Scaling Educational Innovations in Singapore: the roles of Policymakers, Practitioners, and Researchers

Shu-Shing Lee

NIE Working Paper Series No. 9
Executive Editors: Helen Hong, Kenneth Poon, Dennis Kwek, Jeanne Ho, Kiat Hui Khng, Roberto de Roock
Executive Editors
Helen Hong, Kenneth Poon, Dennis Kwek, Jeanne Ho, Kiat Hui Khng, Roberto de Roock

Editorial Assistant
Connor Gilbert

Production Team
Denise Goh, Nur Haryanti Sazali and Leah Phoon

2017 © Office of Education Research, National Institute of Education, Nanyang Technological University

About NIE Working Paper Series
The NIE Working Paper Series is intended as a means of regular communication between the mutually dependent spheres of theory and practice in education. Forward- and outward-looking, the Papers are conceptualized with a local issue at hand, and will survey international and local state of thought to assemble a principled response appropriate for our context. The intended audience for this publication are policymakers, school leaders and practitioners with an interest in how theoretical and empirical perspectives inform practice. The Working Papers are published in a highly readable style, and appended with an expanded exposition and comprehensive reference for readers who want to know more.


ISBN: 978-981-11-3832-4
Executive Summary

Scaling Educational Innovations in Singapore: the roles of Policymakers, Practitioners, and Researchers

Shu-Shing Lee

Aim

1. This proposition paper (Hung, Lee, & Wu, 2015, see Appendix A) outlines two views of scaling—top-down and bottom-up approaches—as well as its limitations and relation to education systems. The paper proposes an ecological model to describe scaling efforts in the Singapore education landscape. Our postulations are exemplified by existing research projects from the National Institute of Education (NIE), Singapore.

2. The ecological model of scaling emphasises a sufficing standard that considers top-down and bottom-up structures as well as qualitative and quantitative dimensions. Qualitative dimensions stressing tacit understandings are more important than replicating explicit or procedural knowledge. Spreading educational innovations involves cultivating professional learning communities (PLCs), keeping tabs on their growth, and identifying areas for improvement through quantitative studies.

3. Further development of the above paper is elaborated in a book chapter (Hung, Lee, & Teh, 2015, see Appendix B). The ecological model of scaling (Hung, Lee, & Teh, 2015, see Appendix B) is expanded to focus on diverse stakeholder views of scaling, how to leverage productive tensions, lessons learnt based on scaling practices in Singapore, and the roles of practitioners, policymakers and researchers in the Singapore scaling agenda.
4. The conceptualisation of scale in the book chapter (Hung, Lee, & Teh, 2015, see Appendix B) is expanded to include dimensions of depth (degree of change), sustainability (endurance of change), and spread (principles of innovation understood by more people) at the project/innovation level as well as dimensions of ownership (shift of knowledge and authority of innovation to schools) and evolution (adaptations of innovation to localised contexts) at the system-wide level. Scaling from a system-wide perspective must consider the issues of ownership and evolution as the core of the scaling effort, not as an afterthought, after the project level dimensions of scaling have been accomplished.

5. Elaborations from the book chapter will be interposed throughout the executive summary to provide further insights. The book chapter will contribute significantly to draw implications for policy, practice and research.

Background

6. The Singapore education system faces a paradoxical trend of decentralisation within a centralisation paradigm (centralised decentralisation). The government maintains high quality education by centralising controls on strategic directions. Concurrently, the government promotes decentralisation by empowering schools to accommodate diversity, and be flexible and innovative. The challenge for schools and educators is to engage in reforms and innovations, and maintain students’ content knowledge and grades.

7. The creation of the Education Research Funding Programme (see http://www.nie.edu.sg/research/research-offices/office-of-education-research) signals Singapore’s recognition of evidence-based research to inform the reform agenda, enact new pedagogies and create cultures of innovation in schools. Over the last decade, educational innovations have reached fruition. It is now important to consider possibilities for different innovations and issues that enable innovations to scale and become widespread.

Views of Scaling and its Limitations

8. Scaling in medical research moves linearly from the laboratory to mass market. This view does not consider relevance or adapting innovations for the context. It assumes that contexts are similar. It
Lee Shu-Shing

stresses explicit knowledge (the gold standard) and less on educating people or developing tacit knowledge to sustain and enact innovations.

9. On the other hand, scaling and spreading innovations in decentralised education systems emphasise student-centered learning processes and variability in settings. Transfer of innovations to everyday practices is not fixed on procedures. Variations are allowed based on differences in the social context while maintaining core design principles. The limitation is that bottom-up innovations take time to cultivate substantive change before spreading to other contexts. Lessons learnt are contextualised and may not be easily replicated.

10. Other views of scaling include the “3-Ts” (Carlile, 2004)—Transfer, Translate and Transform—that is appropriated from manufacturing to educational contexts (Sabelli & Harris, 2015). The “3-Ts” model, when applied to education, goes beyond quantitative aspects of scaling to also emphasise the goals and processes of sustainable change or improvement over time. Briefly, transfer is aligned with the traditional linear, one-size-fits-all scaling model where change is one directional—designers are active while implementers are passive. Translation and transformation emphasise adaptation and knowledge utilisation in local contexts. The difference is that translation looks at how the developer, possibly through Design-Based Implementation Research, interprets the innovation and develops shared meanings across contexts. Change is bidirectional—brought about by developers and actors’ expertise and collaborations at local sites. Transformation privileges implementation sites. Change is multidirectional where diverse actors go through a sense-making and co-construction process. The actors can be within and beyond education contexts (Sabelli & Harris, 2015). The constraint of the “3-Ts” model is that it foregrounds the goals of change as well as ideologies related to the process of scaling based on these expected goals. The scaling process is left somewhat implicit and how the scaling up happens depends on the actors and implementation sites. Each “T” does not flow into the next “T”, thus, there is limited progression in change / improvement goals. In other words, there are insights gleaned from iterative scaling processes within each “T” but the change and improvement goals related to scaling remain the same.
11. Different views of scaling—whether linear, centralised or bottom-up decentralised approaches—each have their strengths and limitations. Our proposition of an ecological model of scaling is that there should be a balance between the quantitative dimensions emphasised in the linear approach and qualitative dimensions related to the context where teaching and learning occurs. We argue for an ecological model of scaling that considers a balanced and systematic approach. This is also aligned with the centralised decentralisation perspective that the Singapore education context adopts.

12. A balanced approach creates an ecology where centralisation enables efficiency and decentralisation enables autonomy. Understanding scaling at the system’s level informs that the process of large-scale adoption of innovations is not simply “rubber-stamping” the same innovation into multiple contexts but empowering teachers in the design process of student-centred lessons, fitting, and adapting for local circumstances.

