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Author(s)	Yancy Toh, Azilawati Jamaludin, Wei Loong David Hung and Paul Meng-Huat Chua
Source	*The Asia-Pacific Education Researcher, 23(4*), 835-850
Published by	De La Salle University Manila

Asia-Pacific Edu Res (2014) 23(4):835–850
DOI 10.1007/s40299-014-0211-4

REGULAR ARTICLE

Ecological Leadership: Going Beyond System Leadership for Diffusing School-Based Innovations in the Crucible of Change for 21st Century Learning

Yancy Toh · Azilawati Jamaludin · Wei Loong David Hung · Paul Meng-Huat Chua

Published online: 10 September 2014

Abstract Driven by the impetus for the school system as a whole to actualize deep twenty-first century learning, innovation diffusion has become increasingly an important vehicle for isolated pockets of successes to proliferate beyond the locale of the individual schools to form connected clusters of improvement at a greater scale. This paper articulates an ecological leadership model for enabling such system-wide innovation diffusion in the context of Singapore. Through the explication of leadership practices demonstrated by two exemplar schools that have successfully levelled up their school-based innovation, we argue that ecological leaders have to go beyond system leadership to think and act in a more encompassing way. Specifically, ecological leaders have to embody systems thinking and East-Asian collectivist beliefs to benefit other schools, converge and contextualize the kernel of innovation, align efforts by mitigating tensions and paradoxes within and across the subsystems in the ecology, leverage on resources in the ecology and manage the emergent dynamics engendered through interactions with multi-level actors. These five thrusts cut across the five dimensions of ecology: microsystem, mesosystem, exosystem, macrosystem and chronosystem. With the favourable socio-political climate that encourages collaboration rather than competition, we posit that leaders can endeavour to forge ecological coherence. This can be achieved by establishing synergistic structural and socio-cultural connections within and across the five subsystems of influences underpinning the hub school and networks of innovation-adopting schools, thus bringing forth transformative changes in the system.

Keywords Ecological leadership · Systems leadership · Scaling and diffusion · Ecological coherence · School-based innovations · East-Asian collectivism

Y. Toh (✉) · A. Jamaludin · W. L. D. Hung · P. M.-H. Chua
Office of Education Research, National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616, Singapore
e-mail: yancy.toh@nie.edu.sg

Introduction

Driven by the impetus to actualize deep twenty-first century learning, schools are rethinking learning and pedagogy as well as tinkering with changes to create innovative learning environments (OECD 2013). However, more often than not, these introduced changes merely result in short-lived ripples that fail to culminate into systemic impacts beyond the enclaves of individual schools. As such, the fleeting nature of innovations precludes the deep and disruptive changes that optimistic educators have romanticized about (Glazer and Peurach 2012; Rowan 2002). Against this backdrop, leadership plays a vital role in diffusing and sustaining school-based innovation networks across schools for twenty-first century learning (Cravens and Hallinger 2012). This paper aims to examine school leadership beyond the typical arena of schools to that of district-or cluster-level enactments that can benefit the school system.

Singapore's education system over the past decade evolutionarily encouraged the integration of traditionally valued content-disciplinary focus, and the new literacies of self-regulated learning, collaboration, critical thinking and creativity. There were constant reviews of existing policies and introduction of new initiatives into schools by the Ministry of Education (MOE). For example, the "Teach Less, Learn More" (TLLM) initiative and the IT

Masterplans were attempts to improve the quality of teaching and learning in schools through system-wide reforms. The education system continuously evolved from a predominately centralized to a centralized–decentralized system. More recently, MOE (2014) delineated the national framework for twenty-first century competencies and student outcomes, focusing on developing students' social and emotional competencies; civic literacy, global awareness and cross-cultural skills; critical and inventive thinking; communication, collaboration and information skills. These competencies could be infused in academic curriculum, co-curricular programme, character and citizenship education and cross-disciplinary applied learning programme.

In such a milieu of change, MOE seeded opportunities for schools to engage in curriculum reform and provided additional incentives and resources for teachers to engage in different forms of pedagogical innovations. Schools as a whole were incentivized, and one such endeavour was the establishment of Future Schools (FS)—where exemplary schools in the school district with a history of experimenting different technology-mediated pedagogical innovations were identified and became model schools for others to emulate.

These school-based innovations—which we will illustrate in the case studies in the subsequent sections of this paper—did not just influence their respective schools, but were able to create structures and opportunities of influences to other interested participating schools. Whilst MOE encouraged these lead-model schools in their endeavours with "top–down" support, our research observations indicated a form of leadership which had an intrinsic ecological belief for the collective good. These school leaders were not policy makers from the MOE but were fluent implementers, communicators of vision and contextually astute mediators who were able to manage the multiple tensions of policy and teacher enactments on the ground level. These school leaders were also able to broker MOE's policies for school reform-change and the teachers' interpretations of curricular mandates; but more importantly, they understood the teachers' dilemmas and found ways to develop the teachers' capacities and beliefs to engage in these transformative experiences. These school leaders were also perceptive towards managing and mitigating the different levels of issues inherent in the school system, and were observed to possess an ecological belief.

This paper introduces a new notion referred to as "ecological leadership". Ecological leaders exhibit initiative to coalesce or juxtapose apparently discordant orientations within and across different subsystems of the ecology—in the change-reform agenda, and which enable them to be successful in their efforts to diffuse school-based innovations for school improvement. We describe the work of these school leaders via two case studies, and distinguish them from Hopkins and Higham's (2007) concept of systems leadership and Michael Fullan's (Fullan 2014a) notion of systems player.

Literature Review

Self-Improving Systems

The rhetoric on school improvement has gradually shifted from individual school re-design initiatives to system-wide changes (Harris and Chrispeels 2006). Literature shows that it takes protracted time for individual schools to plan systematically for coherent and sustained transformation (Bain 2007; Coppola 2004; Dimmock et al. 2013). One can expect the intricacies to intensify further when school change and transfer of practice are situated within the context of a multiple school change process (Hopkins and Higman 2007). Yet, despite its exponential level of complexity, the impetus for promulgating such school partnership for improvement remains compelling to many. Specifically, David Hargreaves (2010) argues that for school reforms to be sustainable, they have to be premised on the development of "self-improving school systems" (p. 5) where schools, instead of relying on centralized provision, are primarily accountable for their own improvement. According to him, a self-improving school system is one that leverages on deep inter-school partnership which can be developed via three major inter-related thrusts: "professional development", "partnership competence" and "collaborative capital" (Hargreaves 2011, p. 5). Overtime, the maturity of self-improving school systems will culminate into each nodal school becoming an "alliance architect" (p. 32) to help other schools attain similar achievement. In a later think piece, David Hargreaves (2012) also points out that the differential expertise embedded in these self-improving school systems can result in collective sophistication through the pervading "social capital" of trust, reciprocity and identity (p. 13).

