacles, the cacophony inside of the school, prevented the school from reaching agreement in which direction it should pursue its administrative goal. Even if we agree on the general direction in education, any minor factors from the attractors, in their initial conditions as well as their intermediate conditions, could change the course to an entirely unscheduled direction.

The attractors in initial phase are analogous to new agenda, proposals, or even critiques inside or outside of school organization, ranging from the principal to an invisible student. At this phase, there is no guarantee where about the decision may arrive; nonetheless, it is the sign of the beginning of democratic decision making.

2. Bifurcations: developmental phase parameter

Bifurcation is a ('control') parameter that is indicative of qualitative changes in the dynamics of nonlinear systems. Bifurcations make the matter bigger; for instance, the way how parents, teachers, and school administrators react to students' delinquent activities may bring them to totally different avenues (Guastello, 1995, 24-25). The significance of bifurcation variables for EDP is in that a tiny change in the phase of bifurcations might result in a huge difference: one single and trifling decision can steer the school to utterly different consequences. For instance, according to Critical Model of Educational Decision Making (Habermas, 1987), there are several agencies that influence a school's decision: provincial government, division board, and district board in the level of instructional structures, and directors, principals, and teachers within the school's administrative system. The involvement of these agencies can be bifurcation points.

It is noteworthy that bifurcations can make the developmental phases go into a chaotic situation; on the one hand, it is not easy to grasp the situation, clarify the cause of a problem, and make a judgment for appropriate solution. On the other hand, there is an order or a pattern, though it looks complicated. The change of phases is not a static order driven by outer force, but a latent order initiated by an inner self-regulative force. The final phase is the fractal structure, which is explained in the next section.

3. Fractal structure: recursive phase parameter

Fractal structure has self-referential (or recursive) and self-similarity dimensions: though it looks complex, there are self-referentially repetitive patterns with idiosyncratic shapes (Briggs, 1992; Mandelbrot, 1983). Fractal structure in nature shows that it is not a random structure but a systematic, self-referential structure, which has "structural integrity and orderliness" (Cambell, 1993: 162). This paper argues that this principle of fractal structure is also applicable to many practices in EDP. For example, the core foundation for establishing democratic education starts from the genuine democratic decision-making process, from the smallest group or individual level.

Similar to fractal structure, democracy on a small scale constitutes democracy on a larger scale. For democratic education, the practice and execution of democracy needs to be started from home, class, school, district, and to the state. A democratic EDP on a small scale, in a classroom, can be a pattern that can be used as a source for self-referential fractal structure for democracy on a larger scale, e.g. in an entire school district. A genuine democratic nation originates in a genuine democratic home or community. Each democratic home reproduces its structure and procedure with a self-referential strategy, to become a constituent unit for democratic community. In the next section, a model of EDP is suggested based on the NDS theory that has been discussed so far.

B. Suggesting a Complexity Model of EDP

Based on the introduction of parameters for EDP, this paper suggests a model of EDP in terms of NDS theory, borrowing three elements of NDS discussed so far. The followings are the major notions of the model adopting from the NDS theories. Attributes of these three parameters—*attractors*, *bifurcations*, and *fractal structure*—contribute to each phase of the decision-making process: *initial phase*, *developmental phase*, and *recursive phase*, respectively. Each parameter has its own variables, as it is explained above: *attractors* have fixed-point attractor, repeller, limit cycle, and strange attractor, which work as ‘*positioning factors*’ in the decision-making process. *Bifurcations* have bifurcation point, period doubling, control parameter, and order parameter, which act as ‘*influential factors*.’ *Fractal structure* has traits of self-reference, complexity, chaotic attractor, and Annihilation phase, which function as ‘*constituent factors*.’ These variables and their traits can be organized as shown in the following <Table 2>.

