Chapter 13
Moving forward – how to create and sustain an evidence-informed school eco-system
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Aims of the chapter

- To synthesise the arguments and research evidence from the chapters in this book in terms of the levels of the ecosystem
- To bring out further implications of ecosystems thinking as applied to the research-engaged schools
- To present a revised ecosystems conceptualization of the research-engaged school
- To suggest the role for policy-makers, researchers and leadership of a research-engaged school ecosystem

Introduction

In this chapter I re-state our ecosystem framing and build a richer picture of what a highly research-informed ecosystem of schools could look like, synthesising the learning from the preceding chapters. The chapter also builds on this from an ecosystems perspective, suggesting some theoretical and methodological ways forward; these include suggestions for study of the ecosystem and elements within the system. Finally, this chapter proposes some recommendations for policy-makers about how to support a richly research-engaged eco-system and for the role of leadership within this system. The aim throughout is to stimulate further thinking rather than have the last word, in particular the roles of various stakeholders, institutions, types of research and the role of government in the ecosystems theoretical framework.

It is worth clarifying what we have meant in this book when referring to the 'ecosystem'. We see this term increasingly used by companies like Apple and Google to show the inter-connectivity of programmes, data storage and hardware –to explain how each part of this system needs to be 'surrounded' with supporting procedures, protocols and structures. In education, some have suggested the need for an 'architecture' of evidence-based practice for teachers (Goldacre, 2013). However, Goldacre's suggestions rather limit the nature of the research engagement ecosystem, focusing almost entirely on the construction of knowledge that has its foundation built from randomised controlled trials of teaching strategies. He proposed that this foundation should support a layer of diffusion via teacher journal clubs, taking inspiration from the way some medical practitioners discuss research knowledge. In this book we have aimed for a more ambitious model of the ecosystem and a more inclusive notion of research informed practice. The ecosystem involves an interplay between people, knowledge and 'things' i.e. physical resources, structures, processes and also cultures (including meanings, language, and values). An 'effective' ecosystem would be adaptable, dynamic, resilient and sustainable.

We have looked at the ecosystem in two related ways:

1. The notion of an ecosystem as a supportive, nourishing environment in which research-engagement can flourish (and lead to learning and improvement)
2. School education as an ecosystem with multiple levels

The first approach relies on an assumption, held by both of us, that research-engagement – i.e. doing and 'using' research is inherently of importance and adds great value to the school education system, both to practice and in policy-making. Research-engagement in schools is the focal system with 'soft boundaries' (McGinnis & Ostrom, 2014) and is a sub-system of the wider educational ecosystem. There are clearly a near infinite number of other potential foci in the wider education system, such as teacher recruitment, maintaining school buildings, the incorporation of information technology and so on. The educational ecosystem also interacts with other ecosystems, for instance social care, health, transport, employment and the business world. We have looked at multiple levels of this focal ecosystem (Macro, Chrono, Exo, Meso and Micro), pivotal being the concept of research-engaged schools (see Chapter one). The book has included many, but by no means all elements in the ecosystem that have a direct effect on research engagement in school education. For instance, there has been no direct analysis of the role of government in this system. This chapter turns to the latter in the concluding section.

By picking out some of the key findings from the chapters above, table 13.1 summarises some of the elements we can expect to see in a school system that is highly research engaged. Alongside each level there is a list of ecological conditions that support this ecosystem. Following the table summary, I extend the analysis of these levels, incorporating a range of approaches from the ecosystem literature.

Table 13.1 Elements of a highly research-engaged school ecosystem

Level	Indicators of high research-engagement	Ecological conditions
Macro-system	- Schools are institutions that successfully promote high-level societal aims such as equality, diversity and social justice as well as excellence in learning and achieving qualifications and skills. -Research-engagement helps to achieve these aims	- High levels of trust and stakeholder involvement. - Belief in key role for professional practitioners and academics. - Clear and inclusive narrative about research-informed practice to encourage optimal rational choices. - Consensus about the aims of education and thus how research can help achieve those aims.
Chrono-system	- Changes to policy-making and practice are incremental, coherent and informed by research-engagement.	- Strong professional bodies/political systems to act as buffer against short-termist policy or practitioner fads - Research-practice models that take the learning from research through to implementation
Exosystem	- School collaborations, networks and partnerships enable research knowledge to be effectively mobilized and combined with other professional knowledge. - Practitioners, schools and networks actively engage in research and enquiry as well as 'using' research.	- Long-term resourcing of knowledge mobilisation networks, including online resources and social networks, plus quality assured, effective distribution and translation of research for professionals. - An accountability system and middle tier that supports collaboration and promotes trust. - Changes to funding and structure of work for some practitioners and academics in order to traverse communities of practice. - Universities and other research organisations support schools, providing high quality professional learning, expertise, support and critical friendship.
Meso-system	-Schools operate with learning and enquiry at their heart for adults as well as their young learners. - Research-practice projects are integrated into the developmental cycle of schools. - School staff use data effectively to inform school improvement	- Leaders with skills to promote research-engagement within and across schools - Teachers with time to engage in and with research and enquiry in order to develop practice. - Universities and other research staff afforded time and career incentives to engage in research-practice collaborations. - Support from data-brokers from within and outside schools to help practitioners take effective evidence-informed action.
Micro-system	- Teachers and other professionals have skills and knowledge to implement societal aims for education system. - Mutual trust high between school staff, parents, and students due to increased (research-informed) professionalism	- Initial education and professional learning of teachers and school leaders gives research-engagement a clear priority. - Coherent system of teacher professional bodies that set the goals, criteria and standards for research and research-informed practice. - Responsibility to engage in and with research backed with entitlement to appropriate training, support and funding.