As a corollary, self-improving school systems can be perceived as autonomous agents who can organize themselves, especially in building social networks when perturbed in order to renew itself (Glazer and Peurach 2012; Olsson et al. 2004; Morrison 2002). There is also an element of self-referentiality which enables the system to sustain its own identity, culture or ethos even though some of its constituent elements may change. This is analogous to David Hargreaves (2012) purported "collective moral purpose" (p. 16)—values and ideologies of teaching and learning that bind the constituents together. We believe the social capital of trust, reciprocity and identity can be a pivotal vehicle to forge or the culminating outcome of

collective moral purpose. Through autocatalytic reconfigurations and re-clustering, schools form alliances to enhance its performance, thus "transcending their individual capacities" (Bain 2007, p. 6).

Greany (2014), however, cautions that self-improving school systems may inherently perpetuate inequality, through self-serving interests. To assuage such tension, systems can put in place intentional strategies for schools to be alliance architects to help other schools improve, thus amplifying good practices. With this as a backdrop, we posit that leaders of self-improving schools need to exhibit systemic and/or ecological awareness so that they can create within and across schools the enabling conditions for both innovations and improvements to happen (Hargreaves and Shirley 2012). The next section looks at how system and ecological thinking can promulgate self-improvement in schools.

System Thinking and System Leadership

Fullan (2004) argues that for systemic change to occur, systems thinkers are needed. These systems thinkers are "leaders who work intensely in their own schools, or national agencies, and at the same time connect with and participate in the bigger picture. To change organizations and systems will require leaders to get experience in linking to other parts of the system" (p. 8). System thinking is built upon the literature on systems theory, which suggests that the defining characteristic of a system "cannot be understood as a function of its isolated components … the system doesn't depend on what each part is doing but on how each part is interacting with the rest …" (Kofman and Senge 1995, p. 27).

Hopkins and Higham (2007) introduced the term systems leadership to embrace the type of leadership that system thinkers deploy. They define system leadership "as a form of leadership where a head teacher or principal is willing and able to shoulder wider system roles and in so doing is almost as concerned with the success and attainment of students in other schools as he/she is with his/her own" (Hopkins and Higham 2007, p. 148). However, Hopkins (2007) contrasted systems leadership with just involvement in some form of collaborative or networking activity. As system leadership is an "emerging practice" (p. 148), Hopkins and Higham (2007) seek to identify the roles that system leaders could play in the improvement of other schools, as well as the practices they enact to fulfil their roles. Through an empirical study, they identified that systems leaders could: lead and improve a school in extremely challenging circumstances; lead in partnership with another school facing difficulties to improve it; and become a mentor or expert leader to other schools in difficulties. Through the same empirical study, they found that the core practices of system leaders are setting direction (based on the moral purpose of improving students' learning); managing teaching and learning; developing people and developing the organization.

In essence, Fullan discusses how to develop system thinkers in action in a sustained manner, whereas Hopkins and Hignam delve more into the role taxonomy of system leaders. Taken together and juxtaposing the thesis of system leadership against the literature on instructional or learning-centred leadership, the latter primarily emphasises the improvement of quality of instruction and student learning within one's own school context (Hopkins 2001); whereas the former foregrounds an expansionist outlook that encompasses cross-school improvement and the balancing of systemic tensions and creation of enabling conditions that are not directly related to teaching and learning. Such an expansionist outlook requires leadership which is ecological in orientation—a concept which we will delve into in the following sections.

Ecological Framing of School Systems

Originally used to describe the study of habitats in which organisms live, the term "ecology" has now been widely used as a metaphor to elucidate the mutually constituting influences underpinning the sustainability, management and development of social ecosystems (Olsson et al. 2004, p. 75). A prominent example of ecological framework often cited by scholars of the ecological paradigm is Bronfenbrenner's (1979, 1993) model of human development. Informed by his insights on how the five subsystems of changes (micro, meso, exo, macro and chrono) can influence the development of human through the trajectory of time, we map out the nested context of ecological systems that shape the diffusion of innovations across schools (See Fig. 1).

At the micro level are the classroom-level influences, such as classroom culture, group dynamics or teacher's epistemological beliefs and technological–pedagogical-content knowledge. The mesosystem refers to organizational attributes such as institutional culture and profile, leadership practices, structural affordances or impediments. The exosystem constitutes influences exerted by the peripheral members of the school ecology. Examples include commercial and research partners as well as adopting schools of innovations. The macrosystem refers to the national or global trends that have bearings on the landscape of Singapore's education. We posit that each school or node in the innovation network is subjected to such totality of influences that can shift over time (chronosystem) depending on the ebb and flow of reforms.

The ecological framing in this paper was established based on the recognition that schools, like other social systems, are not subparts of mechanistic entities wherein "non-working" components may be identified, extracted,

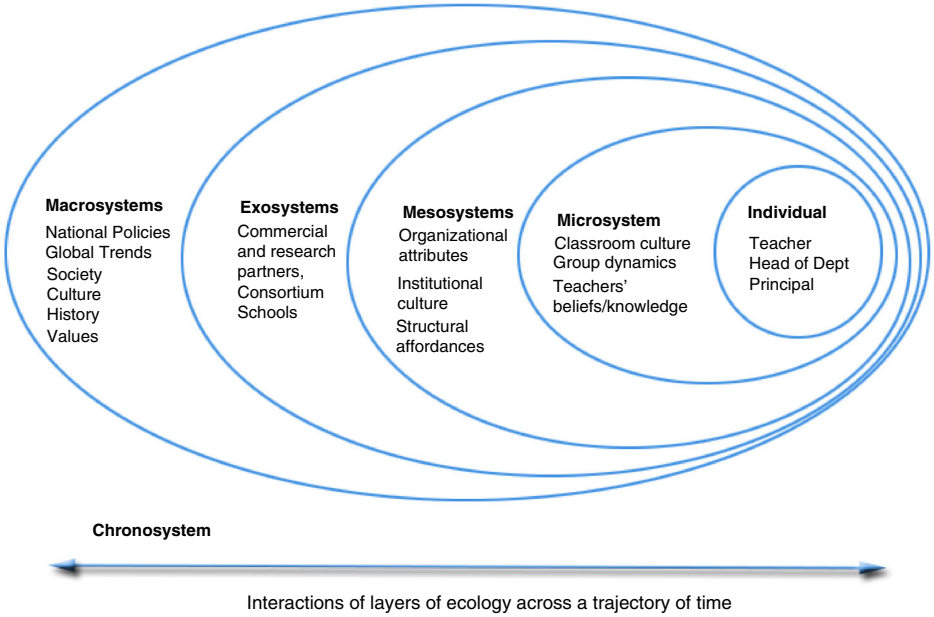

Fig. 1 Ecological influences underpinning the diffusion processes of school-based innovations

treated and rehabilitated within the system. Instead, we view schools as ecological systems where the mobility of people and the subsystems are constantly impacting and influencing the entire system (Bronfenbrenner 1979; Goodlad 2001).

Three inter-related lines of inquiries have emerged from the literature review discussed above:

(1) How do leaders of self-improving schools in Singapore foster structural alignments within and across the different subsystems of the school ecology when diffusing pedagogical reforms across schools?
(2) How do leaders of self-improving schools in Singapore foster ecological coherence (including alignments and sense-making) amongst diversified actors who may also exert competing influences at various subsystems of the school ecology?
(3) What emerged as a result of such local actions to forge structural alignment and ecological coherence?

We will address the three questions after the explication of the macro context of Singapore's education landscape in the next section.