Proposing an Ecological Model for Scaling and Translation

13. This paper proposes an ecological model where the path towards greater adoption of educational innovations is complex and cannot be assumed to be linear. We envision a model where various innovations (teacher-, school-, and system-led) are happening concurrently. These innovations vary in complexity and “grow” under different conditions with varying structural supports. Innovations that may easily spread might be those whose core kernel designs (pedagogical principles) are more widely accepted by teachers and schools.

14. The ecological model stresses a sufficing standard that considers top-down and bottom-up structures as well as qualitative and quantitative dimensions. The ecological model does not ask if a gold standard has been achieved but focuses on seeking sufficing standards and tacit understandings to enable innovations and cultures of innovation to spread through the system. Growth of innovations would be evolutionary rather than a radical change process.

15. We leverage our understandings of existing NIE research projects and attempt to unpack the characteristics and types of innovations related to our proposition of an ecological model of scaling.
Approximately 200 NIE research projects were reviewed to suggest three types of projects populated across the Singapore education system: (1) teacher/researcher-led; (2) school-led; and (3) system-led. Descriptions of the projects as well as their roles in the ecological model of scaling are shown in Table 1.

<table>
<thead>
<tr>
<th>Type of project</th>
<th>Description</th>
<th>Role in scaling and ecology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-/researcher-led</td>
<td>• Translates theories into classroom practice&lt;br&gt;• Ownership is shared by both teachers and researchers or gradual shifts are made from researcher to teacher&lt;br&gt;• Project is driven by teachers' and/or researchers' initiatives</td>
<td>• Populating the ecology with bottom-up projects/innovations</td>
</tr>
<tr>
<td>School-led</td>
<td>• Diffusing teacher-led projects to the school-wide level&lt;br&gt;• Creates schools' cultures for new ways of teaching and learning as well as creating the environment for sustaining the innovation</td>
<td>• “Growing” projects/innovations from teacher to school level</td>
</tr>
<tr>
<td>System-led</td>
<td>• Project/innovation that has been successfully adopted by several schools&lt;br&gt;• System supports are leveraged and considered based on project's characteristics and school profiles</td>
<td>• “Dispersing” projects/innovations to more schools with system supports</td>
</tr>
</tbody>
</table>

Table 1. Description and role of projects for Scaling

16. NIE’s research has created an array of teacher / researcher-led (22.22%), teacher / school-led (51.85%) and school / system-led projects (25.93%). Teacher / researcher-led means researchers work with teachers to translate basic research ideas, such as Knowledge Building¹ (Tan, 2012; Teo, 2015) and Productive Failure² (Kapur 2010),

---

¹ Knowledge building is a pedagogy that develops students' disposition and capacity to always want to know more. It is about putting students' ideas and questions in the centre of the classroom. Students' ideas become teachers' teaching resource.

² Productive failure relates to the design of instruction that builds on students’ initial representation and solutions to problems for disciplinary learning. It is part of a family of research called student-generated design which leverages students’ ideas, representations and solutions as the basis for the design of teaching and learning.
Scaling Educational Innovations in Singapore

for implementation in classrooms. Teacher / school-led relates to classroom interventions that have moved to the school level where innovations are adopted minimally at the department level, for example using Second Life to develop disciplinary understandings\(^3\) (Lim, 2015). School / system-led means the school’s innovation has spread to other schools (but not the whole system), for example, Seamless Learning for Science\(^4\) (Wong & Looi, 2011) has spread to five other schools.

17. Teacher / researcher-led innovations seem to move towards school-led / school-supported innovations when strong sociality (for example, PLCs) and structural supports are built. School-led / school-support innovations require schools’ commitment and principals to rally support and make resources available to grow innovations within and across departments. Other innovations could have grown from teacher- or school-led to system-wide levels or when MOE initiates system-led projects, such as 10’CMT\(^5\) (Kumar, 2011), due to the need to possibly regulate local level initiatives or when reforms are needed to narrow gaps in achievements. The supporting criteria to move innovations to the next level are described in Table 2.

18. Not all innovations may grow linearly from teacher, school to system levels. The growth and impact of innovations would be a gradual and evolutionary process. Teachers and schools may begin the

---

3  Second Life is an online virtual world, which allows user to create their own worlds and avatars. It was used in Geography lessons to let students explore different landforms and learning possibilities. Students get to experience geography phenomena in 3D and develop a strong grasp of the concept through tinkering.

4  Seamless learning for Science is a learning notion that stresses the bridging of different learning efforts across diverse learning contexts, such as formal-informal learning, individual-social learning, and physical-digital learning spaces.

5  10’CMT is an ICT based pedagogical design that leverages ICT to enable personalised learning and teaching of mother tongue languages – C for Chinese; M for Malay; and T for Tamil. Web-based learning environment promotes learners’ interest and competencies in the target language. The pedagogical design is based on proven classroom practices experimented and implemented abroad.
Lee Shu-Shing

<table>
<thead>
<tr>
<th>Type of innovation</th>
<th>Criteria for moving innovation to the next level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teacher-/researcher-led</td>
<td>• Teachers have developed contextualised understandings by translating theory to classroom enactments</td>
</tr>
<tr>
<td></td>
<td>• Intended learning objectives have been accomplished according to students’ needs</td>
</tr>
<tr>
<td></td>
<td>• Core kernel designs are socially accepted and disseminated through professional learning communities</td>
</tr>
<tr>
<td></td>
<td>• Teachers are recognised for their efforts</td>
</tr>
<tr>
<td>School-led</td>
<td>• School supports with infrastructure to “grow” the innovation at the school level</td>
</tr>
<tr>
<td></td>
<td>• School leadership provides resources and time for teachers to redesign curriculum</td>
</tr>
<tr>
<td></td>
<td>• Trust has been established between school leaders and teachers</td>
</tr>
<tr>
<td></td>
<td>• Other teachers from the school are committed to the innovations</td>
</tr>
<tr>
<td></td>
<td>• Teachers from other schools join in the community</td>
</tr>
<tr>
<td>System-led</td>
<td>• Innovation is fundamental in that all students in the system can benefit, for example leveling up core competencies</td>
</tr>
<tr>
<td></td>
<td>• Innovation must have system-wide impact and be adaptive so that they can be locally relevant without changing core kernel designs</td>
</tr>
<tr>
<td></td>
<td>• Tacit knowledge that resides in teachers can be easily translated to explicit knowledge</td>
</tr>
<tr>
<td></td>
<td>• Teachers are generally ready to take up the innovation</td>
</tr>
<tr>
<td></td>
<td>• System support and infrastructure is available to support all schools while considering the innovation’s characteristics and different school profiles</td>
</tr>
</tbody>
</table>

Table 2. Supporting criteria for moving innovations to the next level

Scaling-adoption process at different starting points (e.g. teacher-led or school-led projects). Teacher-led innovations are experiments at the local, classroom level. Supports enable teachers to work collectively and spread innovations locally to include more subjects, classrooms and eventually progress to school-led/school-supported status. Spreading innovations from teacher-led to school-supported status involve efforts that are locally driven to grow innovations in schools and may possibly lead to uptake by the system (MOE), where system-level supports help innovations spread with greater efficiencies. Varying supports and communities that consider the complexity and intents of innovations are needed to grow innovations at teacher, school, and system levels.
19. The value of the ecological perspective suggests that the growth of innovations is not solely based on quantitative dimensions and top-down supports but also by qualitative dimensions and tacit understandings. A balanced approach is stressed where top-down structures and tacit understandings enable both efficiency and autonomy. It is thus expected that adaptations are made for resources, supports, and PLCs to grow innovations within and/or across levels (school, cluster or system levels) depending on the intentions of scaling.

