Chapter 3
Scaling Community, Conditions, Culture and Carryovers Through Apprenticing and Ecological Leadership: The SCAEL Model

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Abstract The Singapore education system provides all schools with opportunities to innovate through educational interventions. Based on a review of research work in innovation diffusion in Singapore schools from 2013 to 2017, we have developed the SCAEL model- a context-sensitive translational and scaling framework that can translate theories to practices for sustained educational changes. SCAEL stands for 'scaling community, conditions, culture and carryovers through apprenticing and ecological leadership'. Apprenticing leadership and ecological leadership refer to leadership that facilitates professional learning and support at the peer-to-peer (apprenticing leadership) and vertical levels (ecological leadership). We use the SCAEL model to analyse recent Singapore-based education innovations that

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have attained substantive traction as well as recent reforms in the German education system. We also propose an iterative practical framework for school leaders for operationalising SCAEL.

3.1 Introduction

Change is a complex phenomenon, as any effort to scale change in an education system will demonstrate. The Singapore education system provides all schools with opportunities to innovate through educational interventions. Based on our review of research work conducted by the National Institute of Education (NIE), Singapore, in innovation diffusion in Singapore schools from 2013 to 2017, we have developed the SCAEL model. This SCAEL model is a context-sensitive translational and scaling framework that can translate theories to practices for sustained educational changes. SCAEL stands for scaling 'community, conditions, culture and carryovers' (four items collectively represented by "C") through 'apprenticing and ecological leadership'. Apprenticing leadership refers to leadership that facilitates peer-to-peer professional learning and support within each horizontal level of a hierarchical system. Ecological leadership refers to leadership that facilitates professional learning and supports across vertical hierarchical levels within a typical school or within a school system. Apprenticing and ecological leadership provides the necessary horizontal and vertical alignments, respectively, for professional learning and support in educational change (Toh et al., 2014).

SCAEL is essentially a translational and scaling pathway for sustained educational change. While the model's four dimensions may appear to be intuitive for experienced school leaders and organisational change researchers, we believe that the model will provide an optimal translational and scaling pathway to sustained educational change through the dynamic adjustments of the four dimensions in line with apprenticing and ecological leadership.

The SCAEL model is salient for educational policy formulation and for school leaders to understand that the spreading or scaling of learning and pedagogical innovations is unlike other prescriptive efforts such as the proliferation of pharmaceutical drugs in medical studies (although we recognise that getting pharmaceutical drugs to market in today's context is not easy). School leaders need to recognise the complexities of scaling and that artefacts do not travel by themselves. In fact, it is the capacity of teachers and other people involved that bring artefacts along to other contexts.

Medical science is well known to have developed effective translational pathways from basic science to the introduction of drug treatments in the market (University of Miami, n.d.). A typical translational pathway in medical science is shown in Fig. 3.1. In developing our SCAEL model, we hypothesised that the translational pathways used in the medical sciences would not apply wholesale to the education sphere. Medical science's translational pathways adopt replication metaphors where the product at hand is the focus. However, we posited that the translation and scaling of social phenomena such as education are people-focused and dependent on

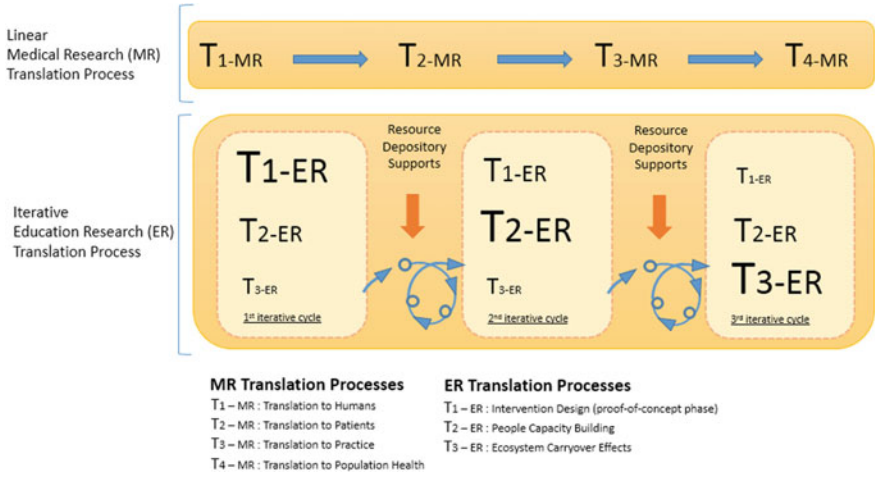

Fig. 3.1 Medical research translation process vs. education research translation process, University of Miami

the supporting structures, environment and carryover mechanisms needed to sustain them. Thus, the T1 to T3 phase of the educational translational pathway is not a linear exercise. It is a social phenomenon representing actual stakeholders who grow alongside the growth trajectory of the model. Medical science's linear translation frames create outcomes that are judged in relation to a "gold standard" previously benchmarked to an initial intervention (with fidelity in implementation). In educational change, we recognise that context does not stay constant when scaling occurs, and hence, the appropriate metaphor for the goal of educational change is a "sufficing" one (Hung et al., 2015b). Scaling diffusions of change in education are thus not straightforwardly about multiplying an innovation (hardware) per se; rather, it is more about building people capacity (software) for that innovation and adapting the cultural context (heartware) that surrounds it while leveraging the carryover effects (shareware).

3.2 SCAEL: An Ecological Approach

The SCAEL model is thus an iterative process of growth in people capacity alongside the multiple artefacts and products/resources that accompany an innovation and change process. The four items represented by "C" mentioned above and hereby referred to as the "4Cs" denote the following:

- C1 – community, or *software*
  Community reflects *collective* capability rather than *individual* capability required to sustain change.

- C2 – conditions, or *hardware*
  Conditions refer to structures provided to enable change.
- C3 – culture, or *heartware*
- C4 – carryovers, or *shareware*

It is important to note that the 4Cs are developmental and benchmarked relative to themselves in self/system improvement cycles. The iterative developmental process is denoted in the C4 process as carryovers in which sharing is key to improvement. This evolutionary and developmental process is the very essence of the SCAEL framework – a model of forward-moving improvement cycles. Still, it is worth noting that the 4Cs are not strictly distinct phenomena and there will usually be some ambiguous or overlapping boundaries. Therefore, it is not necessarily the case that change in one fundamental factor will simplify the change in other less fundamental factors. With ambiguous and overlapping boundaries, making fundamental and lasting change may require complex nonlinear pathways with multiple aims in relative tension. Figure 3.2 illustrates our thesis.