The Macrosystem

While it has not been the focus of this book to comment in depth about the purposes and goals of the education system, rather to focus on the first proposition above, the two intentions go very much hand-in-hand. The values held in the macro level permeate down to policy enactment, to institutional and organisation arrangements and ultimately to the micro-level. If we add that management of ecosystems requires regular monitoring and evaluating of actions, then there is a synergy between 1 and 2 above, in that research enables us to achieve the end of an 'effective' ecosystem (values, purposes).

In chapter one we outlined the need to think of the school as an institution as well as an individual organisation. This way we re-affirm the values behind education and the purposes for and in society of the school system. In a research-engaged school system, research would be clearly directed towards helping achieve such aims. In order to do so, there will be a need for some consensus about where this system should be heading and why. In order for there to be sufficient uptake or demand for research-informed practice, the narratives that emerge from government, the research community, schools, universities and other institutions need to be clear about its value. In this way, teachers and other practitioners are more likely to make the kind of optimal rational choices that Brown analyses in chapter eleven. Professional bodies (and even quasi independent political processes which have at their core a commitment to establishing long lasting educational values) have a clear role in taking the lead in this respect and can offer a buffer to the turbulence caused as new governments come in and propose their own new sets of requirements and fads (see chapter five). They can do so by outlining a clear professional ethic and promoting wider educational values of equality, diversity and social justice, for instance. A clearer balance between the aims of building 'qualities' in young people, such as resilience (character), and to finding ones place in democratic society are also possibilities around which, we would contend, there would be widespread agreement. Given the current, and dominant worldwide, fueled by national and international league tables of schools and education systems that education is primarily about achieving qualifications, and sometimes to the detriment of children's (and teachers) well-being, this would provide welcome balance.

Research not only helps educators to achieve wider educational ends and means, but they can also inform the debate. For instance, in England we have seen the research community make a robust challenge to the idea of increasing the number of schools that select by academic performance in tests at age 11, this is despite the covert ways that schools and government have sought to increase the capacity of existing schools and thereby increase the number of places available[1]. Arguments about the social inequity caused by school academic selection, have provided powerful counter-arguments to further expansion of 'grammar schools' nevertheless (e.g. Burgess et al, 2017).

We have seen also, that building trust plays a vital role when promoting learning from school research-engagement (see chapter 6 and exosystem below). Therefore, the accountability system (including the media) needs to balance the need to punish underperformance with a developmental and co-constructive approach that supports learning and growth. It also makes less sense to blame others, if we accept our own responsibility in the same ecosystem. Therefore public condemnation of 'failing schools'[2], often fueled by inspection reports, are counterproductive to the aim to promote high trust and encourage innovation through research and development.

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[1] https://www.bbc.co.uk/news/education-44727857

[2] e.g. http://www.itv.com/news/2017-12-13/ofsted-annual-schools-report/

In Chapter twelve, Wisby and Whitty pointed out that our ecosystem for research-engaged schools should be empowering, inclusive and adoptive of a broad church of research practice. If, as has been argued, the push is for narrow ideas of technical-rationalism in teaching and educational leadership, expressed through dominance of a 'what works' agenda in research-engagement (Godfrey, 2017) then we are in danger of falsely applying certainty to a complex system. In doing so, rather than producing teachers who are empowered to use their professional judgement to meet these complexities, teaching may instead be reduced to a mechanical process of implementation of 'evidence-based' strategies.

