



Received: 02 July 2014
Accepted: 06 February 2015
Published: 12 March 2015

*Corresponding author: F.S. David Ng,
Policy and Leadership Studies Academic
Group, National Institute of Education,
1 Nanyang Walk, Singapore 637616,
Singapore
E-mail: david.ng@nie.edu.sg

Reviewing editor:
H. L. Wendy Pan, Tamkang University,
Taiwan

Additional information is available at
the end of the article

EDUCATIONAL LEADERSHIP & MANAGEMENT | RESEARCH ARTICLE

Leadership learning for complex organizations

F.S. David Ng^{1*}

Abstract: Many school leadership programs are set and delivered in specific modules or workshops in order to achieve a pre-determined set of competencies, knowledge, and skills. In addition, these programs are driven by the faculty member and the prescribed content. As Singapore schools become more complex in the roles and responsibilities to educate the future of the nation, new ways to develop school leaders is needed. This study investigates the effects on leadership learning based on a complexity theory-based design leadership program. The learning outcome emerged as practical leadership knowledge that participants generated as they actively participate in the leadership program. A serious implication of complexity-based design would mean shifting from an “objective and course-driven” learning to “learning that emerged and process-driven.”

Subjects: Educational Change & School Reform; School Leaders & Managers; Theories of Learning

Keywords: leadership; leadership development; complexity theory; program design

1. Introduction

Singapore’s educational landscape is dynamic and has seen major transformations in the last four decades since gaining independence in 1965. The dynamic landscape is a reflection of how the government sees education as a vital tool to develop the nation’s human capital that is aligned with the economy and social sectors.

Over the past 40 years, many processes to develop a rigorous curriculum emphasizing knowledge acquisition, development of thinking and process skills, and inculcation of values have been put in place. Macro performance indicators such as improvements in the literacy rate and mean years of



F.S. David Ng

ABOUT THE AUTHOR

F.S. David Ng is an Associate Professor at the Policy and Leadership Studies Academy Group, National Institute of Education (NIE), Singapore. He is a key faculty member in the leadership programs at NIE and international educational leadership programs. His areas of specialization include school leadership, principalship, and learning technology such as computer simulation programming. He is the author of the books, “Change Leadership: Communicating, Continuing, and Consolidating Change”; and “Interactive Learning for School Leaders.” He has published book chapters and articles on leadership, innovation, and change.

PUBLIC INTEREST STATEMENT

Many school leadership programs are set and delivered in specific modules or workshops in order to achieve a pre-determined set of competencies, knowledge, and skills. In addition, these programs are driven by the faculty member and the prescribed content. As Singapore schools become more complex in the roles and responsibilities to educate the future of the nation, new ways to develop school leaders are needed. This complexity theory-based design is a viable and sustainable alternative to generate learning that matches the challenges and complexity of the twenty-first century. A serious implication of complexity-based design would mean shifting from “faculty-centric” to student-centric learning. It would also mean that faculty members must be willing to step back and allow learning to emerge rather than to dictate how learning ought to proceed.

education revealed that the education system has been successful in addressing the problems of low literacy rates and low education levels which confronted Singapore during its early independence years.

Today, the strength of the education system is reflected in the students' overall performance and achievement and in international studies such as Trends in International Mathematics and Science Study (TIMSS), Progress in International Reading Literacy Study (PIRLS), and the high percentage of students proceeding to postsecondary education

From 1997, at the opening of the 7th International Conference on Thinking, the Prime Minister of Singapore, Mr. Goh Chok Tong, articulated the need to develop the capacity for learning so as to build the nation's wealth in the twenty-first century. He shared that Singapore's vision to meet the challenges for the future is best encapsulated in these four profound words "Thinking Schools Learning Nation."

Since then, several major initiatives such as "Innovation and Enterprise" (I&E), which was launched in 2004, in order to develop an innovative and enterprising spirit in the young through the schools, and "Teach Less Learn More" (TLLM), launched in 2005, aims to enhance innovation and diversity in the curricula and pedagogical aspects of education. The most recent initiative in 2010 that is based on the twenty-first century competency framework is the new "Curriculum 2015" which envisions every child to be developed into a confident person, a self-directed learner, an active contributor, and a concerned citizen. Teachers must be convinced that "improving overall literacy achievement is directly associated with the country's economic productivity." This is the clearest expression of how the government sees education as directly linked to the economic direction and future of the nation.

These new educational initiatives give more autonomy to school leaders and teachers to lead and manage schools. There are fewer prescriptions of programs. Instead, school leaders and staff are encouraged to emphasize on innovation and to instill greater professionalism in the management of schools.

The article looked at a case study where elements of complexity theory are incorporated into the design of a leadership development program for school leaders amidst the fast-changing educational system in Singapore. The article argues that the traditional "behavioural-designed learning and development is insufficient to prepare school leaders in an increasingly complex environment." Complexity theory establishes the founding knowledge in understanding the school as a complex organization, as well as an important stakeholder in addressing the demands of the nation

The following two major questions guided the case study:

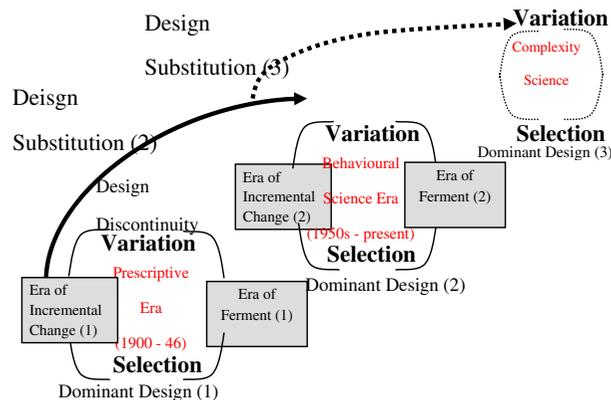
- (1) From the perspectives of participants, what practical knowledge emerged from participating in the learning process in the leadership program?
- (2) How did the practical knowledge emerge?

2. Evolution of leadership development

In the past 50 years, educational leadership programs have often seen incremental improvements rather than discontinuous change within a dominant design (Figure 1). In addressing this, we have conducted an extensive review of literature and traced the evolution of educational leadership development to three eras: prescriptive, behavioral, and proposed complexity era. During each era, the design and delivery of programs were based on the conceptual framework of the era. In each era, the discontinuation of the dominant design came about because of a technological substitution and deep dissatisfaction of the current limitations of the design. The following sections highlight the conceptual framework of each era and discussed how the framework determines leadership learning.

Figure 1. Evolution of educational leadership development.

Note: Adapted from Tushman and O'Reilly (2013) and Ng (2014).



2.1. The prescriptive era (1900–1946)

There was little formal training in this era. Most school administrators learned their profession on the job through the trial-and-error processes during the prescriptive era. The little formal training that was provided taught courses on basic pedagogy, philosophy, school management principles, and leadership characteristics. The emphasis was on the “great man” and trait theories (Cooper & Boyd, 1987) and the application of philosophical knowledge to schools (Murphy, 1998). The “great man” theory was based on identifying leadership traits of successful leaders in the political, business, and battle field. These successful leaders were deemed to have certain traits such as being bold and being decisive. Leadership development then was designed based on how best to teach these successful traits to participants. For close to 50 years, the prescriptive approach was the dominant design for every leadership program in the world.

In every design, the era of incremental improvement will take place where a program will be refined within the parameters set by the dominant design. Inevitably, the law of diminishing return sets in where the degree of improvement becomes significantly diminished—causing dissatisfaction in the design outcome. This dissatisfaction leads to the start of an era of ferment where institutions begin to seek for alternative theoretical frameworks. The emergence of scientific research provided the platform for technological substitution ushering in the next dominant era of design—the behavioral science influence.