20. It is also important to note that in spreading innovations, the ecological model does not ask if a gold standard is achieved. The value is on seeking adequate, sufficing standards to grow innovations and cultures of innovation throughout the system. Characteristics and indicators of the sufficing standard, as elicited from understandings of existing NIE projects, are listed in Table 3. Using a sufficing standard shifts away from optimal replication and quantitative dimensions to stress tacit understandings and communities to spread and sustain innovations.

<table>
<thead>
<tr>
<th>A Sufficing Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Characteristics</strong></td>
</tr>
<tr>
<td>• Teachers’ enthusiasm, commitment and readiness of the innovations to contextualise pedagogy for their classrooms</td>
</tr>
<tr>
<td>• Resources and support at the school, cluster, or MOE levels</td>
</tr>
<tr>
<td>• Schools leaders are willing to support the innovations</td>
</tr>
<tr>
<td><strong>Indicators</strong></td>
</tr>
<tr>
<td>• Adoption of school-led innovations by other schools</td>
</tr>
<tr>
<td>• An increasing community of teachers</td>
</tr>
<tr>
<td>• More dialogue and sharing between schools and teachers</td>
</tr>
</tbody>
</table>

*Table 3. Characteristics and indicators of a sufficing standard*

**Observations for moving forward**

21. In typical scaling efforts connoted by centralised education system, policymakers are concerned with rolling out educational innovations and quantitative data would be collected to inform its implementations, efficacies, and degrees of fidelity. The concerns of policymakers are valid. However, in a centralised decentralisation milieu like Singapore, the strategy encouraged stems from the ecological perspective where a sufficing standard is advocated. This
standard focuses not only on numbers and quantitative dimensions but also on qualitative dimensions. The qualitative dimensions focus on contextualised pedagogy and designs to be developed as well as the capacity of teachers to be built locally to enact student-centered pedagogies for their contexts.

22. The use of “sufficing” standard as opposed to “gold” standard shifts the focus away from expecting a par excellence model that is considered optimal for roll out at the system level (Hung, Lee, & Teh, 2015, see Appendix B). Given the substantial variations of contexts in education settings, even if a “gold standard” can be identified, it will not likely be the “gold standard” for another situation. Thus, we underscore the importance of policymakers to shift towards a sufficing standard and understand how to support teacher-led, school-led, and system-led innovations by building up tacit knowledge in the form of teacher capacity building rather than focusing on explicit knowledge / artifacts and replicating it system-wide.

23. A healthy ecology of innovations must have a good spread of innovations at the teacher, research, school and system levels as well as support both linear, “mechanic” and bottom-up, “organic” scaling. Linear, “mechanic” scaling takes the traditional replication view of scaling. This approach is appropriate, when across all schools in the system, (a) the tacit knowledge can be easily codified, (b) teachers are ready to enact the innovation, (c) infrastructure to support the innovation is available, and (d) innovation is fundamental so all teachers can benefit. Given the substantial costs involved, system-led innovations must be carefully selected based on costs and benefits considerations. Within a system, there is always room for bottom-up, “organic” scaling where teachers are given time and space to try out new innovations for their classrooms, schools, and to develop skill sets to enact the innovation. Bottom-up, “organic” scaling happens when teachers initiate and share innovations in collaborative learning situations. Bottom-up, “organic” scaling fosters tacit understandings in the form of teacher agency, professionalism, and is useful to prepare teachers for linear, “mechanic” scaling (Hung, Lee, & Teh, 2015, see Appendix B).
**Policy and Practice Implications**

24. It is important to recognise that teaching is the interplay of tacit knowledge and developed resources. There are currently system-level and school-level structures for creating the ecology and social-cultural context to develop teacher champions and communities to spread and sustain innovative practices. However, structures and processes are also needed to develop teachers, at the individual level, to make sense of innovations and develop tacit understandings for contextualising pedagogy by redesigning, enacting and refining lessons for their classrooms. Building teacher capacity and agency to take ownership and become champions of innovations is a gradual process where networked and school-based learning communities can be leveraged to provide expertise and critique to teachers’ redesigns. The tenets for supporting teachers to develop agency and autonomy to innovate include the following: resources, time, community, trust and recognition. These five dimensions must be available for teachers’ innovation journey to contribute and diffuse innovation within and beyond schools (Hung, Lee, & Teh, 2015, see Appendix B).

25. While system and school-led structures are available for capacity building and scaling, seen in Table 4, in line with the ecological stance, it is important to ensure dual-way interaction loops so understandings gained from networked learning communities can be brought back to school-based PLCs to spread innovative practices to more classrooms. Conferences become platforms to showcase innovations and recruit new members for innovations and communities. Members who belong to both networked and school-based learning communities, thus, play key roles to facilitate these interactions. Interaction loops are also important to energise communities and innovations with new insights and more adopters.

26. School leaders encourage teachers to dialogue and participate in PLCs but the extent of these platforms to develop teachers’ reflectivity and capacity to champion innovations and change mindsets may vary depending on teachers’ readiness for new pedagogies. Thus, it may be useful for NIE researchers to work with in-service teachers to show possibilities of bringing research ideas to classrooms. Taking basic research to classroom is a painstaking process. It involves researchers
Lee Shu-Shing

<table>
<thead>
<tr>
<th>Structures</th>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject chapters or networked learning communities</td>
<td>System-led</td>
<td>These communities are established by teachers’ academies and language centres, led by Master, Lead, and Senior Teachers and Specialists from MOE and NIE, to deepen teachers’ knowledge and skills. These learning networks provide teachers with opportunities to share, collaborate and co-develop new ways of teaching.</td>
</tr>
<tr>
<td>Innovation related learning communities</td>
<td></td>
<td>The Educational Technology Division (ETD) has established learning communities led by Educational Technology Officers (ETOs) to bootstrap understandings of ICT innovations seeded through various MOE initiatives. These learning communities are a strategy of cultivating teacher capacity and leaders where teachers learn through peer support. The learning community is an initiative to spread innovations through lateral networks and enable teacher autonomy in a centralised-decentralisation system.</td>
</tr>
<tr>
<td>Conference and awards to share and celebrate innovations</td>
<td></td>
<td>Conferences, such as ExCEL Fest, International Conference on Teaching and Technology (iCTLT), and awards, such as Innergy awards, best suggestion awards, and outstanding innovation awards are platforms to celebrate the successes of teachers’ learning and innovations. It is also a place for teacher champions to attract teachers to seed the innovations in other schools and attract members to networked learning communities.</td>
</tr>
<tr>
<td>School-based professional learning communities (PLC)</td>
<td>School-led</td>
<td>Many schools have professional learning communities. These communities engender a culture of collaborative professionalism and are natural platforms for teachers to generate new ideas and practitioner-oriented professional growth. Continuous dialogue and feedback enable teachers to drive enhancements and innovations in their practices as well as maintain their professional currency. These communities may be led by teachers and school staff development officers.</td>
</tr>
</tbody>
</table>