The Chronosystem

In Chapter one, I gave one example of the analysis of the development of schools as research-engaged organisations. There, I drew upon research of eight secondary schools in England on different trajectories (Godfrey, 2017a). The development of these school organisations was determined by entrenched and ongoing contradictions in the object of their activities. For instance, the learning derived from PLC activity was sometimes in contrast to the performative aims of the school leadership, driven particularly by the external inspection system. These contradictions had to be negotiated over time, leading to a new 'object' of their activities, often leading to an expanded idea of what it meant to b a professional (to include research-engagement), to an expansion of the community of practice (to include research organisations or advice). Mediating this 'expansive learning' (Engestrom, 2001), a new language derived from the world of research acted as a tool to leverage change. The leading this change, teachers who were able to achieve the kind of ecological agency described in Chapter ten. The contradictions found in the developmental cycle of change described in my case studies above, are also found in discussions of transformational change and leadership described in the ecosystems literature (e.g. Westley et al, 2013).

Contradictions or tensions in ecosystems are sometimes described in terms of a search for *dynamic equilibrium*, i.e. where the forces in the ecosystem are sustainable but not entirely static or without elements of refinement, expansion or even destruction. If an ecosystem is 'static' it fails to accommodate new innovations or trends in society, while one in constant flux does not create the conditions to institutionalise policies and practices. Social ecological systems (SESs) have been described as 'self-organising', and involving:

" the interaction of cultural, political, social, economic, technological and other elements, [wherein] parts of an SES respond to changes in other components, sometimes triggering feedbacks that can amplify change in the whole system or can have a stabilizing effect. Through these interactions, SESs can self-organize (i.e., adjust themselves through interactions among their components), novel configurations can emerge, and adaptation is made possible".

(adapted from p. 6, McGinnis & Ostrom, 2014)

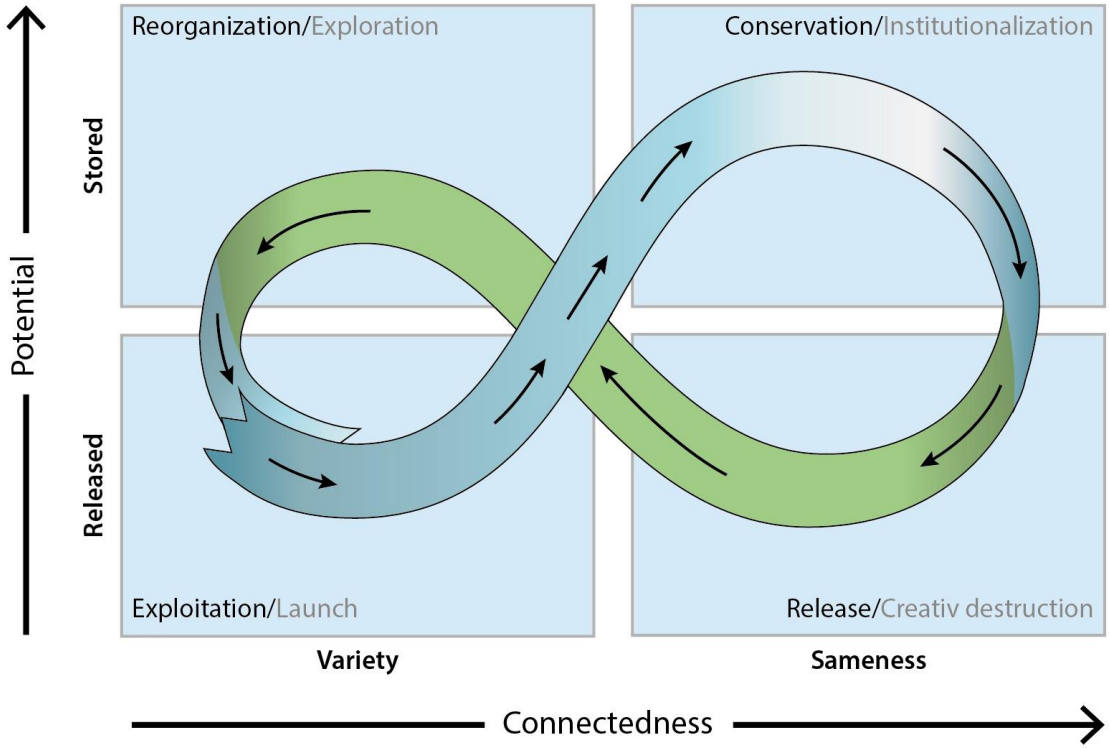
This 'diagnosis' of ecosystems has warranted the development of a framework to extract various elements in detail (McGinnis and Ostrom, 2014). Within this analysis of the resilience of ecosystems, the nature of institutional development has been an interesting source of study and to which I turn below.

It has been proposed that SESs go through four phases of adaptation, powered by the degree to which capital is stored or released and the degree to which the system is either homogenous or heterogeneous in certain features. These four phases of the adaptive cycle: exploitation, conservation, release and reorganisation describe a double repeating loop, where the front loop is characterised by institutionalisation and the back look is the destructive, change part of the loop where innovation occurs (Westley et al, 2013). Where there is a multiplicity of organisational forms, this can lead to more connections and overlap that can help to mobilize action and resources for innovation. However, too much multiplicity leads to fragmentation and therefore makes it hard to release resources in large quantities. Institutional entrepreneurship looks at the opportunity contexts that this adaptive cycle presents, see figure 13.1 below.