2.2. The behavioral era (1947–current)

In the late 1940s to about 1985, theoretical and conceptual material drawn from the social sciences began to influence training programs. This was also a period of ferment in the field of school administration. Much criticism was leveled against “the naked empiricism, personal success stories and maxims or untested principles that constituted the knowledge base of educational administration” (Murphy, 1998). This resulted in considerable changes to the structure and content of training programs to mirror the perceived higher status of school administration in society. Four major changes were noted: (a) educational administration was now viewed as “an applied science within which theory and research are directly and linearly linked to professional practice” (Sergiovanni, 1991), (b) social science content was the predominant yardstick used to indicate a high quality program (Miklos, 1992), (c) almost universal adoption of behavioral sciences’ research techniques and instruments for research (Culbertson, 1988), and (d) a multidisciplinary approach to principal preparation (Culbertson, 1988).

Scientific research in this era provided evidence-based decisions on learning and development. In particular, learning could now be supported by evidence of changes in the three domains of cognitive, affective, and psychomotor.

The behavioral science era quickly supplanted the prescriptive design and became the new dominant design in leadership development. Characteristics of the behavioral science include the following features: a set of learning objectives, a specific body of knowledge (content) to be taught in order to achieve the objectives, and adopting the right pedagogical approach to deliver the body of knowledge. These characteristics meant that learning could now be efficiently and effectively taught.

While the behavioral science era is still relevant to a certain extent, there are inherent weaknesses in the design that again gave rise to discontent and ferment in further refining any program. One of the inherent weaknesses of the behavioral science is that learning is predetermined knowledge. In addition, the increasing complexity of organizations, the influence of external factors such as globalization and information technology has significant impact on emerging knowledge of how educational leaders need to lead and manage schools differently. The awareness that predetermined knowledge and the body of knowledge which is based on known and past knowledge is no longer suitable to meet the new and current challenges. The world is changing rapidly and new knowledge is generated at a fast pace, the behavioral science era is no longer suitable as the only way to design any teaching and learning programs.

2.3. The emerging era (complexity theory)

As stated earlier, the dominant design for educational leadership programs has been centered within the behavioral science era. However, in the last decade, there is no lack of new theories such as strategic choice theory to learning organization theory, to open systems theory, and now to chaos and complexity theory as competing theories in teaching and learning design. This progression suggests a move to take into account the complexity of interactions, uncertainty, unpredictability, and their relationship with diversity and creativity within an organization.

Cunningham (2000), in a conference paper submitted to the Institute of Education University of London, proposes, “Complexity theory may provide a tool for tracing the emergence of simple organizing principles from the complexity of social interaction and have implications for the study of schools and their communities.” Morrison (2002) shares Cunningham’s views and opines, “Complexity theory incorporates, indeed requires, unpredictable fluctuations and non-average behavior in order to account for the change, development and novelty through self-organization.”

The following section will extrapolate from the main diagram and focus on the complexity theory era. It briefly describes the concepts within this new cycle. The section also discusses the approaches to learning and delivery of educational leadership programs based on the concepts discussed.

3. Complexity theory

This section briefly looks at key concepts of complexity theory. A relatively new perspective in the field of educational leadership, complexity theory provides an explanation in understanding the school as a complex organization. Complexity appears in the twentieth century in response to criticism of the inadequacy of the reductionist analytical thinking model in helping us to understand learning, and suggest an alternative approach for knowledge in general and the knower, the object of knowledge, method, and truth.

Morrison (2002) noted that, “Complexity theory incorporates, indeed requires, unpredictable fluctuations and non-average behaviour in order to account for the change, development and novelty through self-organisation.” The ability to successfully self-organize is a vital characteristic for any organization to possess in order for it to flourish in the complex world it exists in. Leithwood and Day (2007) add, “Schools are dynamic organisations, and change in ways that cannot be predicted” as they have observed from leadership studies they reviewed from eight different countries. By looking at the complex system of an organization, leadership should consequently be viewed in a different light. A complex system is a functional whole, consisting of interdependent and variable parts. In other words, unlike a conventional system (e.g. an aircraft), the parts need not have fixed relationships, fixed behaviors or fixed quantities, thus their individual functions may also be undefined in

traditional terms. Despite the apparent tenuousness of this concept, these systems form the majority of our world, and include living organisms and social systems, along with many inorganic natural systems (e.g. rivers).

By evaluating leadership learning thru the lens of complexity theory, it provides a different and new perspective on how individuals learn. This is especially for leadership development programs that are designed with elements of complexity theory incorporated into the learning structures. The process of learning takes on a non-linear and unpredictable manner that makes setting fixed learning objectives meaningless.

The following is a brief explanation of key concepts of complexity theory:

3.1. Emergence

Emergence is a key concept in understanding how different levels in a system are linked. In the case of leadership learning, it is about how the individual, structure, and system are linked. These different levels exist simultaneously and one is not necessarily more important than the other, rather they are recognized as co-existing and linked. Each level has different patterns and can be subject to different kinds of theorization. Patterns at “higher” levels can emerge in ways that are hard to predict at the “lower” levels. The challenge long-addressed in learning is how such levels are to be linked. This question of the nature of “emergence” has been framed in a variety of ways including those of “macro-micro linkage,” “individual and society,” the “problem of order,” and “structure, action and structuration” (Giddens, 1984). In this paper, Giddens’ (1984) explanation of emergence as the relationship between the different levels through the “structure and agency” is adopted.

Giddens stated that the term structure referred generally to “rules and resources.” These properties make it possible for social practices to exist across time and space and that lend them “systemic” form (Giddens, 1984, p. 17). Giddens referred to agents as groups or individuals who draw upon these structures to perform social actions through embedded memory, called memory traces. Memory traces are thus the vehicle through which social actions are carried out. Structure is also, however, the result of these social practices.

3.2. Non-linearity

Non-linearity in this paper that refers to leadership learning means that the causal links of the outcome of learning form something more complicated than a single source or single chain of events. Learning outcome is considered linear if one can add any two sources of learning or solutions derived from the teaching. Non-linearity in leadership learning would mean that the output of the learning is not proportional to the input and that the learning does not conform to the principle of additivity, i.e. it may involve synergistic reactions in which the whole is not equal to the sum of its parts.

One way to understand non-linearity has often referred to how small events lead to large-scale changes in systems. Within the natural sciences, the example often cited (or imagined) is that of a small disturbance to the atmosphere in one location, perhaps as small as the flapping of a butterfly’s wings, tipping the balance of other systems, leading ultimately to a storm on the other side of the globe (Capra, 1997).

3.3. Self-organization

Self-organization happens naturally as a result of non-linear interaction among members of an organization (Fontana & Ballati, 1999). As the word describes, there is no central authority guiding and imposing the interactions. Members in the organization adapt to changing goals and situations by adopting communication patterns that are not centrally controlled by an authority. In the process of working toward a goal (for example, solving a leadership problem), self-organizing members tend to

exhibit creativity and novelty as they have to quickly adapt and to find ways and means to solve the problem and achieved the goal. As a result of interactions among members, the emergence of new patterns in conversation happens. This is an important aspect of self-organization. When there are no new patterns in conversations, there is no new idea and no novel ways to solve problems. It must be noted that new patterns of conversation depend upon the responsiveness of its members toward each other and their awareness of each other's ideas and response. As a result of the behavior of interacting members, learning, and adaptation or novel ways of solving problem emerge.