Table 4. Existing System-led and School-led Structures for Capacity Building and Scaling.

and teachers working through a design-based implementation research process to co-design, implement, and refine innovations in classrooms till it succeeds. Subsequently, the co-designed innovations may be integrated into existing school-based PLCs for continuous discussions. These partnerships enable concerted efforts to spread innovations and 21st century pedagogies throughout the system with a focus on teacher capacity building and tacit understandings.
Policy and Research Implications

27. If we accept the ecological model for scaling, then the system will have more instances of “organic”, bottom-up scaling. Bottom-up, “organic” scaling is important because it encourages teacher-led and school-led innovations as well as lays the foundation for the education system to be innovative through top-down supports for successful system-led innovations and accelerate linear, “mechanic” scaling.

28. Researchers play three roles in the ecological model of scaling. First, researchers are to engage in research to discover theories, translate theories into interventions and test them in controlled experimentations. Successful examples can be “mechanically” scaled as system-led innovations when the criteria set out in Table 2 are met. Second, researchers are expected to contribute to “organic”, bottom-up scaling by supporting practitioners in equal partnership to improve local instantiations of teacher-led and school-led innovations and deliberately support the shift of ownership to practitioners by proactively participating in professional learning communities and communities of practices. Third, researchers are directly involved in studying the patterns of growth, spread, and implementation of innovations from a system lens.

29. In line with our ecological perspective where bottom-up approaches to scaling are enabled by top-down supports, policymakers would still want to have a quantitative, system’s view of the teacher-led, school-led, and system-led innovations that are grown locally and supported by various levels of the system. Examples of baseline data to be considered include: (1) types of innovations, (2) extent of spreading, (3) teachers involved, (4) number of local communities, and (5) spread of innovations across school clusters and zones. A partnership between NIE and MOE may be forged to investigate this area of work. Research of this nature provides policymakers with baseline data from a systems view relating to the progress made through the ecological approach of scaling. The data can be used to inform models, framework and criteria for supporting scaling at various levels (teacher-, school-, system-led innovations) as well as enable the shortlisting of innovations that have the best chance of being sustained by the system with the necessary resources and supports from stakeholders. This envisaged, future baseline study is different from the CORE Research Programme as
it looks more from the scaling point of view rather than changes in pedagogical practices and student outcomes.

30. The CORE Research Programme plays a role in providing baseline data to understand whether the populating, “growing”, and “dispersing” of teacher-led, school-led, and system- innovations has resulted in changes of learning and teaching in Singapore schools. The CORE 3 research programme is currently in progress (see http://www.nie.edu.sg/project/oer-29-15-ccy). The CORE 3 Research Programme runs as three waves and is currently in wave 1. Its objectives are to evaluate the structure, logic, and quality of pedagogical practices that is triangulated with student outcomes.

31. Studying the natural “growth and spread” of innovations may be a way for NIE and MOE to collaborate to understand local phenomena, spread, and further optimise the efficiencies and cost-effectiveness of subsequent instantiations without compromising core pedagogical designs. NIE researchers are currently working with ETD to study existing models of scaling in eduLab projects through a meta-study. The meta-study hopes to inform MOE of the tenets that enable schools and possibly clusters and the system (through centralised structures) to create contextual readiness that support the scaling of ICT-mediated innovations.

32. Policymakers, practitioners, and researchers hold different roles in the scaling agenda. It is important for policymakers and practitioners to realise that the primary role of researchers is to create theories and translate theories into interventions. The role of practitioners is to infuse interventions into professional practices to improve teaching and learning. The role of policymakers is to ensure that innovations are given the necessary support and conditions to scale across different levels of the system. Policymakers include senior political leaders and junior policy officers who provide proscriptive supporting conditions for innovations to seed, grow, and spread. Examples of these conditions could include cushioning and protecting teachers and schools from external pressures which may disrupt the innovation. Policymakers need to understand that enacting linear, “mechanic” scaling also requires deliberate coordination and informed dialogue amongst all stakeholders (researchers, practitioners and the public) to establish shared understandings of
problems to mobilise resources, develop, and spread innovations across the system to address these existing problems.

33. Policymakers should also be careful not to overly expect system rollouts through linear, “mechanic” scaling to be particularly high in fidelity and to be concerned if perception survey results show that innovations are working well. The tacit nature of educational settings requires time for innovations to take root as well as for teachers to experiment, develop capacities, and change pedagogies and mindsets.

**Concluding Remarks**

34. Educational settings differ across classrooms and contexts. Hence, there is no one-size-fits all solution in scaling innovations. In this paper, an ecological model of scaling is advocated. Flexibilities and adaptivities occur throughout the system with sufficing standards (largely determined by teacher readiness, leadership supports, and infrastructural adequacies) as target goals at each local instantiation.

35. The proposed ecological model is aligned to the centralised decentralisation view adopted in Singapore. Our thesis emphasises a balanced approach and creates an ecology where centralisation enables efficiency and decentralisation enables autonomy for scaling innovations. Balance is important because there may be propensity to move away from the existing system in pursuit of diversity and innovation. Our thesis considers the centralised decentralisation paradox and remains cognisant that any initiative has to be centrally driven and balanced rather than free flowing and radical.

36. We are mindful that our proposition stems from a theoretical stance. We acknowledge that scaling innovations is a complex agenda that needs to consider different issues, such as educational policy and implementation, accountability, and school contexts.

37. Scaling and sustaining innovations are more than just compliant implementation. It is valuable that the proposed ecological model recognises both qualitative and quantitative dimensions, top-down and bottom-up efforts. Sufficient time is needed for a healthy ecology and culture of innovations to develop across schools in Singapore. MOE, NIE, and schools need to undertake research and development efforts to
further understand and implement the scaling process in order to level up
the base of 21st century learning and literacies.

Acknowledgements
This executive summary was prepared by Shu Shing Lee (Research
Scientist, Office of Education Research, National Institute of Education).
Any opinions, findings, and conclusions or recommendation expressed
herein are those of the author's. Special thanks to Azilawati Jamaludin
(Research Scientist, Office of Education Research, National Institute of
Education), Jeanne Ho (Senior Teaching Fellow, Centre for Research
in Pedagogy and Practice, National Institute of Singapore), Helen Hong
(Teaching Fellow, Centre for Research in Pedagogy and Practice,
National Institute of Singapore), and Connor Gilbert (Research Assistant,
Centre for Research in Pedagogy and Practice, National Institute of
Singapore) for providing support and constructive feedback towards the
completion of this executive summary.