Using the heuristic in the figure below, a number of education systems could be said to have gone recently through a phase of 'creative destruction' in which there has been fertile ground for innovation and much entrepreneurial 'land grab' as new opportunities for the release of resources and capital have emerged. This would be my characterisation of the landscape in England, for example, that has gone through a period of structural changes to school institutions and the way they work in networks (Godfrey, 2017b). This has been accompanied by many opportunities for researchers to look into these changes and the effects they are having on educational outcomes. Assuming England is now moving towards a more stable phase in which there is a great deal of heterogeneity of structures and institutions, then this calls for research that helps identify which practices, policies and institutional arrangements should be connected together, consolidated and reinforced or indeed, cut.

Research and development also plays an essential role in this system to encourage innovations to be trialled, evaluated, refined and spread more widely across the system. An understanding of the scalings in the ecosystem is important, however it is also necessary to appreciate the drivers of change at each level and the varying rates of implementation, embedding and institutionalisation of innovations. The leadership challenges in diffusing innovations in research-engaged schools across the ecosystem is discussed later in this chapter.

Figure 13.1 Opportunity contexts in the adaptive cycle



(from Westley et al., 2013, p.27)

The Exosystem

One of the major shifts in ecological systems theories is from the idea of the organisation as a discrete 'sealed' unit to one that has 'semi-permeable boundaries (Godfrey, 2016, p.23). This is important in Pollock et al's discussion of the 'middle-tier', specifically of the KNAER network in Chapter two. They explain that to promote research-engaged schools in a healthy educational ecosystem, it is necessary to actively mobilise multiple forms of evidence through multiple processes of communication, collaboration and interaction. These networks are more than the sum of their parts, as they cannot work independently to the same extent, benefiting from sharing resources and harnessing collective knowledge. In a symbiosis, the individual school organisations can benefit the network and the network also is of value to practitioners operating on a daily basis in the 'core business' of the school. The knowledge created within the network can come from individuals, departments, whole schools, or within cross-school partnership levels. Some of these may also involve multi-disciplinary projects with outside organisations, such as universities, the KM network allowing there to be gains from working at scale and allowing greater diffusion of innovations emerging through research engagement. Furthermore, through the kinds of thematic networks and communities of practice, illustrated in the Ontario KM case, these can engage resources from the government level and also to achieve aims collectively in a way that individual schools would be unable to do on their own.

For these kinds of KM networks are to come about and to lead to positive changes that permeate down to the microsystem, new ways of working will need to be embedded across the ecosystem. As they point out:

"there has been a shift from the traditional relationship models toward new models that are more interactive and value partnerships and networks has developed. Although this is a positive move, it is becoming increasingly recognized that there needs also to be attention to the wider ecosystem in which research and evidence are part of a culture and infrastructure of co-development, critical inquiry, genuine collaboration and attending to existing structural challenges in accessing, adapting and applying research in and for education"

(Chapter two, p.7).

However, for these KM networks to promote learning, improvement, resilience and adaptability through research, the regulatory and accountability mechanisms need to work in a way that does not lead to too much standardization and control. In Chapter three, Ehren outlines the many ways in which schools change their understanding of educational quality in high stakes accountability regimes by adopting the external inspection framework for their own school evaluation, in lesson observations and by becoming overly preoccupied with being 'inspection ready'. Schools concerned with being judged on an individual basis will not work effectively in networks, and the value of such networks can be wrongly assessed by the accountability system in terms of the aggregate of the quality of individual schools, rather than network level outcomes (Ehren and Godfrey, 2017). Ehren explains how the external accountability environment can lead to *coercive isomorphism:*

"Schools are part of an exosystem in which they interact with other schools, local community organisations, parents, and suppliers of services and resources (e.g. suppliers of textbooks). These organisations and stakeholders exert pressure on schools (both formal and informally), particularly when schools are dependent on these organisations."

(Chapter three, p.3).

She goes on to suggest that, “Inspections play an important role in creating such coercive pressures and in defining how schools are expected to be structured and formed” (ibid, p.3). In order to build the high levels of trust needed to encourage research-engagement, the co-construction of the goals of the network level accountability are a crucial area of alignment in the exosystem.

The Mesosystem

An implication of the semi-permeable organisation boundaries in the exosystem is for a new kind of ecological understanding of the mesosystem too. This will need to be multi-faceted and enable numerous connections to occur at the network level, with outward-looking organisational foci being essential in the formation and sustainability of strategic alliances. In successful ecosystems, organisations gain nourishment from these connections as well as feeding into the success of the ecosystem of which they form a part.