Context of Singapore's Educational Landscape

The Evolution of System Leadership in Singapore Schools (Chronosystem)

In the Singapore education system, the first evidence of systems thinking for school improvement emerged in 1979. A new efficiency-driven education system was recommended to develop students of different abilities differently (Ho 2008). Another landmark change occurred at around 1997, which started to systematically and systemically cultivate systems-oriented thinking in all school leaders (principals and middle managers) under the banner of the "Thinking Schools, Learning Nation" vision. A new position called cluster superintendents was created and positioned as system leaders. System leadership was deeply embedded into the talent assessment, development and selection process. The prospective leaders were assessed, amongst other competencies, on their visionary competencies which encompassed their ability and willingness to think and act for the betterment of the country and education system as a whole through contributions to cluster, zonal, ministerial and national committees.

Two Dualistic Tensions in the System

Collaboration Versus Competition

Similar to the observation made by Hopkins and Higham (2007) on the tension between system leadership and the individual accountability of schools, the exercise of system leadership in Singapore school has been optimized through the re-balancing of the dialectics of competition and collaboration in the operating environment in which Singapore schools are in. Of late, there have been explicit moves to blunt the competitive edge amongst schools, so as to correspondingly encourage sharing, collaboration and partnership amongst schools. The MOE is intentional with these

enactments through the constant monitoring of the systemic state of play of schools. The instantiation of blunting the competitive edge of school shifts the balancing point towards greater collaboration to enable system leadership in Singapore schools to be optimized in this stage of our development. Schools that are well ahead are now encouraged to be socially more responsible for schools that may not have attained to their stature. This collaboration versus competition paradox is overcome by requiring these schools to diffuse their successful models to other schools. Moreover, school leaders who are high performing recognize that the MOE might post them subsequently to the schools which lag behind, and hence these leaders know that the good they do to others, would be reciprocal in one way or other. There is the notion for collective moral good as David Hargreaves (2012) alluded. This balance act is characterized as dynamic (Lee 2014) and carefully calibrated to where it will optimize the system's performance as a whole.

Centralization Versus Decentralization

Another instance of such balancing occurring in the system is the simultaneous operating of the centralization and decentralization stances in the system. Centralized decentralization could be defined as the calibrated application of the forces of centreing and calibrated release of the force of centreing (resulting in decentreing) in order to achieve coherence and optimal results and outcomes for a system (Chua et al. 2014).

Centralized decentralization is built on the premise that decision making needs to be made "on the ground" by principals and teachers since they are closest to the students and can make the decisions that respond to local conditions. For example, the Ministry developed the TLLM initiative in year 2004 where schools were given the flexibility to develop their own pedagogical approaches as long as those approaches were aligned to the intent of curricular goals. However, much as the flip side of increasing autonomy had been the increased accountability for results. From MOE's perspective, centralized guidance is needed to maintain some semblance of coherence as a system (Chua et al. 2014), which is aligned with Dimmock and Tan's (2013) observation of the tight and increasingly loose couplings between the central and peripheral actors in Singapore's educational system. This is consistent with the Fullan's (2014b) notion that autonomy on its own does not work. Centralized decentralization is also evident in the underlying thrust of MOE's ICT Masterplan Three policy initiative where school leaders are given the autonomy to provide direction and conditions to harness ICT for learning and teaching, subject to the overarching mandate of fostering students' self-directed and collaborative learning through the effective use of technology.

Two Case Studies of Leading Cross-School Collaboration

The preceding section provides a broad-stroke description of the socio-cultural norms and systemic structural affordances that are inherent in Singapore's educational system. In this section, through qualitative case studies, we explicate how school leaders of two FS lead successful technologically mediated curricular innovations between schools. Northern Learning School (NLS) and Crescendo School (CS) (these are pseudonym of schools), being present and past FS, respectively, are considered "intrinsic" (Stake 1995) case studies as they have (i) decade-long culture of using technology to create twenty-first century learning environments; (ii) received local and international recognition for integrating technology into their curriculum, pedagogy and assessment; (iii) harnessed capacity and re-organized resources from within school to benefit other schools; (iv) augmented "collaborative capital" for innovation propagation and (v) exhibited different trajectories of diffusing "home-grown" innovations beyond the locale of their schools. These two schools have embarked on individual school re-design journey a decade ago and have recently become champions for propagating their innovations to multiple schools. Thus, unlike the context in England where the nature of school collaboration is coalesced around the purpose for performing schools to transform challenging schools; the nature of school collaboration in our research context is for ICT-prototype (early adopters) schools to propagate successful innovations to mainstream schools in order to address the problem of intransigent teaching practices.

NLS illustrated the "depth" of change in classroom pedagogy, and hence a slower diffusion; and CS illustrated an approach which worked at the wide-spread adoption of an innovation. The five schools that participated in NLS' joint professional practice came from the same zone and were identified with the help of a Cluster Superintendent. The Superintendent identified these participating schools based on the school's readiness in appropriating ICT pedagogically in the area of science learning. The identified schools were given free choice of whether they would like to come on board. With such an involvement, the Superintendent was increasingly recognizing the value of networks for teacher learning and school-to-school collaborations. For CS, the participating schools were more geographically diverse and spanned over clusters and zones in an organic manner. Both groups of school networks were recently established beyond the existing formal structures of MOE cluster system. There was no tight central regulation on these networks, but educational technological officers from the MOE attended meetings that took place in the network of innovation-adopting schools to exchange views and distill the core

principles of innovations—the purpose of which was to inform themselves about the overarching design of their centrally conducted professional development courses on technology-mediated innovations, rather than policing the development of the networks formed through these two schools. Both schools tapped on MOE's funding mechanisms to embark on their diffusion work. These funds were used to procure equipment, hire more manpower and to support networking. Insights from both cases will provide us with a holistic understanding of leading technology-mediated diffusion to networks of schools in Singapore's context.

Data for the case studies were drawn from interviews with the school leaders (e.g. principal, head of ICT department, head of Science department and subject heads) as well as observations of classroom lessons, fieldtrips and professional development sessions conducted for the participating schools. The three overarching driving questions that arose from the literature review were used to organize the write-up of the two case studies.

Case Study of Northern Learning School in Leading Other Schools

In NLS, pedagogical innovations are integral to the school's efforts to improve teaching and learning. Notably, their six-year flagship project on mobilized science curriculum (see Looi et al. 2014) which leverages on 1:1 mobile technology to enable cross-contextual inquiry-based science learning for primary three and four students (aged 9–10 years), has been diffused to another five schools within the same zone since 2013. Using this innovation as an anchor, we examine how NLS school leaders have exercised leadership to create structural alignment and 'ecological coherence' within and across schools.

Structural Alignments for Deepening Alliance, Sociality, Reflexivity and Competency

In the attempt to foster structural alignment across the five participating schools of seamless learning, the school leaders of NLS had intentionally built architectures of alliance, sociality, reflexivity and competency across the different subsystems of the school ecology. At the macro level, the school leaders received support from the cluster superintendent in terms of identifying participating schools that had shown willingness to commit time and resources to the endeavour. At the meso–exo level, the school provided platforms for participating schools to deliberate on issues and build social affinity over time. These platforms include (i) dialogues with the heads of the Science and ICT departments as well as allied educators of the five schools; (ii) fortnightly professional development sessions for participating teachers to co-design lesson plans, observe lessons of the champion teacher; and to reflect on their teaching practices after enactment; (iii) half-yearly professional development sessions conducted by university researchers for the participating school leaders, middle managers and teachers; (iv) shared repository for notes to meeting, lesson plans, teaching resources and professional development materials and (v) starter kit to clarify cyber-wellness issues, the roles of ICT support staff, the nature of the technological infrastructure and the standard operating procedures related to equipment deployment, installation and maintenance.