Educational change is complex, especially when situated in an education system that has to manage consistent academic excellence in schools while at the same time introducing new innovations for reform change. Our SCAEL model of scaling and diffusion looks at educational change from a systemic perspective. The SCAEL model is also consistent with social phenomena from an ecological perspective. In addition, the apprenticing and ecological leadership within the SCAEL model is also described.

From the research conducted by the Office of Education Research (OER) at NIE, we have observed that systemic change in our centralised–decentralised system involves three layers. We have named these layers the macro-, meso- and micro-layers of change as shown in Fig. 3.3. Each stakeholder has an important part to play, with the middle or meso-layer playing the most important role as they act as

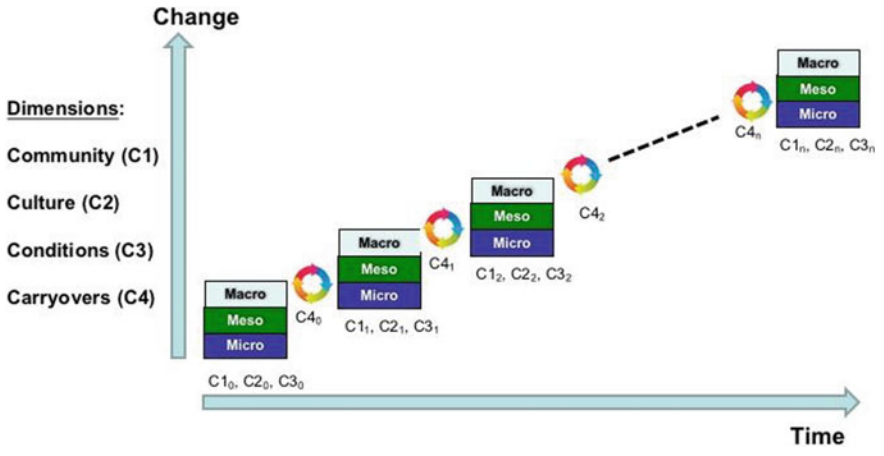

Fig. 3.2 SCAEL model

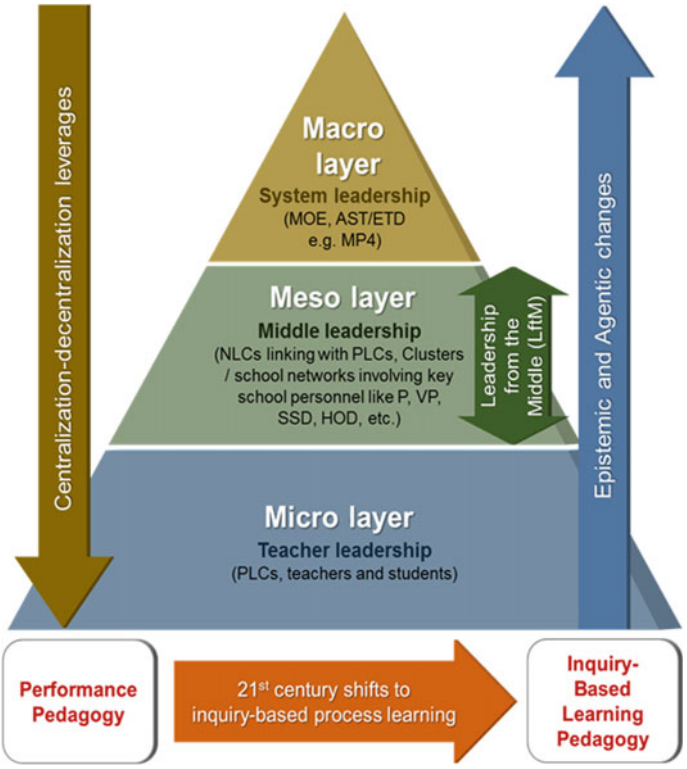

Fig. 3.3 Ecological system of coherence and alignment at the macro-, meso- and micro-layers as an integrated whole for the change process. *Source* Koh and Hung (2018a)

the interface between the two other levels, and also because they have opportunities to percolate innovations upwards and downwards in the system to help align policy, implementation and practice.

We will now address each level from the systemic perspective using the SCAEL model. Firstly, the macro-layer comprising the school leaders and education ministry (or the equivalent at the state or provincial level) is important because they are the stakeholders who have to buy into and lead the system with a vision and strategic goals. On the other hand, at the micro-layer, we have the school teachers who are at the heart of system change because not only are they directly involved with pedagogical practice and implementation, their pedagogical content knowledge, practice, capacity for lesson design and mindsets directly impact students on a day-to-day basis. They fulfil the system's everyday needs. The middle layer, also known as the meso-layer, comprises of social networks of teachers and groups of core school personnel who are able to lead from the middle due to their inbuilt capacity for their functions and their ability to leverage their network effects. This meso-layer mediates the attainment of strategic goals and the fulfilment of system needs and is thus the better lever for

school and educational change. Not only does the middle layer lead from the middle, but it also cultivates a change in mindset from leading in the middle to leading from the middle.

Figure 3.4 describes the impact of ecological leadership and the upward and downward percolation of change in a centralised–decentralised system like Singapore's. Again, it is at the meso-cluster where ecological leadership is built through a process of apprenticeship. Through the various networked or professional learning communities, the collective and individual apprenticing of teachers are open to mediation by such structures. A teacher from the micro-layer, who has undergone a change in mindset and who is a champion for innovation, is called an "influencer" of social change in our model, and in Singapore's system (or any other system) he or she is sustained by support from the ecological carryover effects. In turn, he or she will