I propose furthermore, that an extension of our notion of the research-engaged school is the aim of being an *adaptive organisation* (e.g. Fulmer, 2000); i.e. one that matches its capacity to meet the demands of the external environment. Referring to Wielkiewicz and Stelzner’s (2005) work in the ecological leadership literature, several challenges emerge for leaders of adaptive, research-engaged schools:

1. The need to balance the swift decision-making possible in traditional, hierarchical models of leadership with the more open ended participatory leadership that allows for greater flow of feedback and information.
2. The need to devote time to thoroughly understand the context for taking decisions.
3. In order to build organisational adaptability, rich ‘feedback loops’ are needed to understand practices, policies and procedures from the evaluations of learners, employers, governors and parents, triangulated with the analysis of peer reviews, inspection visits or other enquiries by staff.
4. Adaptable organisations should scan the horizon by taking into account the views of people from a variety of cultural backgrounds. However, this drive for diversity and inclusion can conflict with the need to make single-minded decisions.
5. School leaders need to exercise courage in their long own vision to pursue a course of excellence, rather than relying purely on external, accountability driven measures.

The above challenges require a shift in thinking from mechanistic, industrial ideas of bureaucratic organisation towards more organic, ecological, systems thinking and managing a series of ‘tensions’. There should be less emphasis on singular, positional leaders to direct activities and more on seeing leadership of organisations as emerging in a number of ways and afforded in particular circumstances and contexts. This ecological leadership is discussed further on in this chapter.

The Microsystem

The aim in our microsystem is to have research-informed professionalism where practitioners (especially teachers) are empowered to take decisions, exercise good and wise judgement and expertly execute the kind of approaches that enable students to fulfill their potential. The link to the macrosystem is essential; the values that society, government, parents, business leaders and so on want from schools are largely in the hands of the

professionals that work in them. Therefore the research-engaged school ecosystem needs to empower such practice, be inclusive, set standards for this work and shape the agenda.

Staff in research-engaged schools will be motivated and supported in their engagement through a number of levels and dimensions in the ecosystem. In Chapter ten, Priestley and Drew draw attention to the 'ecological conditions' necessary for the achievement of agency and that can be promoted through enquiry approaches to teacher learning and thus enabling teacher leadership of school improvement. Such enquiry approaches can be nourished and sustained through a variety of means, many originating outside the school and passing through the semi-permeable boundaries of the organisation. The practices that occur will then be re-configured, influenced by the context, the leadership and many cultural influences of the individual school. We have seen earlier in this book how teacher research-engagement can be directly supported during initial teacher training (Chapter eight), through the encouragement and support of professional bodies (Chapter Five) and also by virtue of the school's membership to a knowledge mobilisation network or a research-practice project with a university (Chapter two).

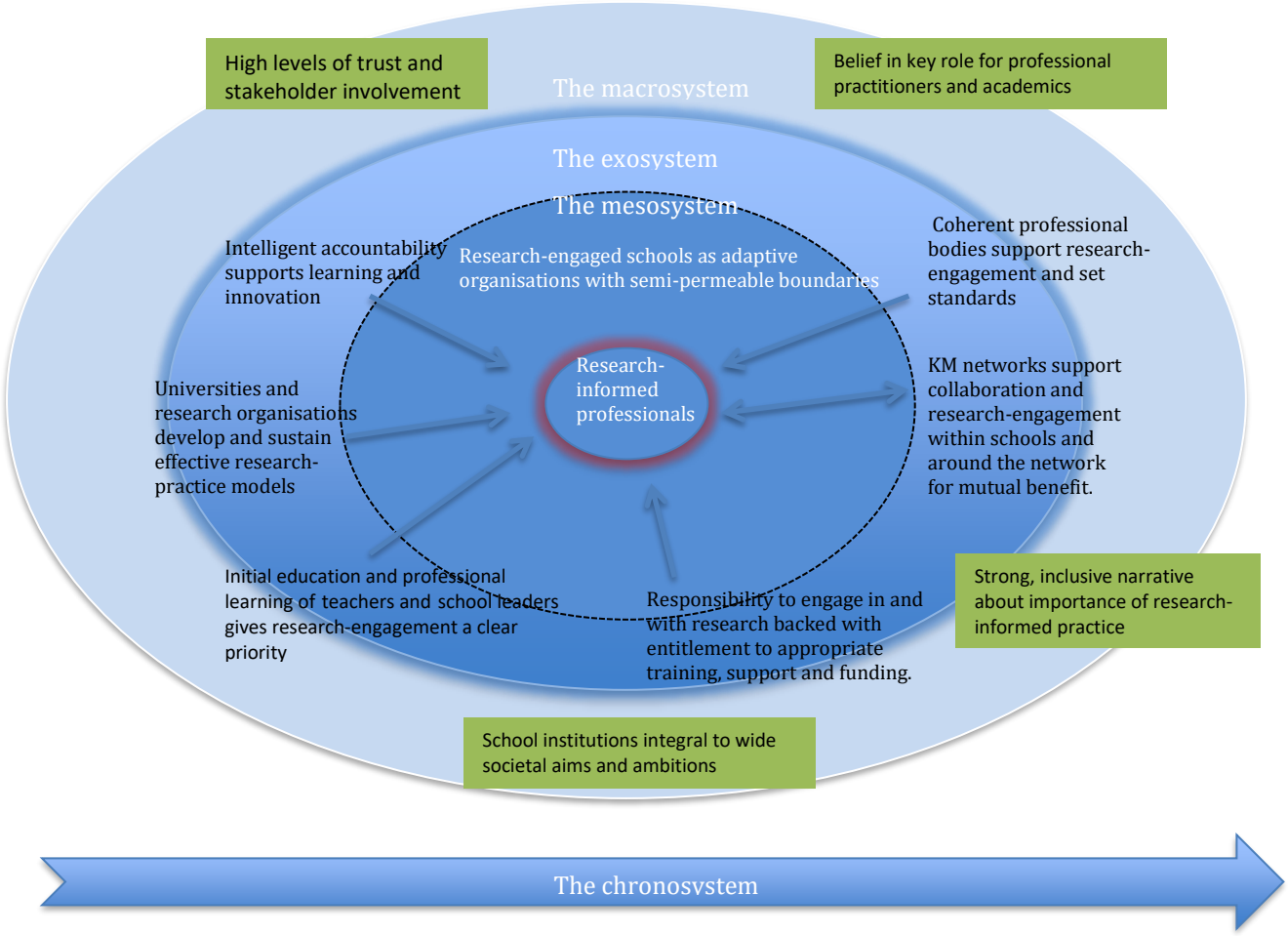
An ecosystem of research-engaged schools