References
Carlile, P. R. (2004). Transferring, translating, and transforming: An integrative
framework for managing knowledge across boundaries. Organization
Policymakers and Practitioners from Singapore. In Scaling Educational
Innovations (pp. 31–50). Springer Singapore.
sufficing standard and not a gold standard. Educational Research for Policy
and Practice, 14(1), 77–91.
pixel-online.net/ICT4LL2011/common/download/Paper_pdf/IBL61-399-FP-
Kumar-ICT4LL2011.pdf/
intuition. IN Lim, K. Y. T. (ED.), Disciplinary Intuitions and the design of
learning environments (pp. 83–94). New York: Springer.
Educational Innovations. In Scaling Educational Innovations (pp. 13–30).
Springer Singapore.
Scaling Educational Innovations in Singapore


Toward an educational view of scaling: sufficing standard and not a gold standard

David Hung · Shu-Shing Lee · Longkai Wu

Abstract
Educational innovations in Singapore have reached fruition. It is now important to consider different innovations and issues that enable innovations to scale and become widespread. This proposition paper outlines two views of scaling and its relation to education systems. We argue that a linear model used in the medical field stresses top-down replication of a “gold standard” to multiple contexts. This view is similar to scaling in centralized education settings. A project-oriented view stresses bottom-up spreading or diffusing innovations from localized settings to wider contexts. This view is more aligned with scaling in decentralized education systems. Instead of top-down or bottom-up views of scaling, this paper proposes an ecological model of scaling from a system’s perspective. It emphasizes a sufficing standard that considers top-down and bottom-up structures as well as qualitative and quantitative dimensions. Accommodations are made to populate different innovations across the system. Top-down supports are given to enable bottom-up innovations. Qualitative dimensions in the form of tacit understandings are more important than replicating explicit or procedural knowledge. The spreading of education innovations is cultivated by nurturing professional learning communities, communities of practices, and keeping tabs of their growth within the system as well as identifying areas for improvement through quantitative, baseline studies.

Keywords: Scaling and translation, Ecological model, Gold standard, Sufficing standards
1 Introduction
The Singapore education landscape has evolved through different phases: survival driven (in the first two decades after 1965), efficiency driven (in the late 1970s), and ability driven (in the late 1990s onwards). The Survival phase aimed to develop every child’s literacy and numeracy skills (Goh and Gopinathan 2008; Mourshed et al. 2010). The Efficiency phase (1979–1996) reduced performance variations by streaming students into academic tracks based on their aptitudes. In 1997, Singapore went into the Ability phase. This phase aimed to create a responsive education system with multiple pathways for different students (Goh and Gopinathan 2008; Mourshed et al. 2010). It stressed the importance for students to learn 21st century skills and cater to students’ different interests and aptitudes (Ministry of Education, Singapore 2008, 2012). Various policy initiatives such as Thinking Schools Learning Nation (TSLN) in 1997, Teach Less Learn More in 2004, and integrated programmes since 2005 were implemented to move away from teacher-centered to student-centered pedagogies.

Singapore’s trajectory stems from a centralized approach where controls of curriculum content, budget, resources, and educational facilities lies in a central body, the Ministry of Education, Singapore (MOE) (Leung 2004; Weiler 1990). Generally, education systems that belong to the West, such as the United States, take on a decentralized approach, where authority and governance are delegated to the local schools (Leung 2004). Individual schools make their own decisions on matters like finance, curriculum, and professional development (Dyer and Rose 2005; Weiler 1990).

The changing goals of each phase suggest that Singapore recognizes the need to embrace diversity and move toward more decentralized approaches. More autonomy is given to schools to manage resources and recruit teachers (Ng 2003). This development is in line with growing interests in educational decentralization in developing nations, such as South Asia, Latin American, and Eastern Europe (Leung 2004).

Although the Singapore government has repeatedly stated its intentions to decentralize power and create platforms for diversity and innovation in schools, its efforts may be more accurately described as centralized
Appendix A

decentralization (Ng 2010, 2013). Singapore’s approach is closely aligned with pragmatic considerations. Singapore perceives education as a critical vehicle for political and economic strategies. Schools support national, social, and political strategies. The government takes great responsibility in securing the nation’s economic survival, achieving education outcomes, and careful fiscal spending (Ng 2010). This creates tensions because decentralization is associated with a risk of declining standards and a liberal view of education rather than a functionalist view. The liberal view stresses the intrinsic values of education for personal growth and not as economic gain (Tan and Ng 2007).

Thus, the Singapore education system faces a paradoxical trend of centralization within a decentralization paradigm. The government maintains high quality education by centralizing controls on strategic directions. Concurrently, the government promotes decentralization of tactical matters by empowering schools to accommodate diversity, be flexible, and be innovative. Schools need to think out of the box by engaging in pedagogical reforms, innovations, and at the same time, maintain students’ content knowledge and grades. The challenge for schools and educators in Singapore is to embrace to this paradox and achieve the best of both worlds (Ng 2010, 2011).

The creation of an educational research funding further signals Singapore’s recognition of research to inform reforms, enact new pedagogies, and create a culture of innovation in schools. The education research funding in Singapore spans two time periods (2002–2007, 2008–2012) accumulating to about 150 million Singapore dollars. In the first period (2002–2007), the primary goal was on establishing research centers at the National Institute of Education (NIE). Another was to change and enact new pedagogies with a focus on culturing student-centered pedagogies and participations in classrooms and beyond. In the second period, funding continued to sustain the kinds of education research populated across the Singapore education system. Research began to play an inevitable role in the change-reform process. These research efforts brought about various successful educational innovations in schools, such as Group Scribbles (Chen and Looi 2011), Seamless Learning (Wong and Looi 2011), and Productive Failure (Kapur 2010). These examples and many others,
both from MOE and NIE, laid the foundation for a rich and diverse culture of innovation in schools and across the Singapore education system. Furthermore, it also enabled the recognition of Singapore’s educational innovations among international research communities, practitioners, and policy makers.

With a relatively large investment on research in the last decade, educational innovations in Singapore have reached fruition. It is now important to consider possibilities for different innovations as well as issues that enable innovations to scale and become widespread. In this paper, we outline two dominant views of scaling and its relation to education systems. We emphasize that a linear model of scaling and translation commonly used in the medical field emphasizes top-down replication to multiple contexts (Woolf 2009). We argue that this view is akin to scaling efforts in centralized education settings. A project-oriented view of scaling and translation focuses on bottom-up spreading or diffusing innovations from localized settings to wider contexts (Coburn 2003; Dede 2006). This view is more aligned with decentralized education systems.