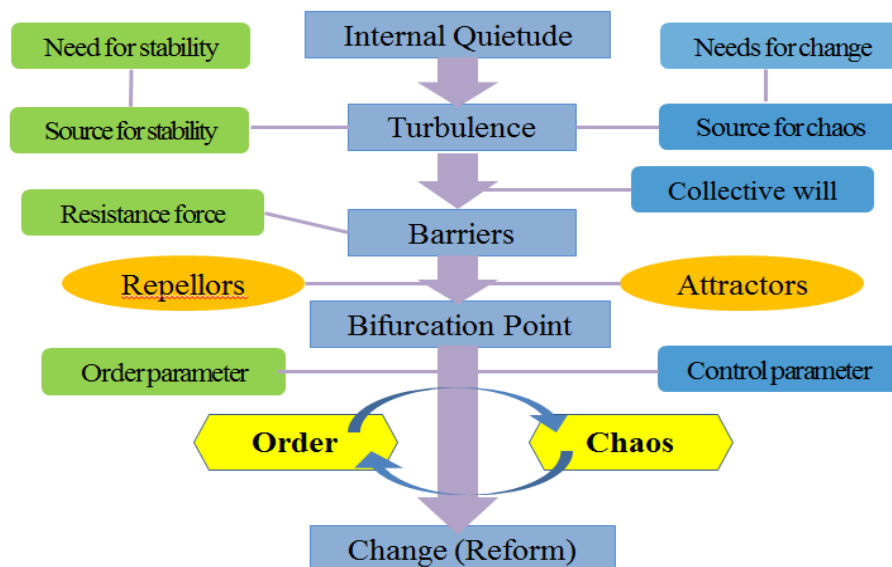
<Table 2> Variables adopted for the NDS theory of EDP

NDS elements	Attractors	Bifurcations	Fractal structure
Decision process	Initial phase ►	Developmental phase ►	Recursive phase
Variables in each phase	Fixed point attractor	Bifurcation point	Self-reference
	Repellor	Period doubling	Complexity
	Limit cycle	Control parameter	Chaotic attractor
	Strange attractor	Order parameter	Annihilation force
Decision making factors	Positioning factors	Influential factors	Constituent factors

To brief the mechanism, EDP is influenced by several positioning factors. These represent the stances, situations, or interests voiced by agencies or members of the institutional system, such as school. The agencies play their roles in the initial phase of EDP while breaking the equilibrium of the current status and making it unstable. Then EDP comes across the bifurcation point, selects a path, and goes through the developmental phase of the decision-making process. During this phase, EDP is influenced by the impact of period-doubling, control- and order-parameters. At the same time, this process embodies some constituent factors like *self-reference*, *complexity*, or *chaotic attractor*, and finally falls into the Annihilative phase. In this last phase, the process might become intermingled or complicated and lose its direction; however, Chaotic attractors could break the stagnation and lead the process into a certain direction or a totally different horizon. These systematic and recurrent phases provoke complexity, diversity, and creativity in the system of NDS.

The typical application of Complexity theory to social science or human affairs is Organizational Development (Porras & Robertson, 1992), which can be termed as “a structured set of techniques for transforming an organization from one state of affairs to another.” According to Guastello (1995), there are three significant assumptions in OD theory: i) the *changing* stage is initialized by the need for a change; ii) anything that appears frozen is “just a temporary respite between bouts of change, which are primarily chaotic”; iii) even where there is internal quietude, *turbulence* characterizes the external environment, which itself is a source of chaotic behavior within the organization (p. 336). The most important lesson from the OD theory is that, even though the development looks chaotic, we can control it. What we need is ‘a need for change’ to break through quietude.

In short, to initiate a change, an organization needs to be moved to a bifurcation point that yields an unstable situation. From that point, change becomes possible. An organization moves to its bifurcation point when its internal entropy level has increased sufficiently. This mechanism of chaotic paradigm of OD implies that creativity induces chaos and chaos induces creativity. Chaos and creativity are thus parts of a reciprocal dynamic, and self-organizing process and communicative link assist the transition from chaos to a creative work. This paper calls it a Complexity model of EDP which can be illustrated as the following flowchart as [Figure 1].