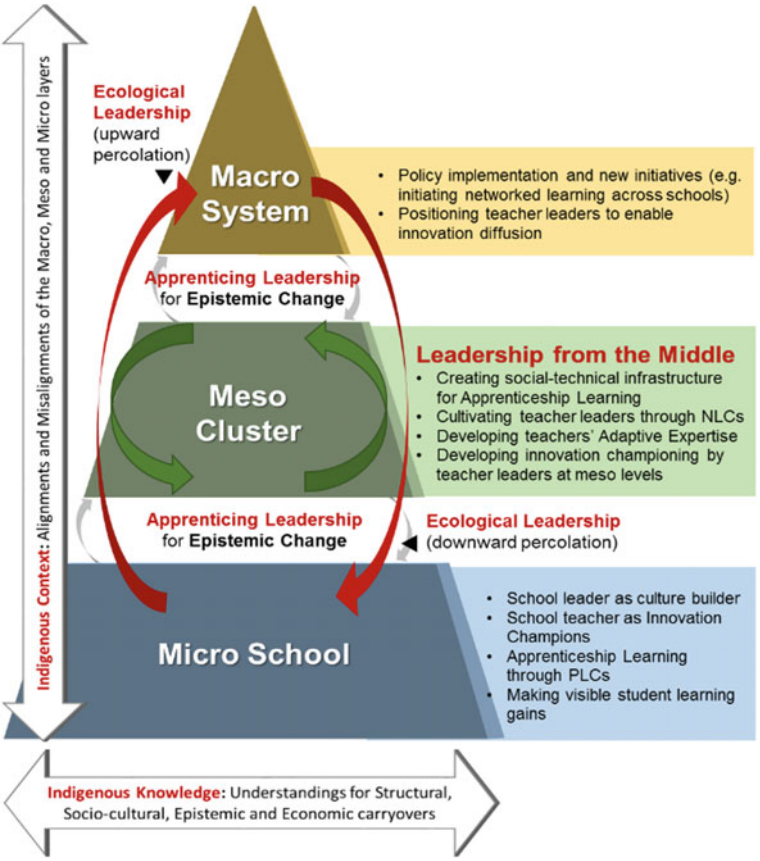

Fig. 3.4 Alignments needed as a system with ecological and apprenticing leadership. *Source* Koh and Hung (2018a)

facilitate the innovation culture in his or her school being **cross-enculturated** with other schools or educational systems.

3.2.1 Sustaining Change

The SCAEL model is a sustainable model as it involves adapting the model for the indigenous sociocultural context. In terms of "native" characterizations, this means that there must be recognition of variations in the functioning of education systems and that their historical, national and regional policy contexts will exert different degrees of influence on the institutions' work and therefore on the role of leaders in schools (Day & Sammons, 2013). We must also take heed of indigenous knowledge as local knowledge unique to a culture or society. This unique local knowledge also comes by other names such as "'people's knowledge', 'traditional wisdom' or 'traditional science'…." (Nakashima et al., 2000). Such socio-technological infrastructure in terms of carryovers enables sustainability. Figure 3.5 illustrates the tenets for sustainable change, which involve the three micro-, meso- and macro-layers (3 M) in an alignment consistent with ecological framing. At the meso-layer, we know that the teacher's epistemic change and hence change of mindset is key to the ecological leadership and apprenticing leadership that enables change to occur (Lee et al., 2016).

In an educational system like Singapore's, we are fortunate to be able to leverage ecosystem carryover effects in sustaining educational innovations that move towards achieving lifelong, life-wide, life-deep and life-wise learning in schools (Koh & Hung, 2018b). Ecosystem carryover effects are defined by Ron Adner (2012) as the process of leveraging successful elements from constructing one ecosystem in order to create advantages in constructing a new ecosystem. Such ecosystem carryover effects occur in self-renewing learning networks and include structural, economical, sociocultural and epistemic ecosystem effects (Toh et al., 2016).

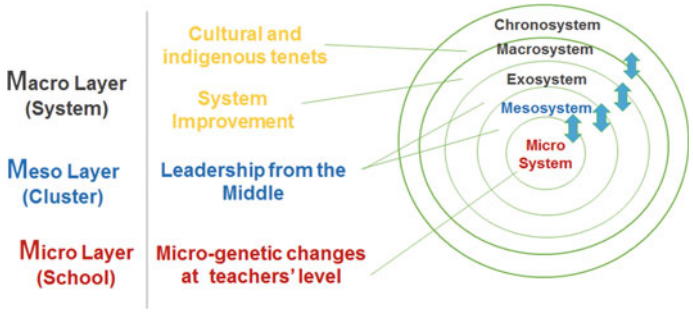

Fig. 3.5 3 M Layers: Tenets for sustainable change. *Source* Hung et al. (2016a)

The SCAEL model proposes a framework and methodology for implementation that is context-sensitive. Its key strategy is rapid prototyping and iterative design frameworks. Carryover effects are after all, designed through social processes. Learning in context leads to cultural change, and deriving positive observable outcomes such as students showing their level of engagement in exploring, explaining, elaborating and evaluating their own work in actual classroom enactments, enables cultural change within and across schools. Day and Simmons (2016) also states that school leaders play an important role in establishing the conditions, cultures and climate for professional learning and development in their schools.

3.2.2 Mitigating Tensions and Obstacles

The above observations about carryover effects also cohere with our work on apprenticing leadership or horizontal percolation within the meso-layer. Apprenticing leadership occurs through an apprenticing journey and phase shifts, namely from tolerance, to gradual acceptance, and culminating in willing acceptance. This change in phases requires the teacher to be very open to listening to their colleagues (Hung et al., 2015a). Teachers who are assigned to curricular innovations and merely tolerate going to NLCs to plan, dialogue, design and enact lessons must first be cognisant and come to accept the need for change in order to effect a change in mindset. From a starting point of deference to authority, apprenticing leaders must end up "taking joy in acceptance" (Koh & Hung, 2018a, 2018b, pp 158). Hung (1999) described apprenticeship as a journey of change in beliefs in contradiction to traditional references to skills and competencies.

Nevertheless, any plans to effect a change in mindset must be contextualised in the local conditions of a particular educational system. For example, while our research indicates that teachers' epistemic shifts are the highest point of leverage for sustainable epistemic change in the whole system, what stands in the way of such shifts are to be found in the local context. In Singapore, evidence shows that the biggest obstacles are fear of failure and inertia. Local teachers are afraid that their students might not be up to the challenge of learning under new pedagogies that are less dependent on the transmission of knowledge, and this makes it very difficult for them to let go of traditional teacher-centred pedagogies. However, if we demonstrate to them that the sky will not fall if they let go, they are more likely to show some willingness to try and get past their inertia. It is also important in changing teachers' "indigenous" beliefs and mindsets that we allow them the time and space to experiment with new pedagogies and to discover the links between the formal and informal curricula for themselves. Genuine epistemic change can only happen to open and willing minds, especially when they are discovering for themselves how to implement changes in their own context (Office of Education Research, n.d.).