Mansfield summarized a dissertation that suggested the application of complexity theory to organizations. Mansfield (2003, p. 2) wrote:

Complexity theory seeks to encourage spontaneous self-organisation and the emergence of new effective developments ... will throw out challenges rather than solutions; it will encourage diversity, creativity and paradox, expecting disagreement as a necessary element in innovation. There will be no imposition of top-down pressure to deliver, indeed diversions from the norm will be amplified and supported. The organisation will support the creation of informal networks or teams that seek to work flexibly to find best-fit solutions.

4. Singapore's executive leadership program based on complexity theory

The Leaders in Education Program (LEP) was conceptualized in 2001 in Singapore. It is a six-month full-time principalship development program that is designed to meet the educational reforms in Singapore. Prior to this program, the program goal is to develop current and future "principalship capability" in an increasingly complex world. Such principalship capability will be values-driven, purposeful, innovative, and able to succeed in ill-defined conditions. The achievement of the program's broad and deep goals demands a vibrant learning structure that is based on active and ongoing participation in a community of professional practice. What participants will learn is determined by the deep interactions and the active participation in the rich processes such as action learning, dialog, reflection, external perspectives, and so on. In other words, participants will be actively creating personal and content knowledge. The section will provide an example of complexity-based learning in the program that has incorporated elements of complexity theory in the design of the program (Ng, 2013). Complexity theory establishes the founding knowledge in understanding the school as a complex organization, as well as an important stakeholder in addressing the demands of the nation.

4.1. Knowledge creation through innovation project

Participants are attached to a school throughout the program and they spend regular weekly time in that school carrying out a major innovation project. They receive support and guidance from the principal of the school, the superintendent, and a university faculty member. The project is expected to help the school to improve in leadership and management practices that lead to student learning and is meant to be a profound learning experience for the participant.

The school attachment provides the platform for participants to create new knowledge. In the short time that they spend in the school attachment, they must lead others (teachers, students, parents) to do new things and must find different ways of doing existing things. The goal of creating new practical knowledge is to take the school to a higher level of achievement.

In brief, the project involves them in challenging current practices by looking at a school from the standpoint of its strengths, and then identifying a range of innovation opportunities. From these opportunities, participants will select a potential idea for a comparatively significant innovation.

The key element in this learning project is the emergence of a workable innovative idea. This parallels complexity theory's element of emergence and non-linearity where participants self-create knowledge (learning) during interaction with the stakeholders and components in the school system.

The implementation of the innovation project is a powerful test of their leadership capability. To date, participants have successfully completed a wide array of innovative projects and many of these projects have been sustained by the schools.

4.2. Syndicates

The syndicate is a key component of the program. Participants meet in a small group setting (five or six members) and the syndicate leader who is a faculty staff will act as a facilitator. The syndicate leader will monitor participants' learning throughout the program, including the school attachment, the innovation project, the learning from the international visit, and the broader classroom-based learning. An intensive learning relationship will thus develop between participants and their syndicate leader, and amongst fellow participants. The syndicate meetings take place on a weekly basis.

The basis for syndicate meetings is to encourage divergent and exploration thinking through conversations. Conversations are complex responsive processes of themes, triggering themes through self-organizing associations (element of self-organizing in complexity theory) and turn taking that both reflect and create power differentials in relationships. These conversational processes within the group result in a continually emerging of thoughts of the individual. Individual and group relationships are also co-created and emerge together as they participate in the deep conversations. In essence, syndicate meetings provide the opportunity for change for the individual and the group when the pattern of conversation changes because it is this that organizes their experience.

If one takes this perspective that an organization is a pattern of talk (relational constraints), then organization changes only insofar as its conversational life (power relations) evolves. Organizational change is the same thing as change in the pattern of talk and, therefore, the pattern of power relations. Creativity, novelty, and innovation are all emergence of new patterns of talk and patterns of power relations.

4.3. Partnerships in learning

Much of the learning is through strong partnerships with schools, business organizations, and educational institutions both in Singapore and overseas and supported by learning in the university class and tutorials.

These participants are exposed to leadership in the business organizations and to ideas from various sources, including government organizations. To further enhance such influences, key officers are invited from the education, civil, and other ministries to engage in dialog with participants and to observe some of the work undertaken on the program.

There is also an international component to the program. This is a two-week all expenses paid international visit by the participants led by the syndicate leader and a senior school principal. The team investigates successful innovative practices overseas, undertake critical analyses, and gain significant insights into how educational innovation in Singapore might be managed. The inclusion of this component, while not unique, provides an extended platform of learning on the international stage. Thus far, participants have visited Switzerland, USA, UK, Canada, Scandinavian countries, Europe, China, Australia, and Hong Kong.

Therefore, a global approach of learning is adopted. The exposure to a larger local and international systems will inadvertently triggers thoughts and perspectives in participants. Although the larger system may seem independent of the responsibilities of the participant as a principal-in-training, there is no doubt that the larger system is directly or indirectly connected. In other words, what happens in the social and economic aspects of USA and Europe, for example, may influence how leaders reshape and refocus student learning and development in Singapore. This parallels the element of emergence in complexity theory where the influence of the larger system may cause a re-formulation of perspectives and behavior of the individual.

4.4. Action learning delivery: Content as learning support

While the interest of most leadership programs is directed at the “content” of a program, the LEP emphasizes on “delivery” as the focus of learning. The content is there as learning support, but the delivery architecture is what sets it apart from other programs. Action learning is a central concept in the delivery of learning. In this concept, participants know what they are taught, but they do not know what they will learn. They have to create their own knowledge through team learning, and this takes place in what is called “syndicates,” a group of six or seven people meeting weekly and facilitated by a university professor. They know what knowledge they have created only when they come to the end of the program through these intensive weekly meetings.

5. Methodology for analyzing complexity-based leadership learning

The case study is adopted to investigate a contemporary phenomenon when the boundaries between the phenomenon and context are not clearly evident (Yin, 2003), meaning that it is not clear when the phenomenon ends and the context begins or vice versa. This certainly applies to the concept of key learning outcomes such as complexity theory in which the situation [or context] is “both constitutive of and constituted in leadership activity [the phenomenon]” (Spillane, 2004, p. 21, italics in original). Although the context may enable or constrain leadership activity, the context may also be created or even transformed through leadership activity, thus blurring the boundary and relationship between leadership (the phenomenon) and the context. This dialectical relationship between leadership and the context in which leadership practice is enacted underlies the importance of studying the leadership learning and complexity theory within a specific situation, or case.

5.1. Sampling procedure

The sample is representative of all participants who attend the leadership development program—LEP. As such, participants in the LEP were invited to participate in the study but for the purpose of a detailed study, five participants were selected randomly based on those who agreed to participate. The sampling was conducted by the researcher in the beginning of the program. The sampling instructions were given to these individuals as an attachment to the letters that was sent to them prior to the start of the program regarding their involvement in the study.

Due to the constraints of the length of the paper, analysis of learning from one participant is discussed in detail in this section. This is because explanation of the thought processes could get quite confusing when multiple participants are included.

5.2. Data collection and analysis

The use of the following methods of data collection in case study was adopted:

- Document study (innovation reports, future school reports, journals, assignments),
- Observations, and
- Interviews.

For the interviews, semi-structured interviewing technique was used. Each interview was facilitated by the researcher and one research assistant. Each interview lasted between 2 and 3 hours.

Data analysis and interpretation was iterative, that is, conducted simultaneously with data collection from semi-structured interviews and supplemented with investigators’ memos and document study. Several techniques were employed to gain trustworthiness and authenticity during the analytical process (Guba & Lincoln, 1994). The initial stage of open coding followed the procedures laid down by Strauss and Corbin (1990). The open codes were systematically identified and grouped into categories and themes (Punch, 2005). This procedure involves strategies for meaning-making such as triangulation, sifting for patterns, comparing, contrasting, and sorting gross categories (Fetterman, 1989; Miles & Huberman, 1994). Broad patterns were generated from the identified themes and categories and their relationships and interrelationships sought. This analytic induction process

ensured that leadership perceptions were carefully read and sorted, combined, and re-orted until a coherent coding scheme was developed. Moderation and standardization of the coding scheme was achieved through frequent and regular meetings between the researcher and research assistant. These meetings involved frequent cross-checking, identifying, and code-forming procedures (Merriam, 2002).