[Figure 1] A Complexity model of EDP for democratic school change

This model visualizes how a change might happen in EDP in term of parameters and variables of Complexity theory. An initial stage starts from internal quietude; however, every institution has problems and defects that need to be reformed. Usually, the need for change comes from the grassroots who are suffering from the problems. Hence, needing work as sources of the seed of chaos, they make the system turn into a phase of turbulence. However, resistance that makes things remain in their status-quo emerges as a barrier against the change. At this point, several *attractors* or *repellers* may work as variables in the decision-making process. These attractors/repellers create conditions for a *bifurcation point*, and this point is also swayed by *order/control parameters* that make the phases of change complex/simple, fast/slow, or order/chaos.¹ In a final phase, the process is still under the influence of known/unknown chaotic factors, which are the source of creativity by themselves. This reciprocal loop of effects between creativity and chaos is the conclusive factor that finalizes the change. However, this newly-drawn change is never an end-result; in the system ruled by Complexity theory of NDS, new order always is a seed for new chaos.

IV. Case analysis: Application of complexity model

This paper applies this model to one real case of democratic school reform in La Escuela Fratney school (henceforth, Fratney school). This school has been introduced as one of the cases that a school policy decision made democratically, overcoming many conflicts among the school members (Apple & Beane, 1995).

A. Backgrounds of the school

Fratney (High) School in Milwaukee, U.S.A. was promoting a two-way bilingual, multicultural, whole-language program. It had 360 students from kindergarten to fifth grade; 65 percent of them are Hispanic, 20 percent African American, 13 percent white, and the remainder Asian and Native American. According to the author (Peterson, 1995: 60), Fratney School encountered five major problems in promoting the bilingual program: i.e., i) a central office wedded to autocratic methods of leadership; ii) a school

¹ Order parameter is a notion proposed by Haken (1981), who initiated the study of self-organization in physical systems and used it in explaining the onset of macro-level, coherent phenomena. Control parameter is another factor that may works for or against the order parameter to affect the degrees of order/disorder.

system structured to inhibit collaborative teaching practices; iii) parents and teachers tied to the authoritarian habits of their own schooling; iv) students conditioned by a mass-media culture that values individual consumption over the common good; and v) a socioeconomic system that places little value on urban schools and the families served by them. These are the obstacles that the school board has to resolve, and here is how they reached an agreement and made a successful school change.

B. The process of reform

Facing the peril of demolition of the school, a reform was initiated by Neighbors for a New Fratney (NNF), which raised an agenda that the school would be run by a site-based council of parents and teachers, in opposition to what the administrators wanted: a teacher training school organized and run by the central office. Consequently, there had been struggles for political power and debates and conflicts over developing the program, including renovating the facility, selecting the principal and other staff, and putting in place the curriculum and related materials. The series of efforts by NNF to promote the new program can be listed as in the following <Table 3>:

<Table 3> NNF's efforts and their relevancy to complexity parameters

The process of change of Fratney school		Parameters
I. Initial Status: The Collapse of old Fratney school → Needs for change 1) Parents' concern for their students 2) Announcement of NNF's vision and mobilization of the community		Collective Will for a change (<i>Attractors</i>)
II. Conflicts Efforts of Change (For a two-way bilingual school: A school run by a local teachers and parents)	Reluctance to Change (For an Exemplary Teaching Centre: A school for staff development)	(<i>Turbulence</i>) Between <i>Attractors</i> & <i>Repellers</i>
III. Seed for change : A exemplary success story of a 1 st grade student		<i>Bifurcation point</i>
IV. Efforts vs. Barriers 1) The effort of parent representatives 2) A nationwide search for a new principal 3) Efforts to get new material and resources	1) Stonewalling of the admin. 2) Puppet principal 3) Administrator's refusal of releasing school materials	<i>Control /Order parameters</i> <i>Attractors met repellers:</i>
A change happens in the critical moment 1) Stormed into the central office, and made the superintendents their allies 2) Change of attitude of Superintendent: Made the administrators in line 3) Finally, the tide had turned in climax, then <i>Period-doubling</i> has occurred		<i>Chaotic attractors</i>
Reform achieved		

The process of change of Fratney School can be analyzed into five stages: i) initial status wanting for change, ii) conflicts between efforts of change and reluctance to change, iii) emergence of seed for change as a *bifurcation point*, iv) a series of efforts of change vs. barriers against the change, and v) continuous efforts made the dramatic change in the critical moment and finally reform achieved. The analysis of the process yields the following six lessons.