Looking at the whole system as a holistic ecology of epistemic change, however, we observe that downward percolation, when leadership is not distributed throughout the system, is significantly higher compared to upward percolation. This points to the

current importance of leadership in making epistemic change coherent throughout the system. Toh et al. (2014) state that "ecological leadership exhibits the characteristics of forging alignments and convergences in the different ecological layers, mitigating systemic paradoxes as well as local and cross-school tensions". Ecological leadership is needed to make meanings and understandings consistent across ecological layers and is looked to first to solve differing and competing understandings and interpretations that may arise among different schools or clusters and lead to contradictory practices.

This is especially pertinent in Singapore where power distance is traditionally a significant problem. Power distance, which describes both the way power is distributed unequally, as well as the way less powerful people accept this unequal distribution, is a particular problem in Singapore as it is in many Asian societies. Power generally decreases the further away one is from the source of power and in Singapore, we more readily accept hierarchical distributions of power than Western societies. This deference to power stands in the way of upward percolation of epistemic change. We conclude then, that leadership must also be distributed upwards for alignments for epistemic change to take place.

Michael Fullan's conception of "leadership from the middle", or LftM, fortunately helps provide a model of ecological leadership that is designed to overcome power distance and help align the macro- and micro-layers of the ecology through alignment in the middle or meso-layer. "… it implicates the whole system starting from the middle out, up and down. In addition to our system-use of the concept, LftM can and should be used within other levels. Schools, for example, are the middle if you use a within-district focus. Teachers, students and families are the middle when you think of intra-school and community work" (Fullan, 2015, p. 26).

If we look at Fig. 3.6, the LftM model therefore breaks the 3 M layers into a further three layers (3 m) each in order to find a middle to each 3 M layer that can anchor leadership within each 3 M layer. Taking the teachers from the school level, the school leaders from the cluster level and zone directors from the system level, this distributed form of leadership will anchor the tight interplay of the percolation of changes upwards and downwards within each 3 M layer, helping overcome power distance within each 3 M layer. This disruption of the hierarchy within each 3 M layer creates a fractal alignment of percolation that is reflected in the next scale up in the system, where school clusters in the meso-3 M layer can lead to epistemic change for the micro- and macro-3 M layers.

3.2.3 Patterns of Innovation Diffusion

Our thoughts about how change can occur naturally lead us to think about how exactly change is diffused through the system. That is, we looked at how efficiently change can be diffused from a single or limited starting point. In model A, shown in Fig. 3.7 below, a single innovative school can influence many other schools. So for example, if School A invents a new way to exploit experiential learning through ICT, this

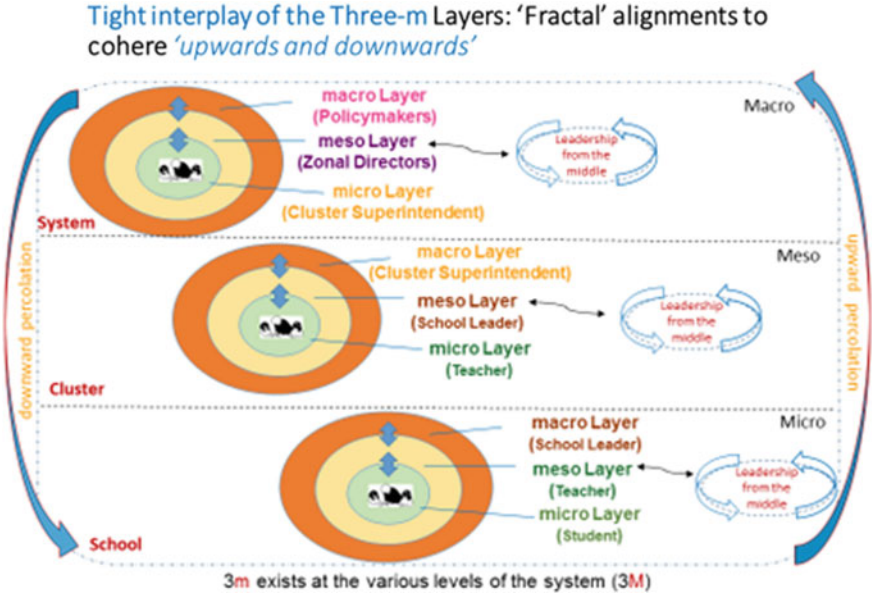

Fig. 3.6 Leadership from the middle. *Source* Hung et al. (2016b)

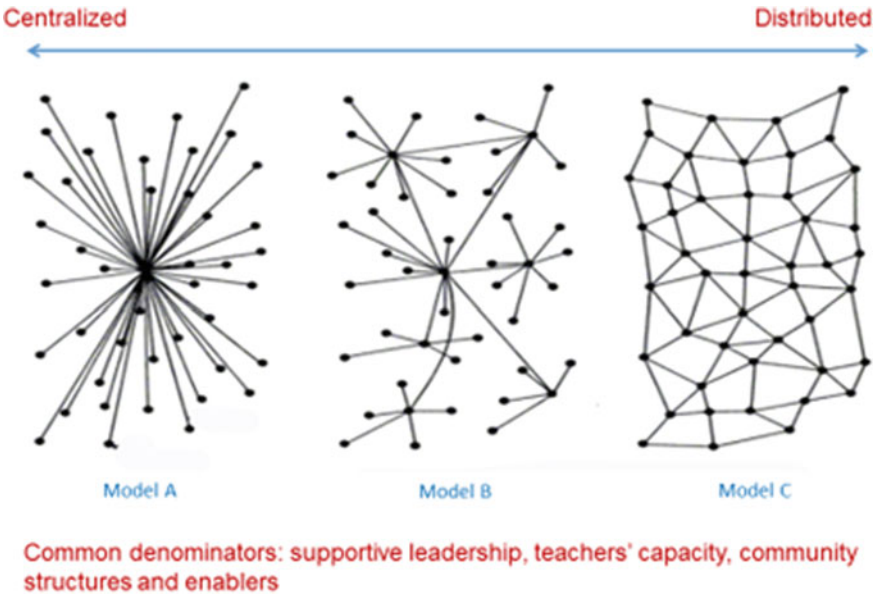

Fig. 3.7 Patterns of innovation diffusion. *Source* Hung et al. (2016a)

innovation may spread through direct formal and informal relationships with other schools. However, since model A depends on schools having direct relationships with the original innovating school, the larger the system, the less likely that all schools will have a direct relationship with any particular originator school.