Jen (pseudonym), the champion teacher of NLS described these vehicles as crucial mechanisms for cultivating communities for support before the participating schools can build a microcosm of the social learning environment in their respective schools. Additional structural affordances provided by NLS' leadership include the creation of bandwidth for Jen to conduct lesson observations at all five schools during alternate weeks. This practice enhanced structural alignment at the micro level as participating teachers, through post-observation discussions, would have the opportunity to exercise reflexivity and achieve convergence in terms of pedagogical practices. The principal succinctly summed up the rationale for putting in place a plethora of structural supports:

> It is about structuring a platform … What we are trying to do is more than projects … We are also sharing experiences in building a PD [professional development] culture too—Principal Interview100913.

The structural platforms are thus building blocks towards infusing a more holistic professional development culture, which is necessary to effect deep changes in schools, especially in the light of developing twenty-first century skills. The principal elucidated:

> It's a very challenging task trying to marry … curricula goals and objectives together with twenty first century goals. … it will warrant a relook into the way you have been structuring your curriculum … teaching and learning environment … whether the teachers have the capacity … you have sustainable culture where teachers believe in doing such a thing, in experimenting in delivering, reviewing, learning all at the same time—Principal Interview100913.

Quintessentially, the principal advocated a whole-school rather than piecemeal approach when creating structural supports for effecting changes. Also acting as systemic resource broker, NLS leaders made the decision to help all five schools coordinate the procurement of equipment and data plans and well as the installations of propriety software. Through the sharing conducted by NLS leaders, the leaders

of participating schools also arrived at the understanding that they need to create more classroom time for the enactment of inquiry-based learning—all these attest to the fact that an ecological overview is warranted when scaling innovations from the original site to other pedagogic sites.

Ecological Coherence for Deepening Collaboration

To foster coherence amongst actors acting at different levels of subsystems, NLS appealed to the overarching purpose of innovation propagation. The principal articulated that schools should be functioning as open systems that could afford sharing of good practices and make explicit the lessons learnt to shorten the learning curve of other schools. The principal felt that the uptake of innovations will build capacity and allow adopting schools to feed contributions back into the "bigger ecosystem of learning community". Also advocating the ecological and communitarian view of amplifying good practices, the science department head of NLS emphasized on the mutual adaptation and learning process that would benefit all participating schools, including NLS.

Ecological coherence can also be forged through deep collaboration—a prominent strategy used by NLS leaders to enable cross-school reform. Recognizing that the school cannot walk the journey alone, the school leaders cemented long-standing partnerships with university researchers through the establishment of an in-house research centre. Resident researchers from university act as "analytic investigators" (Hargreaves 2012, p. 24) to conduct evaluation on learning gains and provide feedback on the progress of implementation. When diffusing innovations to other schools, the principal invited researchers to co-conduct professional development workshops for principals and middle managers of participating schools so that these school leaders can share their perspectives and forge a common framing about school change amongst the community. The principal's ability to corral deep conversation with the key personnel from five schools at critical milestones also ensured a more profound understanding of decisions made, leading to more buy-in and systemic support rendered. In tandem, the fortnightly dialogues led by Jen promoted a collaborative culture where teachers would pool their expertise to co-design lessons and flesh out issues related to classroom enactments. She also delved into the dynamics of collaboration in the classroom, citing that "teachers, allied educators and students are all equal in the seamless learning classroom" (joint-meeting with Science HODs, 131022) As the teachers debated on pedagogical decisions, provided solutions to enactment dilemmas and made attempts to frame problems collectively, the embodied human capital was tapped, philosophical thrusts of the innovation internalized and camaraderie built over time through the shared meaning-making process.

Although there is tighter collaboration amongst schools at this juncture, to sustain it is dependent on the leaders' capacity to mitigate systemic tensions. With regard to this, the principal is of the view that the community will be maintained as long as the people in the ecosystem find meaning to be part of it. To him, this requires leaders to have a clear vision, to articulate that vision and to create a win–win solution for the various actors in the system. As an example, whilst the community was enmeshed in the process of forging a common identity and practice, NLS was also empathetic towards the contextualized needs of other schools. The leaders were cognizant about the different initial conditions across schools, which include variations in pedagogical focus, curriculum, technical readiness, resource accessibility, student demographics, level of school support and teachers' capacity. Respectful about these differences, NLS felt that they should not be advocating what the best scaling practices were. Instead, they saw themselves more as sharing NLS' successful experience in levelling up the use of technology in its own school context. As a corollary, NLS was cautious not to squelch the autonomy of adopting schools and encouraged the exercise of manoeuverability between actualizing collective KPIs at a cluster level and customized KPIs at the school level. However, to prevent the community from detracting formlessly, common cultural artefacts of learning and teaching such as the pedagogical approach of inquiry-based learning and the co-designed lesson plans will act as unifying boundaries for the community.

Emergence of Self-Referentiality and Ecological Memory

Emergence is the tendency for agents in a social system to interact synergistically to produce new capacities and novel order that are different from the individual local actions that engendered them (Jennings and Dooley 2007; Wheatley and Frieze 2009). In NLS, due to the nature of innovation, the leaders favoured the tight apprenticeship model—a deliberate strategy to augment teachers' capacity for designing seamless learning curriculum. Jen remarked that the professional learning community nurtured teachers' readiness in enactment, curriculum-design and allowed them to be attuned to the practice of individual and collective reflexivity by thinking more deeply about the role of technology in teaching and learning (microsystem). The collective wisdom engendered can transcend individual capacities, as articulated by Bain (2007). More importantly, the platform provided emotional support for the experimental teachers. At the exosystem, the principal, in particular, was able to exercise his social leverage to harness resources beyond the conventional support provided by

MOE to forge ecological coherence. He also made the macro culture of innovation visible through dialogic processes with the key leaders of innovation adopting schools (exosystem). NLS disposition for distributed leadership (mesosystem) can also be observed during the scaling endeavour of the pedagogical innovation where key personnel and middle managers also played a key role in connecting stakeholders.

In short, instead of employing a piecemeal, prescriptive and quick-fix approach, the leaders have been using an integrated, situated and longitudinal approach to seed conditions for "social memory" (captured sense-making experiences of actors) to become "ecological memory" (Olsson et al. 2004). To illustrate, the cross-school professional development programme, as compared to the model adopted within NLS, is considered more structured and encompassing as it involves the engagement of stakeholders across the different subsystems in a calibrated, phased and synchronized fashion. At the organizational and school leadership level, NLS forges on-going dialogues with the key personnel of the five schools and has plans for researchers to conduct professional learning courses related to broader themes such as school reform. At the mirco level, NLS has also made attempts to situate the innovation within the contexts of the participating schools. Jen explains:

> we are going through a series of PD [professional development] sessions with teachers, [the] more theoretical kind of things. But ultimately next year when they try it out in the experiment classroom in their school, we thought that we could do more things like discussion by observing the classroom…Maybe more of how they [could] actually modify that lesson to suit the class' needs… the 5 schools [together] design the lesson plan…And then hopefully next year, besides these teachers in the experiment classes…the future plan is to look at a bigger pool of teachers in their respective schools…to build up this group of teachers' competency such that they could actually lead the school, [and] the other teachers in re-designing the lesson package and carry on from there—Jen Interview100913.