5.3. Instrumentation

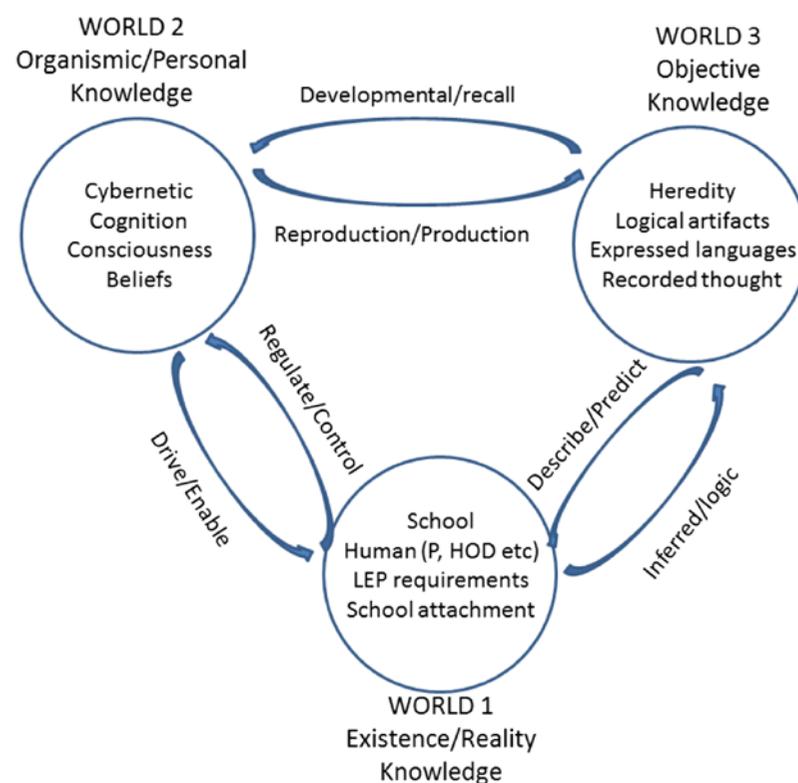
For this study, the focus is in the key outcomes of learning in a complexity-designed leadership program.

One of the key features of complexity theory—emergence, is not easy to “measure” in research. Emergence not only involves the linkages between “structure and agency” but include the individual knowledge and beliefs within the “agent” or member. In this regard, it is necessary to adopt a more structural framework in order to provide a clearer explanation of the linkages between structure and agency. This case study adopted Popper’s framework as the instrument to “measure” learning or new knowledge that emerged.

Popper’s three worlds’ representation of knowledge and learning is relevant and complementary to complexity theory. For example, two kinds of knowledge exist in autopoietic systems. The first is subjective knowledge where Popper’s W2 explained this form of knowledge as the subjective state of consciousness, beliefs, feelings, and memories are found. The second is control information that has been symbolically encoded, where that information can potentially be recalled and decoded (Etxeberria, 2004; Rocha, 1998). This exists in W3 or known as objective knowledge (Figure 2).

Popper’s concept of knowledge applies to living systems. In its primitive sense, “knowledge” is selectively assembles and control information contributing to survival. Popper (1972) divides existence and products of cognition into three ontologically related domains called “worlds.”

Figure 2. Karl Popper’s three Worlds and evolutionary epistemology (Hall, 2003).



Popper (1972, pp. 108–109) states that there are:

... two different senses of knowledge or of thought: (1) knowledge or thought in the subjective sense, consisting of a state of mind or of consciousness or a disposition to behave or to react, and (2) knowledge or thought in an objective sense, consisting of problems, theories, and arguments as such. Knowledge in this objective sense is totally independent of anybody's claim to know; it is also independent of anybody's belief, or disposition to assent; or to assert or to act. Knowledge in the objective sense is knowledge without a knower: it is knowledge without a knowing subject.

World 1: is dynamic physical reality governed by universal laws of physics, chemistry, and biology, for example, the world of phenomena and the ultimate “truth” knowledge of the material world.

World 2: comprises cognition, consciousness, and beliefs of discriminate entities formed within World 1. Beliefs, in particular, are dependent on how adequately the belief “represents” World 1. This adequacy is tested in action. According to Popper, knowledge is a belief or theory about reality that can be tested and acted on. Whether the belief is “true” can never be proven conclusively. Cognitive entities semantically represent and anticipate World 1 to maintain their existence in the face of World 1 perturbations or change. It is akin to what Kauffman (1993) called attractor basins. An attractor is defined as a force; condition that draws the system to repeat a typical pattern (serves as magnet). For example, government policies act as attractors conditioning management and leadership behavior.

World 3: comprises persistent logical content produced by cognition, e.g. experience-based heredity, contents of manuscripts, books, and libraries encoded in language. Such logical content is at the same time objective, intangible, and transcendent. Therefore, any written texts or graphical representations in the form of image, symbols, models, and frameworks can be considered as knowledge in World 3. It could also correspond to what Nonaka (1994) called “tacit” and “explicit” knowledge. More importantly, the logical content can be evaluated by World 2 cognitive processes—i.e. through subjective or intersubjective criticisms.

Popper's (1972, pp. 241–245) key considerations with regard to the origins and development of knowledge from the three Worlds are as follows:

- All organisms are constantly involved in solving problems or existence.
- All problem-solving proceeds by trial and error: “new reactions, new forms, new organs, new modes of behaviour, new hypotheses, are tentatively put forward and controlled by error-elimination.”
- Error-elimination may proceed either by the complete elimination of unsuccessful forms (the killing-off of unsuccessful forms by natural selection) or by the evolution of controls which modify or suppress unsuccessful organs, or forms of behavior, or hypothesis.
- Using “P” for problem, “TS” for tentative solutions, “EE” for error-elimination, Popper expresses what he calls his “tetradic schema”:

$$P_1 \rightarrow TS \rightarrow EE \rightarrow P_2$$

where P_1 is an existentially objective survival problem the individual faces, TS is a tentative solution, EE is a process or circumstances for eliminating errors that tests the tentative solution and eliminates it if it does not “work”, and P_2 is the outcome or solution to the initial problem P_1 and the basis for a new problem after having solved or failed to solve P_1 . Popper notes that there may be multiple tentative solutions to a problem thus they are iterated almost endlessly.

6. Analysis of learning using Popper's three Worlds

Learning does not always happen when there is “teaching.” In the program, each participant is attached to a school to develop an innovation project that will lead to student achievement. The key learning from working on the innovation project in the school comes from the many interactions,

discussions, and reflections related to the innovation project. The school attachment is a journey of personal discovery and deepened participants' understanding of innovation, especially in the school context, as well as seeking ways to influence the school in some positive ways.

Employing Popper's World 1 Knowledge iterative tetradic schema, ($P_1 \rightarrow TS \rightarrow EE \rightarrow P_2$):

where P_1 is Factual knowledge of the requirements of the LEP program, specifically the innovation project, attached school information, etc. The structure provided the factual knowledge of the requirements of the LEP program. The structure involves the following:

The innovation project

Description of innovation and justification for its selection.

Explanation of how it builds on school's strengths.

Explanation of whom it benefits (market) and how.

Description of how the innovation works (technology).

Evidence of impact

Explanation of how evidence shows an impact on the school.