C. The Analysis: Six lessons

Based on the perspectives of the Complexity model for democratic change and the analysis of Fratney School's change, this paper found six lessons as strategies for educational decision-making as follows:

Lesson 1: Grass-root movements can produce real change. One of the answers for querying the secret of the success was "hard work, being well organized, and acting quickly when opportunities presented themselves" (Peterson, p. 78). It asserts that the power of the grass-roots movement should be an important theme woven through all school curricula. Grass-roots movements at a class level were the initiating democratic seeds for a change against static, desperate, undemocratic situations. The initial grass-roots movement was a smaller scale fractal structure to make up a larger scale structure with its *self-referential* development. There are several examples: i) the moment of 'when opportunities presented themselves' can be considered to be a *bifurcation point*, and there was also *period-doubling*; ii) 'acting quickly' was a *control parameter* that will affect the pace of change; and, iii) 'hard work' and 'being well organized' were *order parameters*, which were the driving force of movement, and both eventually did drive the situation to dramatic changes.

Lesson 2: Multiracial unity is essential to successful school reform. The main points of this theme were: i) to make each group of people convinced about the reform; ii) to set up decision-making sub-groups; and iii) to try to institutionalize power relationships between majority and minority groups for the issue. In Fratney school case, the multiracial background of students was a field full of dynamic forces. One goal, for instance, for equal use of a second language for teaching, such as Spanish, had brought resistance from the majority. The goal of equal appropriation of each language was an *attractor* for democratic practice in school. However, the objection from the English-dominant language group was a *repellor*. The attractor, if it does not overcome the repellor, would have remained in a *limit cycle* with no progress. Fratney school, however, had overcome the repellor with the effort to foster a healthy multicultural atmosphere, and this effort appealed to major groups also by convincing them of the good aspects of

the program.

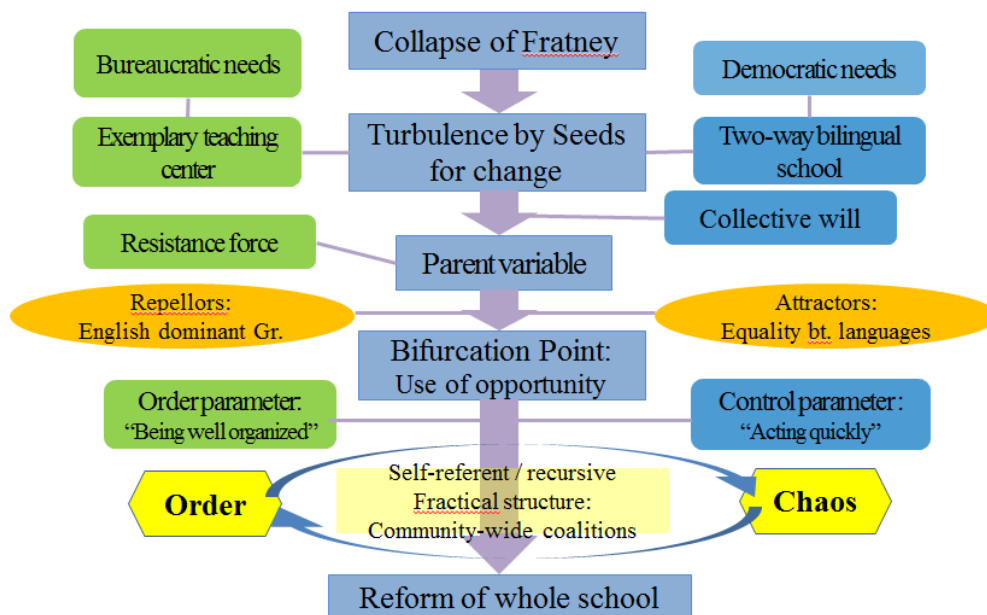
Lesson 3: Build in time to reflect and learn. The groups tried to devote additional time and effort to confront the problem regularly and efficiently. To stay with the existing condition was just not good enough to change the situation. This repetitious trial and recursive feedback on the system would have become a motivational power for reform. Those forces lead a system to the *catastrophic* and *explosive bifurcation*. In Fratney's case, three factors functioned as such explosive bifurcations: i) a collective will from teachers and students was organized; ii) ideas and suggestions reflected by members of each, and structured; and iii) the time and experience shared with each other were accumulated as *period-doubling* forces (or phases) for change.