NLS adopts a long-range view of capacity building so that self-referential knowledge pertaining to the innovation can possibly become embodied across new sites of innovations. A centralization–decentralization ecology is fostered amongst NLS and the five partner schools.

Case Study of Crescendo School in Leading Other Schools

Against a distributed, ecological characterization of a digital learning trails curricular innovation (CI) spread in CS, our analysis was pragmatized through the identification of leadership enterprises in effecting the scalability and sustainability of the CI that has diffused from one school to more than two hundred[1] schools in Singapore. The development of the digital trails innovation was led by the school in partnership with a software development company. CS, a past FS, consists of students aged 12–16 (equivalent to Grades 7–10) and has a campus-wide wireless network implementation and employs a 1:1 computing in place. In leveraging on the strengths of pervasive computing, teachers at CS introduced the use of digital learning trails as a means of harnessing elements of real-world data collection, inquiry-based learning, collaborative learning and active knowledge construction. CS attained funding from one of MOE's funding entities for its diffusion plan of further refining the design of the learning trails CI toolkit whilst simultaneously collaborating with ten other schools on the use of digital learning trails. Beyond working with these ten "consortium schools", CS also employed a wide-scale ecological approach in diffusing its CI to other schools. CI visibility was foregrounded through establishing partnerships with national agencies in organizing nationwide learning trails competition for schools to meaningfully tinker and experiment with the CI. The school then engaged representatives from the exo layers of the ecology to be judges for the competition, heightening the sociality and discourse circumambient to the CI.

Fostering Structural Alignments Through Appreciative Systems and Diffusion Platforms

We noted that the scale and sustainability of CIs in CS may be underpinned by a well-established appreciative system for pedagogical innovations within the school. This was evidenced through cultural manifestations of the school's commitment to harnessing on ICT for teaching and learning for both teachers and students.

> … establish structures so that the innovation can flourish. … it is also about how we do professional development … how we constantly foreground T and L, how we talk about student outcomes and these are the things that we also then scale and share… so as school leader it's multiple levels…—Principal Interview030414.

Such appreciative system for pedagogical innovations within the school was also propagated to other schools-evident from CS' initiative to establish CS academy for digital age learning. The purpose of such an academy was to provide visibility for programmes already implemented in CS, with a view to articulating pedagogical specificity

[1] Figures provided by the school.

for schools interested in such programmes. Whilst the mandate for the establishment of a platform for diffusion arose from CS' future school trajectory, the vision of the academy had been attuned in accordance to the school leadership's recognition of the gap in operationalizing the 'how' of digital age learning; whilst the 'what' and 'why' of interweaving twenty-first century lessons and skills in schools had been established, much less had been articulated of the 'how schools may go about walking the journey towards equipping their students with twenty-first century competencies.

Fostering Ecological Coherence Through Convergence of Vision and Mitigation of Dualistic Tensions

The school principal also worked on promoting a normative commitment amongst the respective ICT leads towards CS enculturation of "self-directed, collaborative, and authentic learning" for all students. At the consortium schools' project level, the ICT lead modelled a similar convergence strategy as he worked with leaders of the various consortium schools who in turn worked with their respective subject teachers on their plans in the implementation of the CI within their classroom and school respectively. Enacting the operationalization mechanics of the project proceeded on a process efficacy approach wherein well-defined guidelines on deliverables to be realized within specific time limits were put in place. Specifically, each consortium school was required to share their learning experiences at one (or more) cluster-level meeting, and through one (or more) presentation sharing either at an international or locally organized conference. In addition, each school was expected to produce a learning package on their enacted learning trail oriented for "scaling across schools", in terms of developing first level utilization of the CI prototype.

> … so that's why we always wanted to convince the partner … to share a common vision which … if we do it correctly, can change learning—ICT Head Interview 020913.

Although adopting schools were given "measurement results" in the form of specific deliverables and expected convergent outcomes pertaining to the project, yet these top-down expectations were tempered by attributing agency for teachers to contextualize the adoption of the CI based on the needs and limitations of their particular institutionalized context. In a sense, although the project was process-oriented in terms of delineating specific deliverables and outcomes, yet it remained non-prescriptive in nature. The innovation was not targeted at particular school subjects for improvement, nor did it provide teachers with a great deal of explicit guidance about curriculum objectives or teaching strategies. Rather, teachers were facilitated through a convergent modelling of a systematic process of development to design unique paths towards powerful learning for its learners, whilst affording adaptations of locally appropriate forms of pedagogical practices consistent with this approach.

As articulated by the ICT head of Zenith School (pseudonym), one of the consortium schools:

> ….as a school we decided how we want to use and implement the learning trails, which subject, which level…..so I would say we are quite independent….—ICT Head Interview260413.

We observed that teachers within the Zenith consortium school preserved agency and ownership towards the kinds of CIs implemented within their institution whilst a whole-school approach towards curriculum shifts was taken. Yet, within the school, the shifts in curriculum approach resonated with the overarching objectives of CS enculturation endeavour, that is, moving away from didactic modes of teaching towards self-directed learning, collaborative learning and authentic learning in out of classroom contexts.

A key function observed of CS' leadership involved balancing external mandates of macrosystems with internal needs of her school, teachers and students; based on professionally informed school- and classroom-based decisions. At an overarching level, CS leadership's role centres on mitigation of MOE's efficiencies in terms of meeting accountability structures yet at the same time attending to accelerated diffusion based on her own teachers' core competencies. A concretization of such mitigations is observed in the establishment of a three-tiered staff professional development model to emphasize on the "whole-school approach" commitment to curricular innovations in ICT. At the first tier, all teachers are inducted into basic competency ICT programmes; the second tier involves looking into the needs of each department within the school and to work collaboratively with the departments heads in planning their department's ICT trajectory and the third and topmost tier is oriented towards specialized training that is meant to "stretch" CS' ICT expertise.

Against this 3-tiered model of professional development in CS, the principal acknowledges that although the school has a "self-imposed" mandate to help like-minded schools in their journey towards digital age learning, the actual work on spreading these innovations are not taxed on CS' teachers. Rather, the school's ethos remained focused on ensuring deep learning for its students, whilst consolidating diffusion efforts within a nested, selective group of inclined teachers. In this way, whilst the school adheres to macro policies of scaling up pedagogical innovations, it balances this challenge by consolidating efforts internally, attuning itself to the needs of individual teachers on the ground. This mitigation is made functional by the principal's

cognizance of her connective role between MOE and her teachers.

> …as a school leader I work very much also on the ground … i think I am the **connection** between HQ and the ground and the **connection** between the school…—Principal Interview030414.