In model B, innovations spread through satellite schools. In this model, innovations originate from a single school and spread to several others through direct relationships. Thereafter, this first tier of schools branches out and influences a second tier of schools that do not have a direct relationship with the original innovating school. This model is more efficient than model A because it does not have to depend on direct relationships with the original innovating school. The efficiency of this model is even clearer in large countries with multiple tiers of branching, where one can more clearly observe its viral pattern of diffusion.

Model C, however, represents the most efficient model of innovation diffusion. In this model, every school influences the closest schools with which it has direct relationships and in that way, as the system matures, every school becomes in a sense, a node or a satellite school. In addition, because every school is a nodal school, the network is represented by a net structure rather than the more familiar spoke wheel pattern. Model C is very difficult to achieve, no doubt, but in Singapore, we have seen some evidence that within one particular cluster of affiliated schools, the schools have developed multi-nodal network relationships with one another (Hung et al., 2016a).

In summary, the SCAEL model provides an iterative design framework and methodology to accompany stakeholder involvement with built-in scalability and sustainability. We have shown the framework and methodology to be grounded upon sensible and stable principles of educational change. The SCAEL model takes the diffusion of innovations' theory which was developed by earlier studies (by the SCAEL team) and conceptualises a translational pathway for implementation.

3.3 Study and Methodology

In this section, we use the SCAEL model to analyse established OER innovations and evaluate factors behind their performance in translating theory to educational change. These innovations are shortlisted from promising OER innovations over the last decade that have attained substantive traction in schools. From a pool of 14 innovations, three innovations were shortlisted as they possessed the following criteria:

(a) Sustained participation by schools
At least some schools which took part in the innovation continued, to some extent, to apply its pedagogy and concepts beyond the formal end of the research project.
(b) Proof of concept
Research has produced preliminary evidence for the efficacy of the innovation.
(c) Teacher base support

A network of teachers, whether or not they participated in the research, has awareness of and actively supports the implementation of the innovation.

We employed a mixed methods approach in examining how the three innovations gained traction among practice and policy stakeholders. Interviews were conducted with principal investigators and research team members as well as participating teachers and school leaders. Transcripts of the interviews were analysed to identify salient themes.

3.4 Findings

3.4.1 Case Study 1—Productive Failure

Productive failure (PF) is a pedagogical learning design embodying constructivist principles that have been shown to be effective in Singapore mathematics classrooms (Kapur, 2008; Kapur & Bielaczyc, 2012). A strong proof of concept and practice findings have been established by the researchers' work with over 13 schools, 100 teachers and 6000 students from the primary to junior college levels.

Scaling efforts for PF were bolstered by ministry support. Several years into the research programme, the Ministry of Education (MOE) awarded a significant grant for the translation of PF design principles to the A-level Statistics curriculum. This enabled PF researchers to work closely with the MOE Curriculum Planning & Development division (CPDD) Mathematics Unit to develop the curriculum and build teacher capacity in the implementation of PF principles.

However, as of this writing, about a decade since the start of the PF research programme, relatively few junior colleges have implemented PF into their curriculum given the extent of ministry support. Viewed through the lens of the SCAEL model, PF benefitted from system leadership but was limited in its scaling by a weaker focus on networked learning communities (NLCs), which in turn hampered its impact on the ground. Without any NLCs playing a role in facilitating the collective and individual apprenticeship of teachers, the innovation did not gain enough teacher leaders to nurture a culture of PF implementation in schools.

3.4.2 Case Study 2—Knowledge Building

Knowledge building (KB) engages students in collaborative solution finding efforts for knowledge problems and in sharing in the responsibility for the success of the efforts (Scardamalia, 2002). Since 2001, researchers have integrated KB pedagogies across multiple schools in Singapore with tools such as the computer-supported Knowledge Forum collaborative platform.

This KB research has generated a proof of concept through iterative and collective efforts by members in the KB network (see scaling effort below), consolidating practice evidence across various subjects from the primary through high school levels.

KB scaling efforts are characterised by a decentralisation strategy anchored by active professional learning communities (PLCs) and NLCs that sustain design effort to bring about mindset change. These efforts are exemplified by one KB project that focused on sustaining KB environments through teachers' discourse and community building. Within each participating school's community, a senior teacher facilitates the continual deepening and sharing of knowledge-building practices as well as the sharing of students' artefacts. Members of a community are encouraged to try out the ideas discussed in their schools and classrooms as well as bring their own enactments and students' artefacts back to the community. These communities ensure that "[w]eek after week, the teachers continued to be inspired by their own students' ideas and work" (Tan et. al., 2014). Starting with one secondary school and two primary schools, the project has spread to other schools. An inter-school professional learning community has enabled teachers to exchange ideas within a larger community.

Viewed through the lens of the SCAEL model, KB scaling efforts have been successful at nurturing innovation champions who exhibit strong epistemic agency in leading the spread of the innovation and creating new knowledge about their practices. However, likely due to the lack of movement at the macro-layer (system leadership), KB scaling is relatively slow, with 15 schools implementing KB over a 10-year period.

3.4.3 Case Study 3—Seamless Learning

Seamless learning (SL) emphasises the bridging of learning efforts across diverse learning settings (i.e. formal and informal learning, individual and social learning, learning in physical and digital realms). As a learning notion, Seamless Learning leverages on 1:1 mobile technology (one-device-or-more-per-student) to enable cross-space learning 24 hours a day, 7 days per week.

NIE researchers Prof. Looi Chee Kit, Dr. Peter Seow and Dr. Wu Longkai first seeded Seamless Learning in a local primary school through the Inquiry-based Seamless Learning in Primary Science project (Looi et al., 2010, 2011). Under the leadership of the school principal and tapping on the school's capacity and appetite for innovation, the project diffused from the first classroom to other classrooms within the school. When another NIE Seamless Learning researcher Dr. Wong Lung Hsiang introduced two other intervention research projects: Move Idioms and MyCLOUD (Wong, 2012; Wong & Looi, 2010; Wong et al., 2012, 2015), Seamless Learning continued to diffuse from the Science curriculum to the Chinese Language curriculum. As of today, the NIE Seamless Learning suite of research projects continues to be adapted and integrated in schools from informal and formal networks.

3.5 Analysing the Case Studies

In Fig. 3.8, we map the three case studies according to their change model or trajectory of scaling through school-to-school networks.