Relevant data collected during implementation, including information on the analysis of data.

Sustainability

Description of how the innovation is built into the routine work of the school.

A sensible time frame plan for the innovation to work.

Therefore, this factual knowledge sets the background or structure for the participant to work from. Participants are then attached to a school to implement the innovation project. The attachment is seen as beneficial to the participant and the school as the school will get fresh ideas and ways from the participant to improve student achievement.

The school's location, demographic details, vision, and strategic plans provide participants additional factual knowledge and set the parameters for how the participant will work on the innovation project. These facts provide the context for non-linearity, self-organization, and emergence to take place.

6.1. Structure and agency and linkage between World 1 and World 2 knowledge

As described, the linkage between structure and agency depends on the individual member's own interaction patterns, knowledge, and beliefs. This is explained by Popper's linkage of World 1 and World 2 Knowledge. Due to the constraints of the length of the paper, analysis of learning from one participant is discussed in detail in this section. This is because explanation of the thoughts processes could get quite confusing when multiple participants are included.

Here's an excerpt from the interview on how details of the school provides a backdrop (World 1 Knowledge) for the participant to explore innovative ideas (World 2 Knowledge):

I think I might possibly need to assess the dynamics of awkward, difficult or unmanageable situations to explore constructive alternatives during my school attachment at AB Secondary School given that I am new in the school environment. Having a good understanding of the reframing process could possibly provide a clear and coherent way of organizing the uncertainty and disorder around me during the course of my innovation project. From the structural frame, here is my perspective of AB School: AB Secondary School is committed to strengthening the profession of education and helping to raise student achievement through improved classroom practices by exploring new ideas and innovative pedagogy.

The establishment of the Creative Studies Consortium (CSS) in Jan 2007, a synergistic amalgamation of 4 subject areas (Art, Music, Design and Technology and Home Economics), is one of many strategies that the school has put in place for its overall Teach Less Learn More (TLLM) endeavours

In the LEP, the learning features that facilitate W2 processes are the weekly syndicate discussions, journal reflections, school attachment, and the innovation project. Participants also draw information and knowledge through a non-linear process such as gathering just-in-time information from readings, class lectures, organizational visits, and international visits. Much of the information-gathering process appears to be independent of each other. However, the learning features and information-gathering processes are directly or indirectly connected to the innovation project therein fulfilled the self-organization feature of complexity theory.

Popper's tetradic schema provides a systematic way to analyze the emerging subjective knowledge in the mind of participants as they go through the program's learning features.

As there is no direct way to record the above thoughts, representation of the thoughts in the form of reflections as recorded in the journal are the best proxies. The following excerpts taken from the journal provide evidence of those explorations:

6.1.1. P1 (objective survival problem) = Exploration on the following questions

What is innovation?

As seen in the following interview excerpts, the participant spent a considerable amount of time reading through the recommended text on innovation. In the process, the participant has already embarked on reflecting on the innovation project.

Interview excerpts

According to Hamel, concept innovation is the ability to discover drastically new models or significantly change existing models in ways, which produce new value for customers, and produce greater than average income. Likewise, in schools, we have to explore how we can produce the new value for our students and how we can produce greater than average results. This will be the mindset I intend to adopt for my innovation project with AB School as I embarked on a curriculum innovation project to use Artful Thinking to define the work of the newly established Creative Studies Consortium in the school.

The direction of the reflection is further guided by the stipulated objectives of the project which include the following question:

What are the strengths of the school and how do I turn them into innovations? Participants in the program were explicitly told by the faculty that strengths referred to skills, knowledge, and attitude of people. As such this participant clearly spent time talking to staff and identifying the key staff who have the skill, knowledge, and right attitude in implementing the innovation project. The reflection on identifying the key staff is seen in the following excerpt.

AB School (NVSS) is committed to strengthening the profession of education and helping to raise student achievement through improved classroom practices by exploring new ideas and innovative pedagogy. The establishment of the Creative Studies Consortium (CSS) in Jan 2007, a synergistic amalgamation of 4 subject areas (Art, Music, Design and Technology and Home Economics), is one of many strategies led by two Heads of Department (HOD) that the school has put in place for its overall Teach Less Learn More (TLLM) endeavours. These two HODs have considerable knowledge in the successful in implementation of the CSS. They conducted courses for the staff and were instrumental in helping staff acquire the skills to implement CSS.

The mission of the CSS is to cultivate an intrinsic interest in our pupils to apply creativity in everyday situations for solving problems and innovation. The vision is for every Vistarians to live to learn i.e. to continually seek to expand their knowledge and to apply creativity to enrich their lives and for the betterment of the nation.

6.1.2. *TS (tentative solution) = Exploration of tentative solutions*

Popper's tetradic schema provided the second process TS (Tentative Solution) which represents the subjective knowledge of World 2 knowledge. In World 2, the subjective knowledge representation of cognition, beliefs, and consciousness could be captured through the reflection of participants in their journal.

The exploration of tentative solutions is captured in the journal as the participant explored the following questions:

What are some innovations that could be generated from the identified strengths of the school?

What are some relevant theories, models, and programs that inform the innovation project?

What were some suggestions shared in the syndicate discussions related to the innovation project? How did the syndicate members help shaped the formation of the innovation project?

To this end, NVSS will be adopting Artful Thinking – a model developed by Harvard Project Zero over 2 years, in collaboration with the Traverse City, Michigan Area Public Schools (TCAPS) for integrating art into regular classroom instruction – to anchor the work of the CSS in order to enhance students' holistic development and teacher capacity. This is aligned with two of NVSS' strategic thrusts of Excellent Arts Education and Effective Teaching and Learning to achieve the school's mission and vision.

The Artful Thinking (AT) Program seeks to improve areas in the curriculum that will strengthen students' thinking and learning. Essentially, the program takes the image of an artist's palette (see diagram below) as its central metaphor. A typical palette is made up of a relatively small number of basic colours which can be used and blended in a great variety of ways. The AT palette is comprised of 6 thinking dispositions and each of these dispositions has specific intellectual behaviours associated with it.

- Reasoning (involves constructing arguments and seeking evidence);
- Exploring viewpoints (involves looking at things from different points of view);
- Finding Complexity (involves uncovering multiple dimensions and layers);
- Comparing and Connecting (involves exploring juxtapositions and seeking connections);
- Questioning and Investigating (involves posing questions and finding avenues of inquiry); and
- Observing and Describing (involves close looking and representing).

6.1.3. *EE = Process that tests the tentative solutions and emergence of the solution*

The third process within the tetradic schema involves trial and experimentation. In this process, the participant go through an iterative process of doing (experimenting), learning from what is successful and eliminating what is not successful (errors). These are the reflection questions that the participant goes through in the iterative process of learning from the implementation of the project:

How should I present the innovative idea to the school leadership?

What are my own experience and knowledge that are useful to contribute to the project?

How does my prior experience in implementing change helps in introducing the innovation project?

The following EE evidence shows clearly the exploration phase which culminated in the participant learning from the process of trial and error.

As I look back to my curriculum innovation work in Victoria School, I realize that, as an educator, I followed the beliefs of idealism in theory with use of pragmatism on a day-to-day basis when I introduced the Teaching for Understanding (TfU) framework in the school. The TfU framework was developed at Project Zero, Harvard Graduate School of Education (HGSE), in collaboration with teachers from a range of schools in the USA and aims to enable teachers to teach for understanding.