Emergence of Alignments Between Ecological Layers

The change strategies for deep learning manifested by CS' leadership may be emergent and contingent (on ground issues) in nature but importantly the principal has constantly endeavoured to be the sustained, focused voice of realignment towards overarching goals. As she works to mitigate external mandates from public policies with internal competencies of her teachers whilst ensuring convergences on shared purpose, collective alignments at the respective ecological layers become the core driver for reform.

> it is with alignment in mind. It is with converging as many parties together onto the same platform as possible and therefore converging as many resources as possible … What I then bring in is also my understanding of where HQ is going and then I bring that in…—Principal Interview 030414.

As she reiterated the importance of a systemic mindset, in understanding that learning is reciprocal and collaborative at both the teachers' and learners' level, that it is unpredictable and interweaves many "agents" acting simultaneously, it reflects her model of leadership that is "ecological in perspective". The leadership in Crescendo School (CS) emphasizes on decentralization of control whilst acknowledging the importance of aligning one's trajectory to centralized mandates to find the intrinsic value for sustained growth and improvement.

> Personally I feel that the school leader is crucial because I set the tone, I set the direction, I determine the narrative, and my narrative is always, **system has to benefit**. … then we are doing what we need to do within the whole ecosystem of the school landscape in Singapore…—Principal Interview030414.

Essentially, it is about carving and enacting a narrative where Singapore's education system as a whole can benefit.

Discussion on Ecological Leadership

From the two case studies, we distilled that the leaders of both schools have the unequivocal view of the need to propagate innovations to other mainstream schools in order to benefit the education system. Whilst system leadership foregrounds the altruistic motivation to improve other schools, we posit that "ecological leadership"—to which we come to next—delves deeply into the interplay of constituent influences that permeate the ecological context in which reforms are premised on. The leaders at each node have to circumnavigate the opportunities and impediments that emanate from both the proximal and distal spheres of influences as well as within and across the different levels of the subsystems. Importantly, a school leader with ecological beliefs is more sensitive to these five subsystems and its interactions even if one is unaware of such classifications as defined by Bronfenbrenner (1979, 1993). More specifically, the leaders act as a mediating layer to broker the interpretation of macro policies, benchmark them against the multifarious affordances of the school, make careful selection of innovations that they want to develop, translate them into micro implementation, consolidate the insights that arose from the processes and re-strategize for innovation diffusion to other schools. The current thesis on system leadership delves into the dialectics of top–down and bottom–up dynamics but is largely silent about this multi-tiered interfacing of ecological constituents within the paradigm of centralized decentralization.

To illustrate, attempts are afoot in both NLS and CS to deliver the overarching goals of ICT Masterplan Three as well as to spread innovations to other schools. However, there is stark contrast in how the schools achieve these goals. The leaders NLS practised a more centralized model of innovation diffusion as it is curriculum-based and required: (i) intensive apprenticeship model that focuses on curriculum re-design and deep transformation in teaching practices; (ii) systemic coherence and synergy amongst departments and agencies; lending itself to a more protracted gestation period for diffusion. On the other hand, for CS's case, we have identified the school's adherence to a distributed model of innovation diffusion, where there is wider outreach, less emphasis on innovation fidelity and greater autonomy for adopting schools to use the innovation either as add-on activity or embedded programme in the school's curriculum. CS also remains cognizant of the ecological underpinnings of pedagogical scale and sustainability from the onset.

The leaders of both schools emphasise learning. However, "joint practice development" (Hargreaves 2012, p. 6) is more prominent in the case of NLS as the principal aspires "to do more than project", and has the vision that cross-school collaboration should culminate into all participating schools "building a professional learning culture" (Principal Interview100913) for the innovation to flourish in their respective context. NLS leaders, thus take more accountability in terms of ensuring innovation

fidelity. Adopting a diametrically different enculturation process, the leaders of CS provide wider latitude and focuses only on the overarching principles of designing learning trails as the leaders believe schools can further contextualize the intuitive innovation. The purpose of fleshing out these differences is not to prove the supremacy of either approach to innovation diffusion, but to foreground the distinctive constellations of conditions that led to the small but tight network forged by NLS and the larger but looser model developed by CS. The onus is on the school to ascertain whether short-term innovations that do not require whole-school re-design; or fundamental changes that require intensive planning would be more apt for them based on the ecological state of the school landscape. What we would like to attempt is to elucidate how leaders marshal their resources and make visible the rationalization process of their decisions related to the propagation of their innovations. The leaders of both schools, which we have discussed in our case studies, are not Cluster Superintendents in the formal sense, but they have functioned in ways that span across schools' networks similar to that of system leaders and more. To wit, they have established professional capital with parties mirco to their respective school, and ecological to structures, resources and human capacities to make innovations productive with respect to their endeavours.

Despite the abovementioned differences in diffusion processes, the leaders of NLS and CS exhibited common thrusts in their leadership, which we conceive as S-C-A-L-E (see Fig. 2):

(i) Systems thinking to benefit more schools so as to bring forth collaboration and imbue communitarian perspective in the system.
(ii) Converge vision and contextualize innovations in relation to overarching mandates.
(iii) Align efforts by mitigating tensions and paradoxes within and across the subsystems in the ecology.
(iv) Leverage collective wisdom and resources emanating from any level of subsystem to diffuse innovations.
(v) Emergence of new adaptive capacities for sustainability.

We conjecture that the spread and effective implementation of new pedagogies and innovations or 'positive contagion' under the right set of conditions (Fullan and Langworthy 2014) achieve efficacy when leaders internalize an ecological perspective and seek to achieve optimal thread and ecological coherence through the S-C-A-L-E dimensions. This is akin to Wielkiewicz and Stelzner's (2005) argument that to understand leadership, one must do so "in the context of ecological systems" (p. 330). Their proposition is that leaders who are more ecologically attuned to the infinite variables of the organization will be more adaptive and able to leverage on diversified feedback loops to improve the system. Bottery (2004) describes this as being "ecologically aware", that is "to be cognizant of those forces which impact not only upon their own practice, but upon the attitudes and values of the other educators in their organizations, the aspirations and endpoints of their students, and upon those in the wider communities they serve" (p. 25). Drawing commonalities between the two studies, there is shift of focus away from "positional leader" (Wielkiewicz and Stelzner 2005, p. 327) to leadership that drew on collective voices emanating from the ecology—a departure from the stance of system leadership which is still predominantly centred on nurturing positional leaders, especially head teachers with macro views of benefitting the school system. Building on the premises of limited literature related to ecological perspective of leadership, this article expounds on how both the proximal and distal ecological influences work in concert to affect the propagation of innovations for twenty-first century learning. In essence, the ecological leader listens to and consolidates different voices in the ecology and exhibits the characteristics of forging alignments and convergences in the different ecological layers, mitigating systemic paradoxes as well as local and cross-school tensions faced by the participants; and is well poised in handling emergent phenomena within and across adopting schools. In other words, such leadership is able to navigate the interplays of the micro, meso, exo, macro and chrono levels of the educational system, thus bringing coherency across these layers. Ecological leaders, as depicted by our case studies, are able to mitigate the following tensions and paradoxes:

- reconcile three seemingly dualistic tensions: centralization–decentralization; competition–collaboration and conformity-collectivism.
- manage the expectations of top-down initiatives and ground-up interpretations of policy documents through aligning the teachers' perspectives, the school's mission and the policy at hand;
- communicate the alignments of shared understandings in schools upwards by identifying the issues on the ground to decision makers; and
- commit teachers to the belief that the leadership is 'walking the journey with them'.