We attempt to highlight limitations of these views and propose an ecological model of scaling that considers Singapore’s education landscape. Instead of top-down or bottom-up views of scaling, accommodations are made to populate various innovations across the education system. Top-down supports, by MOE, are given to enable bottom-up innovations (by schools). Different structural supports are provided to incentivize teachers to adopt, adapt, and embrace tested innovations and hence make them more widespread. The spreading of education innovations is cultivated by nurturing professional learning communities and communities of practices. It is also important to observe their growth within the system as well as identify areas for improvement. This proposition paper, therefore, proposes a way forward by postulating an ecological model to describe the scaling efforts in the Singapore education landscape, from a system’s level of analysis, as exemplified by existing research projects from NIE.

2 Scaling and translation research: from top-down to bottom-up perspectives
In the natural sciences, including that of the medical field (see Fig. 1), scaling and translation from research to everyday practices is a linear and staged process (Woolf 2009). Stage 1 of the translation research (T1) focuses on testing in laboratory settings. The aim is to develop new methods for diagnosis, therapy, and prevention (Woolf 2009). In T1 research, clinical scientists work in laboratories with supportive infrastructures within the institution. This research occurs in community and ambulatory settings. The Institute of Medicine’s Clinical Research Roundtable positions stage 2 of translation research (T2) as translating results from clinical studies into clinical practice and decision making (Sung et al. 2003). In T2, research moves out of the laboratory into real world settings. This is the first attempt to bring T1 research to public settings. T2 research yields knowledge about efficacy of intervention in various controlled real world settings. It focuses on how infrastructure, resource constraints, human behavior, and organizational issues affect the efficacy of interventions.

Fig 1. Linear translation model in medical research University of Miami (2013)
It recognizes that translating interventions is a socially complex phenomenon. Stage 3 of translation research (T3) is about disseminating the intervention from controlled real world settings to the general population. In T3, researchers explore ways to apply recommendations into everyday practices (Westfall et al. 2007). The focus is on how interventions work in real world settings. Medical research, as described from the stages, moves linearly from the lab- oratory to the mass market. The default model is to look for a proof of concept also known as “gold standard” of an innovation, bring this through the T1, T2, and T3 processes, and focus on quantitative outcomes. This dominant thinking is also found in programs such as the i3 (Innovation through Institutional Integration) model of the National Science Foundation (NSF) (The National Science Foundation 2006) see Fig. 1.

Different educational studies discuss what “scaling” means and what it entails (see for instance, Bocconi et al. 2013; Coburn 2003; Fullan 2000; Hargreaves and Fink 2000; Klinger et al. 2013). Scaling as defined in the medical sciences seems to bear some resemblance to centralized education systems—scaling is about replicating an innovation from one context to the masses (Klinger et al. 2013; Sternberg et al. 2006). There is an inherent emphasis on quantitative outcomes.

To a certain extent, limitations of this view of scaling are aligned with constraints of centralized education systems. This view of scaling is efficient in making an innovation more widespread. However, replicating the innovation across contexts is decontextualized because it does not consider appropriateness of the innovation or adapting the innovation for the context. The assumption is that all contexts are similar. There is an innate emphasis on explicit knowledge (that is, the gold standard). Little emphasis is made on educating people (that is, tacit knowledge) to sustain and enact the innovation (Fullan 1994). This perspective of scaling seems concerned with quantitative dimensions by first establishing a proof of concept (that is, the gold standard) and then quickly replicating it to multiple contexts.

**2.1 Variability due to student-centeredness**

Scaling and spreading innovations in decentralized education systems are different from the medical field and centralized education systems.
Decentralized education systems seem to emphasize student-centered learning processes and variability in education settings (Dyer and Rose 2005; Weiler 1990). The focus is on cultivating student-centered process-in-learning such as inquiry and knowledge building. Student-centered processes assume variability in different situations rather than adopt a “one-size fits all” form of instruction.

Based on this assumption, we posit that attempts to scale, if consistent to student-centeredness and decentralized education systems, should not be a mere replication or duplication from the original intervention. Variations should be allowed based on differences in student profiles, curriculum, teacher dispositions, and others. To maintain the integrity and identity of the innovation, however, there need to be core design principles or fundamentals that should be upheld. Or as Locke and Ableidinger (2013) posits “the essence … is sticking with a set of non-negotiable elements that were central to the success of the initial effort, in order to retain the benefits of those elements in the expanded initiative.”

2.2 *Educational settings are socially messy and tacit knowledge is needed*

In medicine and centralized education systems, research starts in laboratories or experimental classes in a context vastly different from the real world when a successful product or innovation will be consumed. Transfer of innovations to everyday practices is fixed on a set of procedures. In educational science, the social context is more complicated (Clarke and Dede 2009), and hence socially messy. The education environment is varied and learning is a socio-cultural process (Beach 1999).

Our proposition about an ecological model of scaling is that there should be a balance on quantitative dimensions emphasized in the linear scaling approach, such as the number of sites an innovation has spread to, as well as the kinds of tacit knowledge related to an innovation. Qualitative dimensions related to tacit knowledge are important due to the dynamic interactions between teachers, students, and the situated context, where the learning and instruction arise. This is in essence the student-centeredness which MOE is advocating and is in alignment with the centralized decentralization perspective that MOE adopts.
2.3 Educational models of scaling from a bottom-up perspective

Current literature discusses on issues about scaling educational innovation and possible ways to address them (Bodilly et al. 2004; Clarke and Dede 2009; Elmore 1996; Klinger et al. 2013). These discussions mostly take the respective innovation or project as the focus. We postulate this to be more aligned with scaling from a decentralized education system’s perspective, where bottom-up innovations are encouraged. Coburn (2003) and Dede (2006) develop a conception of scale that has four interrelated dimensions: depth, sustainability, spread, and shift in reform ownership to the teacher and the school. To elaborate:

- Depth looks at the nature of change, whether change is affected by the organization’s beliefs, whether individuals’ beliefs and thereafter practices have evolved; whether these changes are merely superficial. It is also important to consider the owner responsible for the change.

- Sustainability is about endurance; how long will the change endure; what strategies are in place to assure sustainability of the change.

- Spread refers to the norms, principles, beliefs understood by greater numbers of people. It asks “How widespread is the change?” “Who is involved in the change?” “Who should be involved?,” and “Who will benefit from the change?”

- Ownership is the attempt to shift reform ownership in terms of knowledge and authority to implementers; the schools who should ultimately “own” the process.