Figure 13.2 proposes an ecosystems conceptualization of research-engaged schools, building on the arguments and research discussed in this book (summarized above), an article I published previously about leadership of research-led schools (Godfrey, 2016) and another paper that I co-wrote that analysed the research and development ecosystem in the English school system (Godfrey and Brown, 2018). The elements of the model comprise the macrosystem values level that underpin the ecosystem. These values foreground the policy enactment, institutional configurations and surrounding mechanisms in the exosystem that provide support, nourishment or alignment for research-engagement to thrive. In the case of KM networks and schools the arrow is bi-directional in flow, recognizing the mutual benefits for both the schools and the network as a whole of the alliance. In Chapter three, Dimmock described the importance of leadership in promoting the kind of effective PLCs that are essential to research-engaged schools. But the notion of the school as a learning organisation is not limited to how it creates opportunities for its members to take part in and learn from research but also to how the school learns from their partnerships and links with other institutions. These semi-permeable boundaries of the mesosystem as mentioned above are represented by the dotted lines in the figure below.

The microsystem practices by individuals (professionals) emerge within the research-engaged school mesosystem as described in Chapter one of this book: i.e. a school that promotes engagement in and with research, is connected to the wider educational system and makes decisions and adopts practices, based on its members' research-engagement. The chronosystem element reflects the cyclical renewal of the elements in the system: the adaptive institutional cycle and the need for ecological leadership to cohere and align the various forms of capital and emergent resources needed to keep the ecosystem in dynamic equilibrium.

The conceptualisation below is suggested as a starting point, inviting further thought about additional or missing concepts and elements or refinements. It also serves to stimulate thought about the precise nature of the relationship between elements and how such an ecosystem model for research-engagement could be used to think about systemic reform of schools.

Figure 13.2 An ecosystems conceptualisation of the research-engaged school



Ecological leadership at each level and that traverses levels. Diagnosis of research-engaged school ecosystem according to the adaptive cycle in order to maintain a resilient ecosystem in dynamic equilibrium

Leadership of the research-engaged school ecosystem

In this section I elaborate the leadership aspects of the above conceptualisation of the research-engaged school ecosystem that have as yet been underdeveloped in this model. In particular, the discussion of: i) leadership of adaptive organisations (adaptive management) and ii) of an ecological model of system leadership. For the former, I will refer partly to a review I wrote for the Further Education Sector in the UK (Godfrey, 2016a). For the latter, I will rely heavily on the work of Toh et al (2014) who describe features of 'ecological leadership'.