Importantly, ecological leadership capitalizes on both the hierarchical and decentralized structures to foster deep change and not mere surface and outward reform (due to the propensity of interactants in East-Asian cultures to conform leading to surface acquiesce). Ecological leaders capitalize on formal and informal interactions across levels of the system to convince stakeholders. They are able to foster paternalistic approaches, due to the sensitivities of East-Asian values, with democratic orientations to achieve

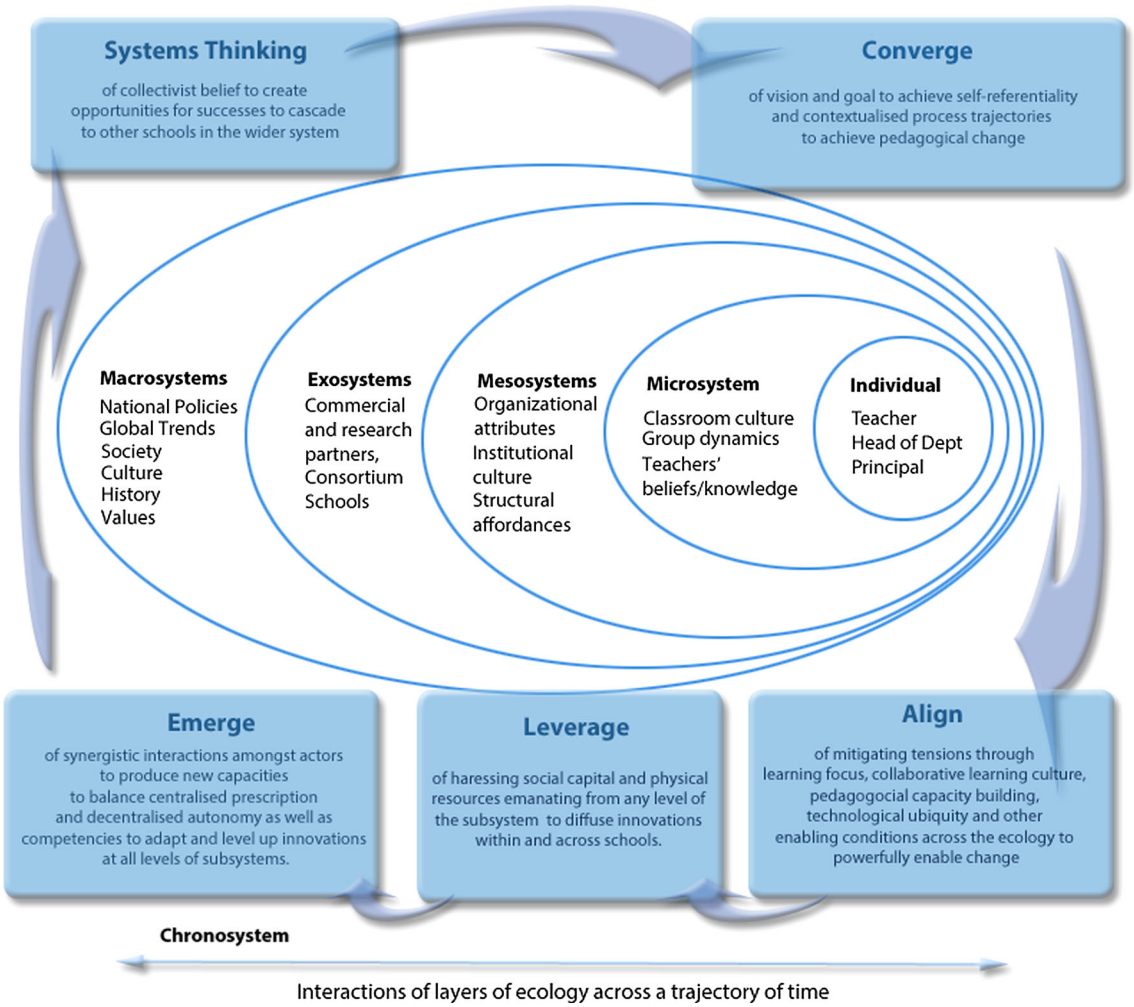

Fig. 2 Exercising ecological leadership for diffusing innovations through SCALE

the alignments and converges needed. Consistent to our case studies, we are able to observe ecological leaders in education who are able to align the centralized goals with the decentralized—these leaders would have to have embodied experiences on both sides of the centralized decision making and decentralized movements in the schools. In our observations, our ecological leaders have held appointments both at the MOE and also in schools, and are able to bring about the tenets delineated in the SCALE framework because of their past embodied enactments of the deep challenges faced.

Ecological leaders are also observed to reduce power distances across the levels by creating relational linkages through their social and collaborative capital. Moreover, they 'work the ground' by creating buy-in amongst stakeholders within and across schools. One of the key strategies is to make visible innovations to policy makers, school leaders and teachers in order to bring all stakeholders to concretize visions into realities. They are able to create structures for fostering professional capital amongst teachers and enabling dialogue on the vision and implementations of the innovations at hand. Such leadership creates the structure for teacher experimentations, capacity building and professionalism (e.g. through decentralized structures such as communities of practices, professional learning communities and learning networks) and develops partnerships with industry, universities and other schools in order to enable resources for teachers' experimentations and exploitations beyond the conventional constraints.

In other words, an ecological leader examines the interplay between social–cultural meanings and physical-material affordances of innovations at micro, meso, exo, macro and chrono levels of a system. An ecological leader is one who is able to capitalize on a distributed leadership, both within his or her school and across schools, to enact these interplays. For the interplays to occur throughout the system, ecological leaders need to be adaptive in that he or she 'makes good' (e.g. create partnerships for resources) the contextual nuances of top–down policies and bottom–up interpretations/enactment. The ecological leader is

acutely aware of the "selective contextualisation" of innovations by considering the ecosystem of the school/schools and the larger socio-cultural landscape influencing school innovations. He or she has the system desire to expand the innovation ecosystem so that it creates impact at a more complex level (with more interconnecting agents) and benefit more schools. We think this altruistic motivation may be prompted by Singapore's emphasis on communitarianism, as seen from the national narrative of putting nation before self (Kong and Yeoh 2003). It should be noted that classroom teachers can have this ecological leadership potential according to our observations. We notice exceptional teachers who work in partnerships with teachers, both within and across schools, because they are committed to certain pedagogies, and bring about their own local versions of S-C-A-L-E. Thus, ecological leadership need not reside in key leaders or individuals, the tenets can be collectively achieved by augmenting the collective capacities of actors in the ecology.