Lesson 4: Genuine parent involvement is critical. The 'parent' variable can work either as *attractor* or *repellor*. Fratney's experience shows that parents are more likely to come to the school if they are able to exercise genuine power in decisions that directly affect the future of the school and their children's lives. Fratney school took full advantage of the 'parental' factor as an *attractor* in developing a democratic school. An *attractor* usually is in accord with the direction of progressive movement, while a *repellor* is not. Fratney school had kept the 'parent' variable from being biased, encouraged a frank approach to sensitive issues, and promoted progressive and challenging policies. These democratic approaches for 'parent' variable were in accord with the school's democratic goal; consequently, these approaches invited it as an *attractor*, not a *repellor*.

Lesson 5: Structures that foster change must be institutionalized. The success of many schools is a result of many people spending enormous amounts of time and energy in a fight against the status quo. Therefore, people must institutionalize structures that allow and foster change in public schools and in the teaching profession. The institutionalization of changed structure means a *fixation of parameters*. This fixation helps us be more concerned about other variables—*attractors*, *repellors*, and *parameters*—and saves our energy for upcoming issues. These structures either can be chaotic structure or fractal structure. The important point here is that the structural efforts, with open and flexible minds, will expedite change without any unnecessary hesitation and stagnation by *limit circle*. It is a kind of scaffolding to promote the change continuously and systematically.

Lesson 6: Successful school reform is part of larger efforts for societal change. Fratney experience has shown us that the reform of any particular school must take place within a larger context of district-wide curricular reform and structural change. Small efforts like La Fratney can be a foundation for the development of community-wide coalitions between parents and schools to enhance activities and movements that will improve schools and communities alike. This lesson shows that *self-referent* and

recursive fractal structure evolves from small scale to larger scale, then spreads to neighbors, districts, and the whole nation. This complex and recursive, but self-referential, evolution is one of the most important features of an open system. Schools, being an open system, are required to be flexible, sensitive to the voices of the grass roots, and continuously ready for any necessary changes and reforms. This attitude makes them live, healthy, and significant for all of the school members and their neighbors. This application of six lessons can be also portrayed in flowchart as in the following [Figure2].



[Figure 2] An application of Fratney school case to the Complexity model for Change

To review the flowchart, there were two choices to save the collapsing La Fratney school: an ‘exemplary teaching center’ initiated by bureaucratic needs, or a ‘two-way bilingual school’ to help real kids in need. Facing the collective will for democratic change, La Fratney school was about to change; however, there were repellers in the course of change, i.e. a resistant force seeking to keep the *status quo*, the ‘parent’ variables, skepticism, etc. Nonetheless, La Fratney school has made a successful change and has been reborn as a democratic two-way bilingual school.

In sum, according to the Complexity model, the presence of *Order* or *Chaos* alone is not a decisive factor that commands the directions of change in EDP. EDP is influenced by both order and chaos that mutually interact all the time as complementary forces, very sensitive to initial condition, and apt to change with even trivial variables.

Therefore, to plan a democratic change in school, we should pay attention to all possible variables and factors that it has been discussed so far. Moreover, when a school system ends up with a certain result, the result might be spread to other schools or districts, as shown in the event of self-referent and recursive fractal structure.

D. Implication of the study

NDS theory gives us meaningful insight to understand and get prepared for the essential complexity of EDP for contemporary schools. There are three fundamental merits of the NDS parameters and variables in applying to our practices of EDP. First is the sensitivity to low-level stimuli. This means that we could be very sensitive to minor, low-level, and intermittent opinion, especially the opinions of students, minorities, and unprivileged people, which makes EDP democratic. Second is the flexibility. Multiple-functional systems that are chaotic are much more flexible, while a non-chaotic system is to be regulated by mono-functional controller. Considering chaotic factors in EDP makes the decision much more situational, adjustable, and reliable. It does not require 'one size fits all' adoption. Third is that it summons up creative resolution. The circulation of chaotic variation is not a closed circuit. Chaotic system, essentially, is open to any change as it allows the system to become complex and look randomly. But within the randomness, there is a seed for creativity, change, variation, and progress. Our job is not blocking chaos, but allowing it in a controllable way for a desirable direction.