PF is characterised by a strong proof of concept, whereas KB is grounded on teacher communities and SL on strong leadership support. School leadership enables sustainability by providing the socio-technical infrastructure, that is, the conditions that enable innovations to be diffused and sustained. From Fig. 3.8, SL and KB have carryover effects from the micro-teacher and meso-school levels, whereas PF has macro-system effects. SL and KB are amenable to pathways of translation to schools in deep ways, whereas PF, while enjoying macro-level support, requires sustained buy-in from the schools in which it is deployed. All three layers of the system are crucial. Innovations can spread from the macro-level (centralisation efforts), or from the micro-level (decentralisation efforts), but ultimately, all layers need to be in alignment for deep change to happen. However, not all innovations are meant for widespread implementation throughout the system.

In retrospect, the diffusion of innovations, supported by the triangulation of the three case studies and aggregated by all 14 OER interventions is best attributed to three key factors:

(a) Strong research/practice-based proof of concept
Research teams were based in schools and deeply involved in the implementation process, receiving just-in-time feedback to their research design, and tailoring and conducting professional development for teachers.

(b) Strong PLC and NLC cultures

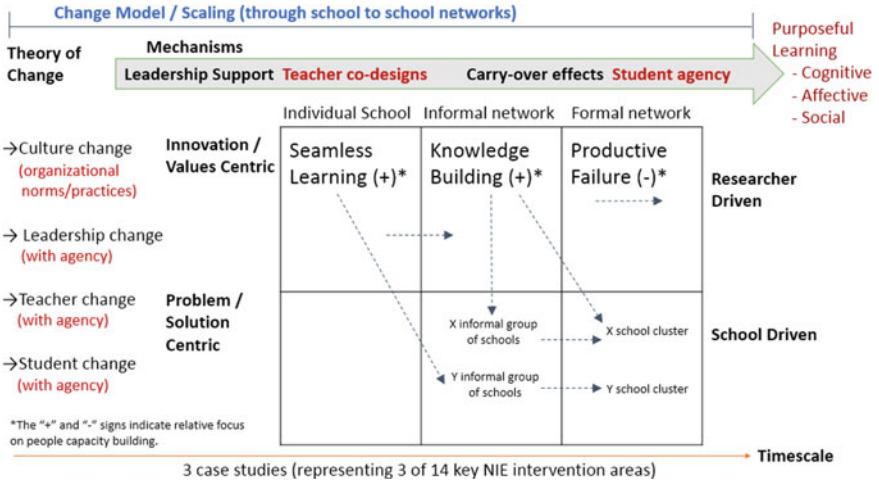

Fig. 3.8 Change model/scaling (through school-to-school networks)

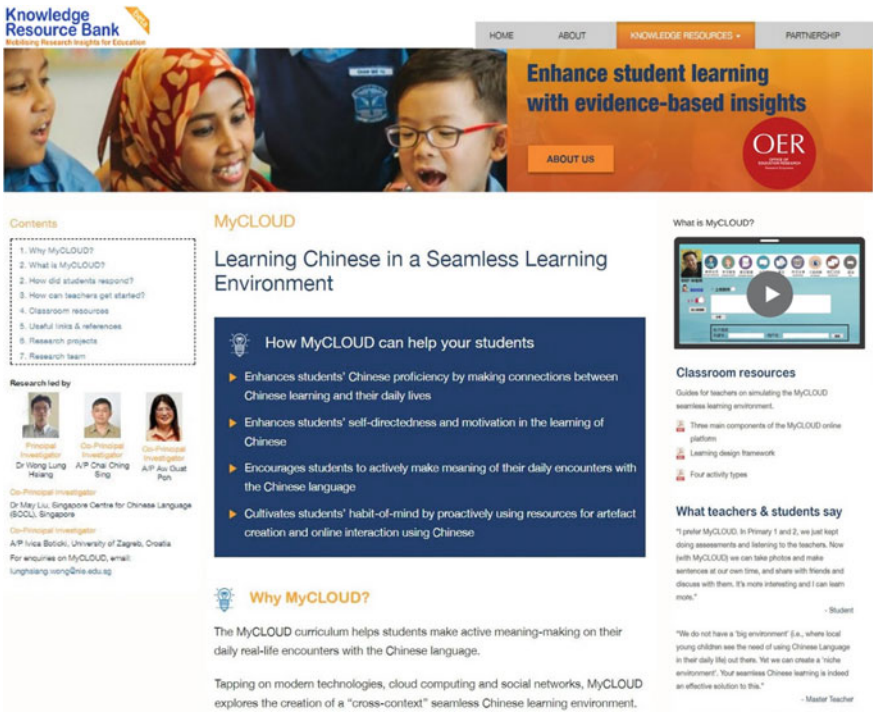

Fig. 3.9 Evidence-based classroom resources from the Seamless Learning project MyCLOUD.[1] *Source* Wong (2012), Wong and Looi (2010), Wong et al., (2012, 2015) on the OER Knowledge Resource Bank portal

[1] This study was funded by the Education Research Funding Programme, National Institute of Education, Nanyang Technological University, Singapore (project no.s OER 17/10 WLH and OER 61/12 WLH).

Teachers' learning and their epistemic change are the crux of any diffusion. PLCs and NLCs are supporting environments that enable teachers to engage in leadership from the middle. The earlier PLCs and NLCs are formed in support of an innovation, the higher the success rate for sustainability.

(c) Strong leadership for middle centralisation–decentralisation strategy through clusters of schools

Key to scaling/diffusion is the middle centralisation-decentralisation strategy that unfolds both at the micro-school and meso-cluster layers (see Figure 3.4: Alignments needed as a system with ecological and apprenticing leadership). Schools, whether through formal or informal networks with other schools, or led by formal superintendents or less formal cluster leadership, enable support for teachers to do ecological and apprenticing work.

3.5.1 Operationalising SCAEL

In operationalising SCAEL, we need an understanding of the monitoring and feedback mechanism supporting the model (see Fig. 3.2: The SCAEL model). To reiterate the tenets of SCAEL, we have earlier presented that the 4Cs occur at all 3 M (i.e. micro-, meso- and macro-layers) layers in the system, repeating themselves as we go up to the next layer. Research data can be collected at all 3 M layers with instrumentation from the baseline to the outcomes- from formative tracking of starting points to stipulated end-goals. Here, we would expect any changes in C4 to be evolutionary and developmental. Within every level of the 3 M layers, centralisation and decentralisation balances are to be monitored for a complete picture of education change at all 3 M layers.