The big idea of TfU is to bring knowledge to life by engaging students in active learning. It is predicated on the assumption that knowledge is a human construct and that learners must play an active part in changing their minds, making sense, connecting prior ideas with new ones, thinking with what they learn, and creatively applying knowledge in novel situations i.e. understanding requires thoughtful application of ideas that are meaningful in the performance context. This is exactly what was advocated in a ASCD video segment the class watched in the final session of LEP 006a which advocated authentic, rigorous, valid and engaging performance tasks in schools to promote “enduring understanding.” I believe that when the students are truly engaged in performing their understanding, they will not fall behind the high-stakes test and exams given their depth of understanding and engagement in the subject matter.

The iterative process between World 1 and World 2 constantly tap on various sources of information that the participant taps on throughout the leadership program. As described in the leadership program, the structure of the program provides participants multiple sources of input through the syndicate discussions, readings, courses, and most of all, through the implementation of the innovation project.

Here is the EE evidence found in the participant’s journal that captured the learning through implementation of the project and input from the syndicate members:

For a start, NVSS will adopt Artful Thinking as an instructional approach for subjects in the CSS. This will also serve as the vanguard to promote a school-wide movement toward a culture of thinking. As teachers worked with the AT, they will recognise it as something that can be applied in all subject areas and that it can help to deepen and sharpen their practice, and give them a common language for exchanging ideas to promote thinking.

I am reminded through the syndicate discussion with regard to ensuring that the innovation project should not be an add-on or isolated programme. As such, I will ensure that CSS will implement the AT with the following 3 key principles:

- (a) The regular use of thinking routines in the subjects in the CSS;
- (b) Detailed documentation of student work in ways that reveal and extend student thinking; and
- (c) Regular teacher study groups that examine student work and explore issues of thinking-centered instruction.

It is very timely that today in class, I was reminded that enabling teachers through just-in-time learning is very important to ensure that teachers feel supported in their work. Therefore, I have reminded the HOD to ensure that ongoing training should be an integral part of the project to ensure the success of AT in NVSS. The just-in-time workshop could be implemented in the following manner:

In the initial phase of implementation, the AT Core Team will be conducting school-based workshop for teachers in the CSS to give them a better understanding of strategies and principles pertaining to the use of thinking routines. The team will run workshops to develop and build up a range of teachers with various levels of skills and expertise in using the AT program - from the novice to the expert level. VP (LEP) will also share with the School Management Committee will the TLLM initiative. The AT Core Team will also make available to all teachers in the CSS a personal handbook of Thinking Routines. The AT Core Team has

met in April 07 to plan and map out the implementation details for the CSS. The CSS will implement the AT program for its existing Secondary 1 curricula from in Semester 2 Term 3 in 2007 for a start.

If the AT program is successfully implemented to support NVSS' TLLM effort, we will to share what we have learnt with the wider community in the cluster and beyond.

6.2. Structure and agency and linkage between World 2 and World 3 knowledge

World 3 knowledge is represented by the evidence of the product—the innovation project document and report. Participants submit a report of the innovation project and their journal of reflection at the end of the program. The innovation project report provides encoded evidence of the practical knowledge that emerged as an outcome of implementing the innovation project while the journal provides evidence of participants' thought processes while implementing the project.

In Popper's tetradic schema, P_2 represents the emerged solution and understanding as a result of solving the problem in P_1 . Perhaps this is the easiest representation of World 3 knowledge as we look for evidence of learning through the successful completion of the project as documented in the final innovation project report that the participant submitted. Here is an excerpt of the "summary" learning that the participant documented in the report:

The innovation project has successfully implemented the Artful Thinking program. Perhaps this is best summarized as a project that requires students to take the image of an artist's palette as its central metaphor. A typical palette is made up of a relatively small number of basic colours which can be used and blended in a great variety of ways. The Artful Thinking palette is comprised of 6 thinking dispositions (Reasoning; Exploring viewpoints; Finding Complexity; Comparing and Connecting; Questioning and Investigating; and Observing and Describing) and each of these dispositions has specific intellectual behaviours associated with it.

In addition, Artful Thinking also provided the perfect platform for the school to launch its 'Student Art Ambassador Programme' in collaboration with the Singapore Art Museum (SAM). The training of the Art Ambassadors was designed and introduced for students who have demonstrated a good mastery of the use of Artful Thinking in their classes. For the first time, 15 Secondary One students from the Express and Normal Stream were given the opportunity to serve as Art Ambassadors at SAM's Open House on 9 Aug 07, in conjunction with Singapore's 42nd National Day as well as ASEAN's 40th Anniversary, where the Art Ambassadors engaged SAM guests and visitors (including Prof Tommy Koh, Ambassador-At-Large at the Ministry of Foreign Affairs and Chairman of the Institute of Policy Studies, National Heritage Board) in artful conversations inside the Museum's Art of Our Time exhibition galleries.

7. Discussion of link between complexity theory and Popper's analytical framework

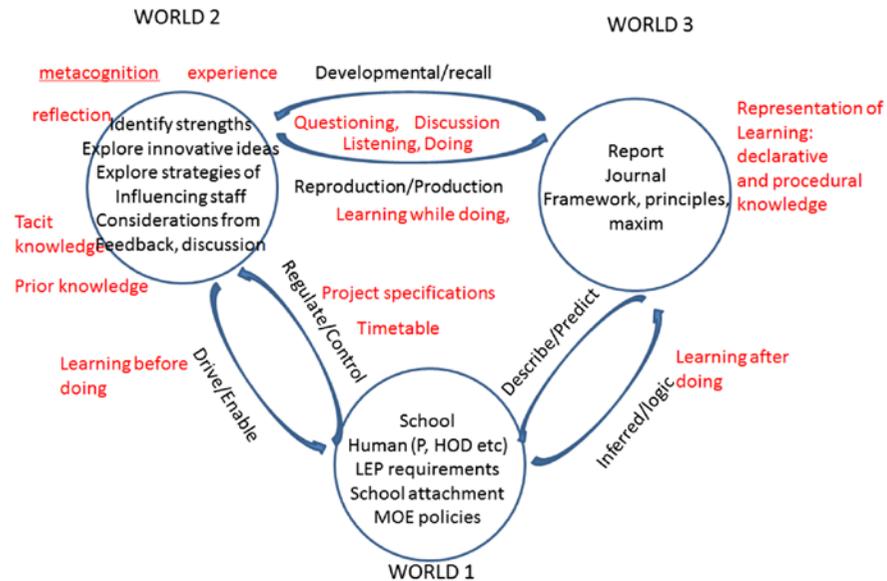
At this juncture, it is important to stress that the main purpose of the article is to provide evidence of learning from a complexity-design leadership development program. The researcher chose to adopt Popper's framework as the instrument to "measure" the evidence of learning by a participant. The fundamental question in complexity-based learning is to understand "how leadership learning emerged?" The following organizer is presented to guide the discussion of the link between Popper's Analytical Framework with complexity theory (Figure 3).

The iterative processes involved between World 1 and World 2 involves the following processes that are the operational aspects of "self-organization and non-linearity:" *learning before doing, project specifications and timetable, prior knowledge, tacit Knowledge, metacognition, reflection, experience.*

The next iterative processes involved between World 2 and World 3 involves the following operational aspects of "non-linearity and emergence": *prior knowledge, tacit Knowledge, metacognition, reflection, experience, questioning, discussion, listening, doing, learning while doing, and representation of declarative and procedural knowledge in the form of a report.*

Figure 3. Karl Popper’s three Worlds learning iteration.

Note: Adapted from Hall (2003).



7.1. Self-organization (complexity theory) and Popper’s W1 and W2

Certainly, the language used to describe self-organization in complexity theory is similar to language used in Popper’s description of how knowledge is learned. In self-organization, members in the organization adapt to changing goals and situations by adopting communication patterns that are not centrally controlled by an authority. In the process of working toward a goal (in this case study, example—implementing an innovation project), self-organizing members tend to exhibit creativity and novelty as they have to quickly adapt and to find ways and means to solve the problem and achieved the goal.