Adaptive management

Research in adaptive management has defined ecosystems as, "complex adaptive systems that require flexible governance with the ability to respond to environmental feedback" *(Olsson et al, 2004, p. 75).* Part of the leadership challenge of adaptive systems lies in the recognition of the complexity and uncertainty faced in the environment. Such issues have been defined as 'wicked problems' (Rittel and Webber, 1974). Wicked problems are difficult to define; have no correct solution, they are inextricably linked to the context, there may be no obvious cause and effect and they are likely to be the cause of much debate, disagreement and conflict. Many of the concerns facing the schools sector are wicked problems, for instance the knotty question of how schools can help reduce inequalities of outcome, the role of technology, the best pedagogical strategies to use in various subjects or how to best organize the curriculum. There are often no agreed solutions to these issues, neither is there an agreed series of 'steps' that need to be taken to go from A to B (whatever B is). No one person or organisation can know everything that is necessary to meet this challenge. In addition, given the interplay of factors such as changes in funding, policy decisions and local contexts, the path from cause to effect is less than clear.

In short, the major issues facing the sector are complex – and need to be acknowledged as such. Heifetz and Heifetz (1994) go further in calibrating problems in terms of their wickedness thus:

- Type I (tame) problems. These are technical in nature and have clearly defined questions and mechanical, straightforward solutions.
- Type II problems that are clearly definable but have no clear-cut solution.
- Type III problems that have neither clear-cut definitions nor technical solutions.

Meeting these problems requires commitment to the kind of inclusive ecosystem of research-engagement advocated in this book with different kinds of research and evidence informing different levels of problems. In relation to the above, solutions to type II problems are only proposals that must be tested and refined on the basis of outcomes. While type III problems are the most wicked and require continual learning to formulate the problem and adaptively work toward solutions (DeFries and Nagendra, 2017, p. 266). The same authors warn against falsely assuming tame solutions to wicked problems and also inertia caused by overwhelming complexity.

The above challenges require new forms of leadership that bring people together to co-construct the future and to face up to these problems. However, as leaders may not like to admit that they do not have all the answers, or are unwilling to communicate uncertainty, there can also be a strong pull towards adopting a more managerial approach. While 'management' issues call for rational, procedural and calculative responses, leadership

approaches that tackle wicked problems require the 'soft skills' of managing relationships and emotions.

Adaptive and resourceful leadership approaches require leaders to: monitor external changes; identify relevant strategies; articulate an appealing vision; identify reasons for resistance to change and seek to convert opponents; build realistic optimism; keep people informed of progress and evaluate the outcomes of strategic decisions in order to refine mental models (Yukl and Mahsud 2010, p.98). In other words, leaders need to articulate theories of action for their proposed changes and to monitor the implementation of these agreed alternatives course of action (see Chapter five and Robinson, 2017). This cycle of organisational learning then is integral to leaders and leadership within and beyond institutional boundaries. The next issue is how to spread this learning and enable improvements throughout the ecosystem, to which the section on ecological leadership below addresses.

Ecological leadership

Through case studies of two exemplar schools in Singapore that have been successful in spreading curriculum innovations across networks of schools, Toh and colleagues looked at the kind of ecological leadership required to do so. Also referring to Bronfenbrenner's ecosystem levels, they describe five thrusts of the diffusion process, summarised with the acronym SCALE:

(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.

(Toh et al, 2014, p. 843)

Toh and colleagues describe this ecological leadership as more encompassing than traditional descriptions of system leadership. They describe the latter as, "still predominantly centred on nurturing positional leaders, especially head teachers with macro views of benefitting the school system" (Toh et al, 2014, p.845). Rather, and drawing on research by Wielkiewicz and Stelzner (2005), ecological leadership capitalises on collective voices emanating from the ecology; staff at various levels of formal and informal leadership and layers of the ecosystem contribute to the scaling up of innovations. Ecological leaders in the exemplar schools looked at by Toh and colleagues, acted 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" (ibid, p.844).

Scaling up innovations involves the communication and translation of a clear narrative that aligns and converges the institutional processes and aims with those of the exosystem. This alignment of approach to implementation also has to recognize the autonomy of each institution while:

"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" (ibid, p.841).

Thus a common language and set of principles are adopted but adapted to context in each school, creating both alignment and convergence. As part of the exosystem, Toh and colleagues also document the important long term role played by partnerships with university researchers in conducting evaluations of impact and feeding back on the process of implementation (ibid, p.841).

Leaders in this ecosystem required the sort of social skills described above in relation to adaptive leaders. This social capital of key leaders enabled resources in the ecosystem to be harnessed that would otherwise have been difficult to obtain directly from the ministry of education. Throughout this process, leaders took opportunities to seed conditions for ''social memory'' (captured sense-making experiences of actors) to become ''ecological memory'' (Olsson et al. 2004, in (Toh et al, p.842). The coherence emerging from this approach created, "virtuous cycles of collaborative capital that can be harnessed by others." (Toh et al, 2014, p.847). This 'emergence', i.e. the tendency for agents in a social system to interact synergistically to produce new capacities and novel order, is different from the individual local actions that engendered them (Toh et al, p.841).