However, there are also concerning voices over the abusive application of Chaos theory into educational practice. For example, Hunter & Benson (1997) argues that the complexity of human behavior is not sufficiently accounted for in the theory, and the initial assumptions governing Chaos theory were not created to account for human behavior. They criticize that 'education chaoticists' are making a similar mistake as the behaviorists who use stimulus response principles in education. Therefore, they urge that proponents of a chaotic theory are obliged to demonstrate that Chaos theory offers a clearer, more coherent, and more consistent understanding of educational events. Responding on such criticism, this paper is an attempt to explicate and suggest a probable model of democratic EDP, based upon the principles and ideas of the NDS theory. This Complexity model can be one trial of such systematic application of NDS theory.

In NDS theory, order is not given from outside, but generated from inside; in fact, order imposed from outside conflicts with the order subsisting inside. As our society is full of chaotic phenomena, there are many chaotic features in EDP in school. Thus, the application of Complexity theory provides intuitive perspectives to understand the EDP; in other words, it is a more flexible, creative, and democratic way to understand the EDP. The democratic EDP is that, as it has been shown from the two schools' cases, the origin

of change is not coming from outside of school, but is generated from inside, based on the need of every member of the school community. Furthermore, the development of decision takes a diverse, inductive, open and self-regulative process, rather than a linear, directive, and hierarchical process. In this sense, the Complexity model for EDP provides an insightful understanding for a democratic decision-making process in school.

V. Conclusion

By revisiting the Complexity theory for NDS in terms of an application to social science, this paper has discussed several important concepts of the theory and tried to adapt them to EDP for democratic school. Among them, this paper chose three major elements of NDS theory: *Attractors*, *Bifurcations*, and *Fractal structures*, and analyzed EDP in the perspective of metaphoric notions of these parameters by extracting democratic methods or strategies embedded in the concepts. This paper has also proposed that several traits of such parameters can be applied to the appropriate stages of EDP, and explained them by suggesting a specific model, the Complexity model for Change. Finally, this paper has applied the model and its analysis to one real schools' case of democratic reform in Fratney School that was introduced in Peterson (1995).

Contrary to the perspectives of linear dynamic system theories, which simply posit contradiction and incompatibility between chaos and order, NDS theory acknowledges complementarity between the two, which says 'order is embedded in chaos.' A self-organizing dynamic force in a chaotic system (or open system) makes the circuit run incessantly: from Annihilation to Attractors, to Bifurcations (or Period-doubling), to Fractal structures (self-reference/ complexity), and again to Annihilation. This paper's application of this conceptual framework to EDP in school is significant because: i) it recognizes schools as complex, open, and organic institutions, which highlights the fact that schools are not static, stratified, or fossilized institution, but very lively, variable, and growing organizations; ii) the inducement of chaos theory sheds new light on EDP in school administration since it helps school leaders, including policy makers, administrators, teachers, and community representatives, to have more flexible, diverse, and creative perspectives on the EDP; and iii) it provides us an idea about what factors are influential for making a democratic school successfully: e.g. recognition of any chaotic movement in small scale, being sensitive to initial conditions, and attention to the voices from the grass roots (students, parents, and teachers).

Although there is criticism of the misapplication or over-application of the chaos theory as metaphor into the practices of education (Hunter & Benson, 1997), it would be helpful for school teachers and administrators to conceive this model confronting with

various dilemmas in the route of school change. Since the bureaucratic culture of school administration in Korean schools is quite not open to the 'bottom-up' initiatives for school reform, this model can serve as a model case for overcoming any conflicts or obstacles to any democratic changes. This paper's discussion may also broaden the theoretical perspectives of the field of school administration in Korea, since the major literature is still concerned in the discourses of bureaucratic theories (Hanson, 1996; Wilson 1989), the rational decision making theories (Hoy, 1980, Simon, 1979), or the conflict theories (Baldrige, 1971; Thomas, 1992). In this sense, with the understanding of concepts and perspectives of the complexity theory and its detailed variables and parameters of EDP, the progress of school administration in Korean can make it a right course for more open, predictable, and eventually democratic way.

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