Furthermore, the SCAEL model presents how apprenticing leadership (peer or horizontal level) and ecological leadership (hierarchical or vertical level) create and sustain the three necessary conditions of *community* (software), *conditions* (hardware), *culture* (heartware) while leveraging *carryover* effects (shareware) to bring about desired educational change. These concepts of and interactions among apprenticing leadership, ecological leadership, capability, culture and carryover effects have already been explained above. Moreover, these constructs should be present in the multiple layers of any system (macro-, meso- and micro-levels) for change to be enacted with the alignments and coherences needed.

In articulating an iterative methodology for applying the SCAEL model, we note the key strategic goals underlying the methodology are to (i) bring the sense of ownership by stakeholders into the change process from the onset, (ii) build personal capacity at all levels of the system, (iii) have a systemic strategy for implementation support using formative evidence and (iv) create an ecosystem which enables multiple localities to collaborate and cross-pollinate.

The main phases of the SCAEL methodology are defined below in broad sequence. Critically, the whole sequence should be iterated until the model is ecologically viable and the transfer of findings is accepted by the community.

1. Collecting a baseline understanding (i.e. conduct a needs analysis)
   Data should be collected on potential stakeholders and analysed to identify the highest leverage points of the system as well as its lowest capitalisation points.
2. Developing an initial hypothesis of the SCAEL strategy
   A testable hypothesis should be conceived for the SCAEL strategy.
3. Early partnership of researchers and stakeholders
   Partnerships between researchers and stakeholders should be forged from the onset of the SCAEL exercise in order to develop shared consensus and buy-in.
4. Developing a design model for initial implementation
   A rigorous design model should be developed that facilitates the generation of credible evidence for subsequent decision-making.
5. Implementing design with ecological carryovers
   The design model should be implemented in such a way that leverages successful elements from one ecosystem to another.

Table 3.1 Trajectory of a typical innovation diffusion through SCAEL

Year 1	Proof of concept	Experimental design	Main stakeholders—Teachers and students	Initial community C1 (usually within school with partners)
Year 2		DBR	Increased involvement with school leaders	Focus on Conditions C2
Year 3		DBIR	School leaders, KPs, and teacher champions/leaders	Focus on Culture C3
Year 4	Established resources for practice, e.g. toolkits	DBIR with large scale experimental design	Cluster of schools "sup" leaders, teachers, students	Focus on carryovers C4 with established mature community

6. Collecting evidence
   Evidence should be collected from initial implementations to support improvement to both theory and implementation.

Steps 1 to 6 are meant to be iterative. With an initial model of implementation, evidence is collected to support an initial hypothesis. The innovation is then iterated with the implemented design features and tested with further evidence for progressive acceptance until the community establishes stability and maturity with the model through shared ownership and consensual decision making. Table 3.1 shows a typical trajectory of an innovation.

DBR refers to Design-Based Research and DBIR to Design-Based Implementation Research. These methodologies are but examples of research methods which can be adopted. Through the course of the trajectory, research ownership is increasingly transferred to the schools and teachers, and the community.

Table 3.2 shows the implementation of research/practice through the SCAEL model.

3.5.2 Community Building

When the SCAEL model in a given context approaches ecological viability and leaders have built on their understanding of enablers and challenges, further measures should be taken to foster a community that will deepen and multiply translational pathways.

1. Formulate a theory of community growth engagement for the SCAEL model by first reaching out to the core team or influencers, and then fanning out to engage in subsequent outreach. See Fig. 3.7.

Table 3.2 Research–practice implementation details

Characterising construct	Research methods and concepts	Data sources	Outcomes
Community	Track through social network analysis	Social networks Interactions and dialogue	Teacher learning Partnership depth
Conditions	DBR and systematic treatment of conditions	School level Teacher level Student level Across school level	Conditions are refined and adapted in terms of organisational norms
Culture	Phenomenology and observations	School leaders and teachers with student feedback	Cultural change
Carryovers	DBIR and systematic treatment of carryovers	School leaders	Sharing and norms established
Apprenticing leadership	Epistemic change	PLCs and NLCs	Teacher champions and succession planning
Ecological leadership	Distributed leadership research designs for upward and downward percolations	NLCs of school leaders	Levels above and below are informed and alignments achieved

Leaders should formulate a theory setting out how stakeholders are to become engaged (or more engaged) in the SCAEL process. This theory can include:

(a) Key messages (of change process)
These are the core messages to be shared with stakeholder groups that communicate the process of educational change while facilitating mindsets conducive to fostering "innovation champions".
(b) Adaptive communication network map and channels
There should be a strategy for the communication channels and networks through which information about the innovation would flow.
(c) Enabling conditions and barriers/challenges
The theory should include enablers and inhibitors in the SCAEL process.

2. Develop evidence-based practical resources
To engage community and support implementation, practitioner resources that are evidence-based should be developed and made accessible. These can take the form of lesson plans, posters, handouts, assignments, etc.
3. Nurture a community equipped with organisational capability
A community with in-house organisational capability should be developed. This paves the way for subsequent community-building efforts and for more participants to join the community.

3.6 Discussion

The evolutionary nature of change we argue, is inherent to social systems that are natural to our human form of life. The SCAEL model merely makes explicit the change mechanisms and community growth dimensions which complex and nonlinear theories can more adequately explain. Singapore's education system can similarly be described through the C1 to C4 developmental trajectory as follows (see Table 3.3).

It was reasonable that in Singapore's post-independence survival phase, the focus was on hardware, such as the development of curricular resources and the building of schools. At present, we are significantly more focused on people capacity, cultures and the design-of-learning capacities of teachers. Such is the student-centred phase the education system is in currently. The nonlinear SCAEL model emphasises that all C1 to C4 variables have been in action since the advent of the education system, albeit to different degrees (see Fig. 3.1).

Nevertheless, illustrating case examples from Singapore and OER may not sufficiently validate the efficacy of the SCAEL model. The SCAEL model suggests creating an ecosystem which enables multiple localities to collaborate and cross-pollinate. This suggests that a physically larger system with a vast number of localities and provincial sub-systems will better illustrate our evolutionary thesis. Here below, we offer a brief overview of the German education system which has sought to decentralise itself over the past twenty years. We also include a description of

Table 3.3 Singapore's education system and its evolutionary trajectory with teacher capacity as key

Stage	4C emphasis	Research	Schools	Community
Survival	Hardware (C2) • Good curricular resources • School buildings • Centralisation			
Efficiency	Hardware (C2) Software (C1) at individual teacher	Baseline studies		
Ability	Hardware (C2) Software (C1) • Individual and community	Baseline and interventions	Partnership with individual schools	PLCs and NLCs
Student-centred	Hardware (C2) Software (C1) • Individual and community Heartware (C3) Shareware (C4)	Baseline, interventions and scaling	Partnerships between multiple agencies	PLCs, NLCs, and school-to-school networks with ecological partnerships

the German School Academy project which created the mechanisms for schools to systematically iterate their attempts at school improvements. We then show how this process of change in the German education system was made possible by the recognition that accompanying community-building exercises were in order.