The beauty of the ecological leadership approach, when applied to the ecosystem concept of the research-engaged school, is that we can avoid the tendency to get into the polarized debate about whether centralized top-down approaches are superior to local, bottom-up ones. Rather we look for synergy and emergence that can be viewed as an interconnected system. This leads us to the role of government and policy.

Conclusions

Implications for policy and research of the ecosystem

The political dimension has been under-explored so far in this book and it is beyond the scope of this chapter to do so in detail here. However, there is clearly an important role for government at all levels in the ecosystem. Above, Toh and colleagues argue that systems leadership needs to be expanded to a more holistic ecological leadership that builds alignment and convergence throughout the levels of the ecosystem. However, as they themselves suggest, the political context in the Singapore system is characterized by collectivism, which does not apply universally, such as in 'Anglo-Saxon' contexts. They do not mention, but it is also the case, that there is also great consensus about the role and aims of the school system in society. In such a context, the alignment between the macro system and other levels may be much easier to sustain. If the aims for the education system as a common good are not stated clearly enough or broadly shared, there is a danger of giving in to a market narrative that hijacks the language of ecosystems. We have seen how these market and hierarchical forces still pervade in the English school system, despite much talk of the vital role of networks and collaboration in the so-called 'self-improving system' (see Greany and Higham, 2018).

An ecosystem is by its nature complex and this presents challenges for its analysis. Traditional science has tended to favour unidirectional, linear and parsimonious explanations of cause and effect. However, in complex social ecosystems the variables are often more dynamic and the outcomes of research may be less certain. However, as has been shown throughout this book, the need for research to test, diagnose, propose solutions and re-define problems is ever present. Research and development therefore needs to take place both of the system and in the system. External accountability structures can play a key role in taking the 'temperature' of the ecosystem, identifying weaknesses and areas for further support as well as emergences from the ecosystem to be further developed.

More work that explores the research-engaged school ecosystem is warranted too, for instance using the social-ecological framework to diagnose ecosystem resilience (McGinnis & Ostrom, E., 2014) or to examine longitudinal changes (the chronosystem) in school networks (e.g. Ehren et al, 2017). Research that looks at ecological and adaptive leadership in the school sector will help understand the kinds of collaborative and social capital that add convergence, alignment and the emergence of new resources in the ecosystem.

Implications for government policy level and decision-making

So many of the problems facing the education system cross professional, geographical, disciplinary and governmental boundaries. The need to broker multi-agency cooperation has been explained in many of the examples in this book. Government has a key role in this. We can look outside of the education sector to find inspiration for how to encourage an ecosystem towards dynamic equilibrium. Finegold (1990) researched the growth and success of Silicon Valley, in particular the way that this area attracted and developed a highly skilled workforce. Finegold suggested four forces in high skills eco-systems: a catalyst, fuel or nourishment, a supportive host environment and a high degree of interdependence. Applying this to a research-engaged school system, we could identify a government role to act as a ***catalyst*** to marshal sources of funding for research and KM networks, to ***nourish*** the development of capacities for leadership in the research-engaged school system, in schools, KM networks and universities. A ***supportive environment*** could include access to specialist advice, local arrangements to support peer review and other research-practice collaborations, and extensive virtual learning environments to store and share resources developed from research and development activity. In terms of ***interdependence*****,** support for a professional identity that looks beyond allegiances to single organisations could be reinforced by government as well as formed by the kind of strong and coherent professional bodies that have been discussed elsewhere in this book.

In our macrosystem there needs to be further consideration of the future relationship between the school ecosystem and related ecosystems such as the economy and the state. For instance, some authors have recognized the importance of schools in developing the so-called 'knowledge-economy' and have speculated on how this would need to lead to radical changes to the nature of schools and the curriculum (MacDonald, 2005). With some economists suggesting the need for a more active and entrepreneurial role for the state in generating and commercializing innovation (e.g. Mazzucato, 2015), then schools could play a key role in the future economic ecosystem. If we broaden out to 'humans-in-nature' – the logical end-expression of ecosystems thinking, we would also want to ask about how school education feeds into the sustainability of the planet's resources. It is hard to see how we can achieve such ambitious aims for our school ecosystem, without the existence of flourishing research-engaged institutions that promote enquiry and the synthesis of knowledge,

autonomy in decision-making, and a high level of collaborative learning among the professionals that work in them.

Implications for the research informed ecosystem

- The characteristics of a research-engaged school ecosystem have been set out in terms of the macro, chrono, exo, meso and microsystems

- The research-engaged school is more likely to succeed under particular ecological conditions at each level of the ecosystem

- An ecosystem of research-engaged schools requires ecological leadership in order to develop adaptive organisations and to spread learning and innovation across the system

- While this book has provided a good starting point for thinking about notions of eoo-systems and research use, there are still many empririical and conceptual gaps to be filled.

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