Moreover, such leadership engages in managing the inter- and intra-ecological constraints and affordances of the system to the advantages of the reform situation. Intra-wise, ecological leaders draw in resources within the ecology at hand into the school; inter-wise, it spreads innovations/resources and forms partnerships to expand the ecology. As to the interplay of the intra- and inter-dimensions, they manage the ecological constraints and affordances with realistic expectations but with a shared vision fostered with all the stakeholders in the ecology. It forges 'ecological coherence' by aligning national, cluster and schools' interests (Toh 2013). As seen from the case studies, the linchpin afforded by leadership practices can be philosophical (self-referentiality), pedagogical (twenty-first century learning), structural (infrastructure, financial, temporal), political (converging discordant interests), technological (provisions) and socio-cultural (sense-making) in nature. These facets cut across the five subsystems, which require not only system leadership, but nuanced acumen as it is relational with respect to the interplays of the different layers of a system. Ecological leaders thus survey and leverage on resources available in the ecology and subsequently, creating new resources that can be used by other agents in the ecology. What ensues is the creation of virtuous cycles of collaborative capital that can be harnessed by others. In this sense, ecological leaders are also contributing a part in edging towards an open ecosystem for innovations.

Table 1 below shows the tenets of system leadership as articulated by Fullan (2004); Hopkins and Higham (2007); as well as ecological leadership as posited by the authors. Attributes that are similar are grouped together for comparison. Building on the seminal foundations on system leadership, we believe ecological leadership has the potential to bring the discourse on leadership further as it exemplifies how leaders respond to top–down imperatives by intentionally planning for strategies that complement the school's capacity and interests; and yet at the same time achieve national mandates. Additionally, after achieving within-school success, the leaders have to re-contextualize the diffusion trajectory of their niche innovations when cascading the innovations to other schools. They are concerned with both the scalability and sustainability of the impact of reforms at a wider school level. Although scalability does not necessarily lead to sustainability, our conjecture is that when ecological leaders observe coherence at each level of the subsystems, there is predisposition for innovations to thrive, especially when both middle managers and teachers are also imbued with ecological perspectives. In our two case studies, the sustainability of the innovation has already been achieved within both NLS and CS before diffusing the innovations to other schools. It remains to be seen whether such diffusion efforts will subsequently affect the sustainability of the innovation in the hub school that propagated it in the first place.

Clearly, the notion of ecological leadership is still nascent and there are several gaps that can perhaps be addressed in future studies. In this paper, only two contrasting case studies were used. We have plans to study more cases of cross-school collaborations to further unpack how school leaders can achieve systemic change, in particular, by forming sustainable partnerships that make innovation diffusion work and whether they have deliberately considered their leadership strategies at the various levels explicated in our SCALE model. Work is also currently underway to study how the downstream schools are translating and implementing the two niche innovations in their school contexts. More importantly and broadly, how their participations in these cross-school professional learning communities have changed their learning culture and how the hub school will continue to support the innovation-adopting schools after the end of funding cycles.

Conclusion

We elucidate in the previous sections that ecological leadership can be collectively achieved by actors in the ecology. At the systems level, the Singapore's education system began from the premise of a centralized system. As it moves towards an increasingly decentralized milieu, ecological leadership is needed to balance the interplay of centralization–decentralization. Underpinned by the desire to adopt a more cautious attitude towards the diffusion of innovations, experiments which began strategically in some schools are diffused and possibly tested out in

Table 1 Situating ecological leadership within the literature of system leadership

Attributes	System leadership for sustainability (Fullan 2004)	System leadership practices (Hopkins and Higham 2007)	Ecological leadership for coherence
Moral purpose/ systemic view	Public service with a moral purpose to raise the bar, "move beyond standard plateau" (p. 6); close achievement gap; treat people with respect; improve the environment and engage in macro perspective of big picture and societal goals	Driven by moral purpose to enhance student learning by providing diversified educational pathways for students, empowering teachers and improving communities within and across localities	Collectivist belief to create opportunities for successes to cascade to other schools in the wider system. Ensures creation of virtuous cycles towards an open ecosystem for innovations. Also to articulate vision and goal for self-referentiality
Changing contexts	Commitment to changing contexts at all levels by interacting beyond local situation in a blended system where local and central levels influence each other within and across the tri-levels of school and community; district or local education authority and state or national policy	Changing contexts by engaging with the wider system: partner low-achieving school, lead improvement partnership, improve challenging schools, work as change agent and act as community leader	Forging alignments and convergences in the different ecological layers, mitigating systemic paradoxes as well as local and cross-school tensions faced by the participants; and is well poised in handling emergent phenomena within and across adopting schools
Managing learning	New "vertical co-dependent relationship" (p. 11) with authority, characterized by finding synergy whilst appreciating differences "Lateral capacity building" (p. 12) through networks Deep learning for engaging learners and creating cultures of systems thinking	Managing teaching and learning processes, developing people and organization	Creating alignments by ensuring structures for learning, collaborative learning culture, pedagogical capacity building, teacher experimentations and technological ubiquity. Underlying assumption is both distal and proximal ecological influences can affect learning and need to be managed
Operationalizing vision	Dual commitment to short-term and long-term results; the former for building trust and attracting continuous investment; the latter for sustainability and co-ordinated efforts	Head teachers setting directions by engaging in personal development and developing strategic acumen for operationalizing vision. Differentiated approach to managing "dialectics of prescription versus professionalism, centralism versus devolution" (p. 161)	Drawing in ecological resources and acting as systemic resource broker: leveraging social capital, collective wisdom and physical resources emanating from any level of subsystem (within school, cross-school, national and international) to diffuse innovations Spreading innovations that have achieved proof-of-concepts to other schools
Succession	"Cyclical energizing" (p. 13), instead of overloading to create intellectual and moral conditions for motivation	Adjusting accountability requirements, creating conditions within the system to incentivize system leadership and placing agency close to school	Synergistic interactions amongst actors to produce new capacities to balance centralized prescription and decentralized autonomy as well as competencies to adapt and level up innovations at all levels of the system
	Developing "long lever of leadership" (p. 13) to nurture systemic thinkers		Examine the interplay between social–cultural meanings and physical-material affordances of innovations at micro, meso, exo, macro and chrono levels of a system and capitalize on distributed leadership, both within school and across schools, to enact these interplays

clusters that share common affinities to prevent "systemic failures" from reverberating throughout the system. Such collaborations between schools are starkly different from the underlying overtures of "competition". In Singapore, conditions for collaboration may be more favourable than in other systems. There is no crowding out effect as suggested by Greany (2014) due to the careful policy for system and cluster leadership. But increasingly, ecological beliefs are needed.

From our case studies of FS in Singapore, we are encouraged to see how innovations are indeed cascaded to other mainstream schools through ecological leadership—more specifically, through the SCALE framework of Systems thinking; balancing act between Convergence and

contextualization; Aligning efforts to mitigate tensions and paradoxes; Leveraging ecological resources and fostering conditions for Emergence. Our view is that policies supporting diffusion should have "ecological" affordances and constraints as intentional designs for sustainability. It is intentional that policies should ensure: (i) schools work together collaboratively around authentic tasks; (ii) ecological leaders are present to ensure coherence; and (iii) leadership is gradually devolved to allow for sustainability and distributed autonomy. When autonomy meets guidance, as manifested in our centralized-decentralized paradigm, the system would likely yield more sustainable results for improvement and innovation. More importantly, leaders need to go beyond system leadership and act as brokers to forge "critical connections" (Wheatley 2006, p. 45) within and across the subsystems to bring social innovations to scale in the crucible of change for twenty-first century learning.

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