Popper (1972) argued that knowledge is constructed in living things as they adapt to the world. As evident in World 1, the problem presented itself in factual information (organizational structure and organizational function) as participants scanned the environment in the school they are attached to. Added to the organizational information is the project specification. Confronted with information from World 1, the participant has to make use of all the information in order to attempt to solve the problem—that is to introduce an innovation project that is unique and new in terms of organizational function and organizational structure.

Self-organization, as seen in complexity theory, is the response of the participant to organizational and project pressures. The process of self-organization is represented in Popper’s World 1 and World 2 where the participant begin to modify the functions of the system’s components and interconnections between the components (the structure) so that some function of the system is more effectively modified and drive the innovation process. The participant does this through the self-directed process of “learning before doing.” The process is not guided by a fixed structure nor directed by a faculty member. Learning before doing engages the participant’s tacit knowledge and involves metacognitive processes such as reflection and questioning techniques. In addition, learning before doing is aided through the “syndicate sessions, in-class courses, readings and observations” that the participant goes through in the program—characteristics of Fontana and Ballati’s (1999) assertion of non-linear self-organization.

Mansfield (2003) stated that spontaneous self-organization and the emergence of new effective developments are two key characteristics of complexity theory. The iteration process between Popper’s World 1 and World 2 required the participant to deal with conflicting nature of system

goals. An example of conflicting goals that the participant has to grapple with is the balance between implementing an add-on/isolated program and integration of new and current practices as evident in the following excerpt:

I am reminded through the syndicate discussion with regard to ensuring that the innovation project should not be an add-on or isolated programme

Therefore, self-organization in complexity theory is adequately explained in the iteration between Popper's World 1 and World 2 as the participant seek for the emergence of an optimum balance between the conflicting goals.

7.2. Non-linearity (complexity theory) and Popper's W1 and W2

Non-linearity in complexity theory refers to the causal links of the outcome of learning from something more complicated than a single source or single chain of events. Non-linearity in leadership learning would mean that the output of the learning is not proportional to the input and that the learning does not conform to the principle of additivity, i.e. it may involve synergistic reactions in which the whole is not equal to the sum of its parts.

As described by Hall (2003) emergent systems involves some degree of self-regulatory feedback to maintain the equilibrium of the structure. This self-regulatory feedback is inherently non-linear. In Popper's terms (1972), systems that emerge are a result of elimination of "errors" and solving of the "problems" such that the system is in equilibrium again. The process of elimination involves learning while doing. "Learning while doing" is non-linear although it might involve systematic structures. What this means is that the participant could systematically adopt questioning techniques, involved in weekly discussion but it is non-linear because the participant has to find the optimum solution by going through many permutations of possible solutions. Possible solutions in turn are dependent on the information and knowledge that are represented in World 1 and World 2. In other words, the extant of information and knowledge in World 1 and World 2 determines the selection of possible solutions. This process could never be linear as information cannot be fully controlled nor the outcome of learning be dictated.

The syndicate discussions and self-reflections described in the previous section that the participant goes through are examples of how non-linear learning could be structured. When the participant looks for answers to "how, why, what and when" questions, knowledge is often generated synergistically. The solution through the successful implementation of the project is never directly attributed to one source of information nor could it be traced linearly through the courses that the participant has attended.

7.3. Emergence (complexity theory) and Popper's W2 and W3

In this paper, Giddens' (1984) explanation of emergence as the relationship between the different levels through the "structure and agency" is adopted.

This question of the nature of "emergence" has been framed in a variety of ways including those of "macro-micro linkage," "individual and society," the "problem of order", and "structure, action and structuration" (Giddens, 1984).

Popper (1972) asserted that the discovery of error provides the opportunity to eliminate error and to move forward toward the identification of new problems. New problems suggest new hypotheses that, when tested, point to new potentialities for error elimination until finally an optimum solution emerges. Giddens's (1984) structure and agency represent the linkages between different levels of structures and involve the interactions between multiple agencies. Examples of levels of structure include the hierarchical organizational structure, national educational policies and initiatives, and even societal norms and expectations of learning outcome for students. Finding new way of doing things or emergence among all these structures in solving the problem (implementing the

Table 1. Summary of complexity learning in the LEP Program and analytical framework of Popper’s three World

	Complexity process of learning	Linking component in LEP	Outcome of learning
W1 Knowledge School Human (P, HOD, etc.) LEP requirements School attachment	Contributes to emergence, self-organization and non-linearity	LEP Program specifications Innovation project specifications School details	New project implemented in school
W2 Knowledge Identify strengths Explore innovative ideas Explore strategies of Influencing staff Considerations from feedback, discussion	Non-linearity (through discussions, reflections, multiple sources of information) Self-organization (spontaneous emergence of working relationship as a result of interactions)	Syndicate discussions School attachment Journal Action learning	New practical knowledge emerged Changes in perceptions and cognitive states of participants
W3 Knowledge Report Journal Framework, principles, maxim	Non-linearity (new learning were created) Emergence (understanding and behavior that emerged as a result of the interactions of system elements)	LEP program deliverables	Innovation project report Journal

innovation project) is a complex process. Add to these structures the multiple agencies—multiple individuals and groups of staff, and students involved, you will certainly appreciate the compounding complexity of trying to find new solutions.

Nevertheless, Popper’s (1972) tetradic schema which shows the interactions between World 2 and World 3 provides a significant handle to explain the process of emergence through the structures and agencies. The process of questioning, discussion, listening, learning while doing involving working with different levels of individuals and working through different levels of structures is captured by the participant’s reflection. Different levels of individuals involved working with students—turning them into thinkers (six thinking dispositions), Head of Department (to ensure that ongoing training should be an integral part of the project), Artful Thinking Core Team members (to develop teachers’ skills and knowledge), Vice Principal (to share the vision), and School Management Committee (to provide legitimacy of leadership backing). Different levels of structures involved working with school level (CSS—name of the school), grade level (Secondary One students), subjects level (Art and Thinking), policy level (TLLM—Teach Less and Learn More), and organizational level (museum). The participant worked through the links between structures and agencies culminated in the successful implementation of a new program for the school and for the museum as well as captured in the following excerpt:

The innovation project has successfully implemented the Artful Thinking program ... comprised of 6 thinking dispositions (Reasoning; Exploring viewpoints; Finding Complexity; Comparing and Connecting; Questioning and Investigating; and Observing and Describing) and each of these dispositions has specific intellectual behaviours associated with it ... For the first time, 15 Secondary One students from the Express and Normal Steam were given the opportunity to serve as Art Ambassadors at SAM’s Open House on 9 Aug 0.

...HOD ensured that ongoing training should be an integral part of the project ... the AT Core Team conducted school-based workshop for teachers in the CSS to give them a better understanding of strategies and principles pertaining to the use of thinking routines ... VP (LEP) shared with the School Management Committee will the TLLM initiative.

Finally, the links between the complexity design features of the program and Popper’s analytical framework could be summarized in Table 1.

8. Conclusion

The “product” described above is a clear example of how leadership learning and knowledge emerged as a result of the participant’s involvement in the learning and action-learning process. This contrasted starkly to the traditionally course-driven learning approach adopted by the behaviorist approach. In leadership development programs, many hope that the participants will learn new and effective ways

to bring about school innovation and reform. This hope cannot be realized if the conventional behaviorist-designed learning or faculty-driven approach continues to be perpetuated. The need to rethink program delivery has gathered momentum over the years and the call for changes in program content has been much discussed in literature even in the early 1990s (Dimmock & Walker, 2005; Hallinger & Leithwood, 1998). Universities have to shoulder an extremely difficult task in this respect because conventional practices of course-driven programs have been remarkably resilient over the years in the face of efforts to effect change in program delivery and a new understanding of complexity in the world of education. School leaders have to navigate non-linear change paths and learning how to navigate this kind of change is a critical competence for twenty-first-century change leaders in school systems.