We see this conception of scale as focusing on the spread and reach from an innovation-oriented, local-project instantiation point of view rather than understanding how to spread innovations at the system’s level of analysis which is inherently more complex and non-linear. We argue that the above conception of scale relates more to a bottom-up orientation of scaling that seems aligned with decentralized education systems. Although they provide detailed accounts about scaling individual innovations from a bottom-up perspective, the
inherent limitation is that bottom-up innovations take time to cultivate substantive change before it can spread to other contexts. Even if substantive amounts of change have taken place, lessons learnt from the innovation are contextualized to the specific context and may not be easily replicated to another context. There is not just one model for successful implementation—there are probably as many models as there are the unique contexts (Leusner et al. 2008). In fact, certain amount of adaptation is needed when the innovation is translated to another context. There is, thus, some inefficiency in this approach because 1) time is needed for substantial traction to grow before an innovation can spread and 2) best practices learnt about an innovation may be localized and require time to be translated to another context.

Linear, centralized, or bottom-up, decentralized approaches of scaling have its inherent strengths and limitations. We, therefore, argue for an ecological model of scaling that takes on a balanced and systemic approach. Education systems, particularly in the Singapore context, are neither solely centralized nor decentralized. Thus, a balanced approach embracing both top-down and bottom-up efforts is useful to look at how innovations can spread to develop a culture of innovation (Dyer and Rose 2005; Fullan 1994). In the East Asia context like Singapore, decentralization does not sit well. Thus, a balanced approach toward creating the ecology is needed so centralization enables control and decentralization enables efficiency (Leung 2004).

Understanding scaling at the system’s level informs policymakers of different scaling patterns, teachers’ and students’ needs on the ground, and facilitates resource allocations. The process of large-scale adoption of innovations is not simply about “rubber-stamping” the same innovation into multiple contexts, but on empowering teachers in the design process of student-centered lessons, fitting, and adapting for local circumstances (Barab and Luehmann 2003), and others. Much greater complexity is involved when educational professionals seek to understand and improve the enactment of innovations, and take it to scale. A systemic approach is needed to spread educational innovations by considering the interconnected relations between curriculum standards, curriculum materials, learning activities, formative and summative assessments, professional development practices, and
educational leadership (Looi et al. 2011; Pea and Collins 2008), as well as taking into account the aspects of organizational learning (Spillane et al. 2009). In essence, “scaling up promising reforms requires a holistic approach…” (Samoff et al. 2001).

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Centralized, linear approach</th>
<th>Decentralized, bottom up approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scaling</td>
<td>Replication “gold standard” or proof of concept from one to multiple contexts without translation</td>
<td>Spreading out from local instantiation/innovation&lt;br&gt;Requires translation to adapt and spread to other contexts</td>
</tr>
<tr>
<td>Direction</td>
<td>Linear from laboratory to mass market/from top to bottom</td>
<td>Bottom-up spread or diffusion from local instantiation to other contexts</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Proof of concept as gold standard&lt;br&gt;Emphasis on decontextualized, explicit knowledge</td>
<td>Lessons learnt are contextualized&lt;br&gt;Emphasis on tacit knowledge</td>
</tr>
<tr>
<td>Outcome</td>
<td>Quantitative dimensions focusing on numbers</td>
<td>Qualitative dimensions in terms of depth, sustainability, spread, and shift</td>
</tr>
<tr>
<td>Time</td>
<td>Efficient due to focus on decontextualized replication</td>
<td>Takes time to cultivate substantive amounts of change before spreading to other contexts</td>
</tr>
<tr>
<td>Relationship to education system</td>
<td>Centralized education systems</td>
<td>Decentralized education systems</td>
</tr>
</tbody>
</table>

*Table 1. Key characteristics of scaling in top-down and bottom-up approaches*

Considerations of “scale” are a key challenge for school reform. Definitions have traditionally focused on an innovation-oriented perspective that emphasizes the expanding number of schools reached by a reform or innovation. There are, however, complex challenges of reaching out broadly, while simultaneously cultivating the depth of change necessary to support and sustain consequential change. Understanding reform, spread, and (out)reach of an innovation from a systemic perspective is inherently more complex and non-linear. Table 1 summarizes the key characteristics of centralized, top-down, and localized, bottom-up views of scaling. Our thesis is on neither of these views individually but to propose an ecological model of scaling that emphasizes a balanced approach—looking at quantitative and qualitative dimensions with a systemic perspective toward scaling. Rather than aiming for gold, par excellence standard, our proposition is to focus on a sufficing standard characterized on maintaining core
kernel designs (that is, best practices) of an innovation, while allowing space for adaptations and building a sociality to sustain the innovation.

In the next section, we leverage on our understandings of existing NIE research projects and attempt to unpack the characteristics and types of innovations related to our proposition of an ecological model of scaling from a system’s level of analysis.

3 Proposing an ecological model for scaling and translation
In Singapore’s education context, the path toward a greater adoption of educational innovation is complex and cannot be assumed to be linear. We envision a model where various types of innovations (see Fig. 2 below) happen concurrently. These innovations “flourish” under different conditions with various structural supports. Innovations have varying levels of complexities. Innovations that can more easily spread would be those that have established and socially accepted core kernel designs. When such innovations are implemented in different situations, with resources well disseminated, and a sociality of teachers built around it (such as through professional learning communities and communities of practice), we can expect more of such innovations to be taken up by teachers for implementation in their classrooms.

![Fig 2. Non-linear model of scaling](image)

There are currently a considerable number of teacher-led projects populated throughout the Singapore education system. Some of these projects have been more successful in spreading across different classrooms and moving toward a school-oriented innovation, while
others have been less successful. This could be due to a number of factors: the complexity of the innovation, the readiness of teachers, etc. Examples of these teacher-led projects can be found in MOE–NIE initiatives such as eduLab. The eduLab initiative is designed to surface and push ground-up Information and Communication Technology (ICT)-enriched pedagogical innovations across schools (eduLab 2009).

MOE and NIE stand ready to engage teachers to spread these teacher-led innovations. We envisage that innovations that are less complex would require less support. To a certain extent, if the sociality built around the innovation is strong, the innovation could grow. Of course, if school-based supports are given, the spreading could happen more quickly at the school-wide and across-school levels. We refer to these as school-led or school-supported projects (see Fig. 2). MOE and NIE also recognize that more complex innovations could require higher levels of support to enable it to spread. Such innovations would require the commitment of schools and principals to rally school-based support from more teachers and to make resources available in order to better support such innovations to grow. Likewise, school principals who opt to undertake these more challenging innovations will be supported and partnered with NIE researchers (in specific instances). Given the more complex nature of these projects, a richer partnership is envisaged.

Another kind of innovation could be for projects that grew from teacher-levels or school-levels to system-wide levels, or when MOE initiates system-wide projects or initiatives due to the need to regulate local level initiatives or when certain reforms are needed due to a system’s view to narrow gaps in achievement. We thus propose that three types of innovations could be populated across the Singapore education system:

- Teacher-led,
- School-led, and
- System-led.

Teachers and researchers can also take a theoretical basis and work around it in classroom (or equivalent) settings and these become teacher-led projects. All three types of innovations happen concurrently.
for a healthy ecology to occur. In line with our balanced approach toward an ecological model of scaling, growth and spread of teacher-led and school-led innovations happen locally and the state of play can be understood from a qualitative perspective according to Coburn (2003) and Dede (2006) frameworks and criteria.