3.6.1 The German School System: The German School Academy Project

The German school system offers a variety of different pathways for students based on their abilities and interests: from practical hands-on training at vocational schools to multidisciplinary research at top universities. The macro-level of the education system governing structure is represented by the minister of a federal state with a succession of subordinate institutions at the meso-level, and with the schools themselves functioning as the micro-level (Maurer, 2006).

School-based management has been implemented in nearly all federal states over the last 10 years in the form of autonomous schools with various levels of decision-making power and resource allocations from each state (Uljens, et al., 2017).

In 2000, Germany experienced a shock when the Organisation for Economic Co-operation and Development (OECD) revealed disappointing results for performance and equality in its schools. In the first Programme for International Student Assessment (PISA) report published in 2001, the country tested below average in mathematics, reading and science and was awarded the infamy of having the most unequal education performance among the 43 countries examined (Baumert et al., 2001).

However, about a decade later, Germany was one of just three countries that had improved in both mathematics performance and equity since 2003. One of the most significant changes in its complex and fragmented education system was structural reform of the secondary school system. The key reforms post-PISA 2003 were the standardisation of curricula and the introduction of nationwide tests (PISA, 2012).

The German School Academy is a nationwide independent organisation active in school improvement and professional development in Germany. Its German School Award, a system-wide school improvement programme, was launched by the Robert Bosch Foundation and the Heidehof Foundation in 2006 to highlight inspiring models of schooling.

The German School Award recognises the high-impact, professional standards of learning and teaching across all German states and various school types. More than 2,000 schools have participated, and there have been more than 65 award winners from primary schools and grammar schools to vocational colleges – all types of schools are represented (The German School Award, n.d.)

The German School Award has become a respected voice in education and has set off a nationwide movement of “more successful schools” as it draws attention to innovative policies, the role of principals and their influence on student learning

in this reform process. Success stories of student learning as well as of high-quality teaching and leadership have spread from award schools to other aspiring schools.

Award-winning schools live up to quality standards by their sharing their leadership, dealing productively with heterogeneity and creating new structures for learning. School leadership teams lead in collaboration with partners: with other schools, with the community, with research institutions as well as private enterprises and cultural organisations. Evaluation and professional learning for self-reflection help shape the school pedagogic approach. The forms of leadership and routines of distance and engagement are critical input for successful goal-setting for continuous improvement. They have a clear vision of how they want to improve. The school leader ensures that achievement data is gathered and used for enhancing teachers and students learning processes. (Schratz et al., 2018).

In recent years, school leaders have benefitted from increasing autonomy and their use of instructional leadership approaches has risen above the OECD average according to school principals' reports in PISA 2012. Germany achieved above-average mathematics scores in PISA 2012, and its performance has improved significantly since 2000. Reading and science scores have also risen significantly above the OECD average since PISA results in both 2000 and 2003 (Klumpp et al., 2014).

We now examine the reform trajectory of the German school system with reference to the SCAEL model. The limitations of centralised school systems managed by different states reverberated across the country and reached a low point during the "PISA shock" of 2001. The inevitable reform in its education system originated from the community (C1). Looking at school improvement and professional development as conditions of the system (C2) opened up new perspectives at both regional and national levels. We see centralised changes in school curricula as well as the rise of a nationwide movement of successful schools helping influence a change in perspectives on what is possible to achieve (C3). The German School Award demonstrated that ground-up initiatives and the creation of innovative conditions for school improvement was possible in a benchmarked school-centred system without wholesale changes made to the pre-existing ecology (C4). The decentralisation of decision-making processes, shifting from federal state system to regional authorities and towards the organisational school level illustrates the importance of systemic improvement cycles from software to shareware in the 4Cs of the SCAEL ecological approach.

We posit that apart from the German system, the SCAEL model can also explain all other systems be they decentralised at the start or centralised. The 3 M layers apply and balances between centralisation and decentralisation are needed. We concur with recent propositions for leadership from the middle as a balanced approach to system change. The SCAEL model in other words operationalizes the leadership from the middle construct espoused by prominent change proponents in the field such as Fullan (2015), Hargreaves and Shirley (2012).

3.7 Conclusion—Leadership *from* the Middle *for* the Middle

The tenets of change as discussed above are effective from the middle of the system. The driving forces of change up and down the system can be mediated by the SCAEL model. The balance of centralisation and decentralisation forces can be reached through system monitoring and ultimately upskilling the capacity of those involved in the change process. In the German system, the German School Academy project worked from the middle. In the Singapore school system, the Ministry of Education enabled policies to build capacity among teachers and created middle structures such as the Academy of Singapore Teachers (AST) and the National Institute of Education (NIE) to be major leverages for teacher capacity building and community building.

However, many of the policies and frameworks are static in perspective and lacking in terms of evolutionary change processes. The SCAEL framework can work alongside the various policies that have been generated for the middle of the system.

The SCALE model is a process framework that provides a translational pathway from research to practice that cannot be forged without teachers. Research capacity cannot be divorced from people capacity. In education, research impact is based on the growing of communities around learning innovations. The SCAEL model explains why and how teachers' participation in PLCs and NLCs is inextricably linked to educational change.

Going forward, the SCAEL framework can be further operationalized for practical use by school leaders. Toolkits (e.g. instruments) and guidebooks can be developed for leadership from the middle. In order for SCAEL to be practical for school leaders, we need to establish the before and after conditions of interventions utilising the 4Cs—the community, conditions, culture and carryover structures that determine the successful strategies used by leaders across both the horizontal and vertical levels to achieve their desired educational change. For each condition, we need to identify the enablers who enhance the necessary conditions for educational change and the inhibitors who impede or prevent the necessary conditions for educational change. To help school leaders apply the model, we need to develop a methodology, toolkits and strategies for enacting educational change and develop professional learning programmes to help support school leaders in their application of the model.

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