The complexity theoretical framework provides us the advantage of an alternative design for leadership development programs that are able to meet current and future challenges that are mentioned by Cheng and Tam (2007), Macbeath and Cheng (2008) and Stacey (2001). Yearly, billions of dollars are spent on training and development. It is important to ensure that the outcome of training, learning, and development must yield practical outcomes that are innovative and implementable.

One of the goals of this paper is to provide a conceptual understanding of learning and design paradigms that determine eventually the outcome of learning. For more than 50 years now, the behavioral-based design has dominated the learning, training, and development landscape in schools, higher institutions of learning, and training and development organizations. The discussion on the design of the program has a significant theoretical implication. The LEP deliberately moves away from the set and planned approach of training and development in its curriculum. Since Peter Ramus introduced the word curriculum in 1576, curriculum is usually seen as a form of planned learning. Many school leadership programs are set and delivered in specific modules or workshops in order to achieve a pre-determined set of competencies, knowledge, and skills. In addition, these programs are driven by the faculty member and the prescribed content. A serious implication of complexity-based design would mean shifting from “faculty-centric” to student-centric learning. It would also mean that faculty members must be willing to step back and allow learning to emerge rather than to dictate how learning ought to proceed. This alternative complexity theory-based design school should be seriously considered as a viable and sustainable alternative to generate learning that matches the challenges and complexity of the twenty-first century.

Funding

The authors received no direct funding for this research.

Author details

F.S. David Ng¹

E-mail: david.ng@nie.edu.sg

¹ Policy and Leadership Studies Academic Group, National Institute of Education, 1 Nanyang Walk, Singapore 637616, Singapore.

Citation information

Cite this article as: Leadership learning for complex organizations, F.S. David Ng, *Cogent Education* (2015), 2: 1017312.

References

- Cheng, Y. C., & Tam, W. M. (2007). School effectiveness and improvement in Asia: Three waves, nine trends and challenges. In T. Townsend (Ed.), *International handbook of school effectiveness and improvement* (pp. 245–268). Dordrecht: Springer.
- Cooper, B., & Boyd, W. L. (1987). The evolution of training for school administrators. In D. Griffiths, R. Stout, & P. Forsyth (Eds.), *Leaders for America's schools* (pp. 251–272). Berkeley, CA: McCutchan.
- Culbertson, J. (1988). A century's quest for a knowledge base. In N. Boyan (Ed.), *Handbook of research on educational administration* (pp. 3–26). New York, NY: Longman.
- Cunningham, R. (2000). *Chaos, complexity and the study of education communities*. Retrieved May 21, 2008, from <http://www.ioe.ac.uk/ccs/conference2000/papers/tpm/papers/cunningham.html>
- Dimmock, C., & Walker, A. (2005). *Educational leadership: Culture and diversity*. London: Sage.
- Ettxeberria, A. (2004). Autopoiesis and natural drift: Genetic information, reproduction and evolution revisited. *Artificial Life*, 10, 347–360.
- Fetterman, D. M. (1989). *Ethnography: Step by Step* (Applied Research Methods Series, Vol. 17). Newbury Park, CA: Sage.
- Fontana, Walter, & Ballati, Susan (1999). Complexity. *Complexity*, 4, 14–16. [http://dx.doi.org/10.1002/\(ISSN\)1099-0526](http://dx.doi.org/10.1002/(ISSN)1099-0526)
- Giddens, A. (1984). *The constitution of society: Outline of the theory of structuration*. Oakland, CA: University of California Press.
- Guba, E. G., & Lincoln, Y. S. (1994). Competing paradigms in qualitative research. In N. K. Denzin & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 105–117). London: Sage.
- Hall, W. P. (2003). Managing maintenance knowledge in the context of large engineering projects—Theory and case study. *Journal of Information and Knowledge Management*, 2(3), 1–17.
- Hallinger, P., & Leithwood, K. (1998). Unseen forces: The impact of social culture on school leadership. *Peabody Journal of*

- Education*, 73, 126–151.
http://dx.doi.org/10.1207/s15327930pje7302_6
- Kauffman, S. A. (1993). *The origins of order*. New York, NY: Oxford University Press.
- Leithwood, K., & Day, C. (2007). What we learned: A broad view. In C. Day & K. Leithwood (Eds.), *Successful principal leadership in times of change: An international perspective* (pp. 189–203). Dordrecht: Springer.
<http://dx.doi.org/10.1007/1-4020-5516-1>
- Mansfield, D. (2003). Complexity theory, school leadership and management: Questions for theory and practice. *Educational Management Administration & Leadership* May 2010, 38, 374–393.
- Macbeath, J., & Cheng, Y. C. (2008). *Leadership for learning: International perspectives*.
- Merriam, S. B. (2002). *Qualitative research in practice: Examples for discussion and analysis*. San Francisco, CA: Jossey-Bass.
- Miklos, E. (1992). Administrator preparation educational. In M. C. Alkin (Ed.), *Encyclopedia of educational research* (6th ed., pp. 22–29). New York, NY: Macmillan.
- Miles, B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook* (2nd ed.). London: Sage.
- Morrison, K. R. B. (2002). *School leadership and complexity theory*. London: Routledge Falmer.
- Murphy, J. (1998). What's ahead for tomorrow's principals. *Principal*, 78, 13–14.
- Ng, F. S. D. (2013). Assessing leadership knowledge in a principalship preparation programme. *International Journal of Educational Management*, 27, 425–445.
- Ng, F. S. D. (2014). Complexity-based learning—An alternative learning design for the twenty-first century. *Cogent Education*, 1(1).
- Nonaka, I. (1994). A dynamic theory of organizational knowledge creation. *Organization Science*, 5, 14–37.
- Popper, K. (1972). *Objective knowledge* (Revised ed. 1989). Oxford: Clarendon Press.
- Punch, K. (2005). *Introduction to social research; Quantitative and qualitative approaches* (2nd ed.). London: Sage.
- Rocha, L. M. (1998). Selected self-organization and the semiotics of evolutionary systems. In G. van de Vijver, S. N. Salthe, & M. Delpo (Eds.), *Evolutionary systems* (pp. 341–358). Dordrecht: Kluwer Academic. Retrieved from <http://informatics.indiana.edu/rocha/ps/ises.pdf>
- Sergiovanni, T. J. (1991). *The principalship: A reflective practice perspective* (2nd ed.). Boston, MA: Allyn & Bacon.
- Spillane, J. P. (2004). *Distributed leadership: What's all the hoopla?* (Working paper), Institute for Policy Research, Northwestern University. Retrieved May 23, 2009, from http://www.ipr.northwestern.edu/publications/.../Spillane_DistribLead.pdf
- Stacey, R. (2001). *Complex responsive processes in organizations: Learning and knowledge creation*. London: Routledge.
- Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Thousand Oaks, CA: Sage.
- Tushman, M. L., & O'Reilly, C. A. (2013). *Winning through innovation: A practical guide to leading organizational change and renewal*. Harvard Business Press.
- Yin, R. K. (2003). *Case study research design and methods* (Applied social research methods series, 3rd ed., Vol. 5). London: Sage.



© 2015 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:
Share — copy and redistribute the material in any medium or format
Adapt — remix, transform, and build upon the material for any purpose, even commercially.
The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.
You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.
No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.



Cogent Education (ISSN: 2331-186X) is published by Cogent OA, part of Taylor & Francis Group.

Publishing with Cogent OA ensures:

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com