3.1 Gradual and evolutionary growth

At the systemic level of analysis, with the three types of innovations (Teacher-, School-, and System-led innovations) populated across the system, we envisage that as teachers and schools adopt, adapt, and implement innovations (with MOE’s support and other school-based structures), local cultures of innovation would be nurtured. Due to the complexity of innovations and the nature of support required, it would be reasonable to assume that our education landscape would be one which is populated with more teacher-led and school-led innovations than system-led initiatives, especially in the milieu of student-centered pedagogies. The more radical and complex the innovation compared to conventional practices, the greater the need for local instantiation and spread in order to develop and cultivate the tacit knowledge underpinnings of the innovation.

As change, growth, and eventual impact of innovations to the community would be gradual, an evolutionary rather than a radical change process should be expected. Teachers and schools can begin the scaling-adoption process at different starting points. Teacher-led or teacher-supported innovations relate to experimentations at the local (classroom) level in small instantiations. The focus of these innovations relates to the identification and contextualization of innovations to meet students’ needs and address issues in classrooms, especially of student-centered pedagogies and designs. Teachers work collectively toward refining innovations, identifying and implementing changes when needed, while preserving the core or kernel principles and building teaching resources that allow innovations to be implemented in classrooms. Through experimentations and consistent dialoging, teachers may begin to adapt innovations for use with their own students in different classroom contexts. Teacher-led innovations and experimentations could grow to influence more people in various local
instantiations. In other words, teacher-led innovations could be scaled or spread locally to include more subjects, classes, different student profiles, and result in eventual “promotion” to school-led status. When spreading from teacher-led to school-supported status, implementation efforts are locally driven and emerged. These innovations could subsequently be taken up by MOE and these could be provided with financial and infrastructural supports to ensure innovations’ spread and sustenance with greater efficiencies. As such, these efforts could eventually be system-led innovations. Examples of these innovations could include leveling up the base of core literacies in order to bridge achievement gaps or when local growth models may be too slow for certain policy priorities.

3.2 A sufficing standard (instead of gold standard)
It is important to recognize that when innovations spread in these ways, we do not seek to ask if a gold standard has been achieved before allowing for the spread to occur. This is because rather than looking for a model of excellence and then replicating it across contexts, we are seeking for adequate standards to enable the spreading of innovation and culture throughout different levels of the education system. In this sufficing standard, the focus is on teachers’ enthusiasm, commitment, and readiness about the innovations. Teachers need to be able to take innovations to their own respective classrooms (or equivalent) and implement the core or kernel ideas of that intervention. Resources are available at the school, cluster, or MOE levels to support subsequent take-ups and support the spreading of innovations. School leaders are also willing to support teachers to experiment and permit possible implementation gaps to happen, if any. Teachers are able to collect evidence-based data for their experimentations to exemplify some form of rigor toward their innovations.

We connote the above characteristics as important issues around a sufficing standard for spreading of innovations, rather than a gold standard. The use of sufficing standard as opposed to gold standard is argued in this paper to shift the focus away from a par excellence model for optimal replication to the system at large. Instead indicators related to a sufficing standard are emphasized. Some possible indicators of spread related to a sufficing standard could be the adoption of
Appendix A

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Teachers’ enthusiasm, commitment and readiness</td>
<td>• Adoption of school-led innovations by other schools</td>
</tr>
<tr>
<td>about the innovations</td>
<td>• An increasing community of teachers</td>
</tr>
<tr>
<td>• Resources are available at the school, cluster,</td>
<td>• More dialog and sharing between schools and teachers</td>
</tr>
<tr>
<td>or MOE levels</td>
<td></td>
</tr>
<tr>
<td>• Schools leaders are willingly to support</td>
<td></td>
</tr>
<tr>
<td>• Teachers are able to collect evidence-based data</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. Characteristics and indicators of a sufficing standard

As we study into the various teacher- and school-led/supported innovations, we will elaborate on the sufficing standard to inform scaling efforts at the policy and research considerations of MOE and NIE, respectively.

4 System's level data of the growth and spread of student-centred innovations

In typical scaling efforts connoted by the sciences and centralized education systems, policy makers would roll out to the whole system or nation a certain proven drug or product. In this kind of linear, centralized scaling, quantitative data would be collected on its implementation efficacies and degrees of fidelity in terms of benefits to different user groups. Figure 3 shows the many combinations of contexts which have to be developed centrally in order to roll out an education program. LA,
Appendix A

MA, HA in Fig. 3 represent low ability, medium ability, and high ability students, respectively. For example, the identified smaller cube in the larger cube below seeks to know how to scale curriculum in classrooms with low achieving (LA) students.

The concerns of policy makers are valid nevertheless. However, the strategy we are advocating in a sufficing standard focuses not only on numbers and quantitative dimensions but also on qualitative dimensions. The qualitative dimensions focus on contextualized pedagogy and designs to be developed and capacity of teachers to be built locally to enact student-centered inquiry and facilitation. Since teaching requires the interplay of tacit knowledge and developed resources, giving teachers time and space to work collaboratively with fellow teachers on crafting the lessons would be a great way forward toward fostering teacher agency and professionalism.

Fig 3. Contexts to consider in scaling education programs
Nevertheless, if we were to argue for this bottom-up approach of scaling with top-down supports (for example, from MOE), policy makers would still want to have a system’s view of what is happening with respect to the various teacher-led, school-led, and system-led innovations grown locally and supported at the various levels of the system. MOE would also want to know quantitative, baseline data. Examples of such data could be as follows:

(1) the number of schools across the system which has these innovations, (2) the kinds of innovations, subject domains, grade levels in which innovations have been implemented, (3) the local spreading that have occurred or otherwise, (4) the number of teachers involved, and (5) the number of local teacher communities. Data for the spread of innovations across school clusters and zones are another example of system-wide quantitative data that are useful for policy makers, and NIE plays a role in providing such data. In other words, quantitative data are needed so top-down supports are created to generate thrust for bottom-up initiatives.

To provide a more concrete example, NIE’s research landscape has constituted an array of teacher/researcher-led and school-led projects (see Fig. 4). NIE does not have system-led projects as yet. Categorizing each innovation into one of the research/teacher-led, teacher/school-led, and school/system-led stages and allowing for natural “growth and spread” of the innovations across various levels of the system (teacher, school, system) may be sufficient to create a diverse and rich culture of innovation in our schools.

- Researcher/teacher-led means that the researchers have worked with teachers to bring basic research ideas into the classroom, for example, Knowledge Building (Ng et al. 2008) and Productive Failure (Kapur 2010).
- Teacher/school-led means that the classroom intervention has moved to the school level.
- School/system-led means that the school’s innovation has spread to other schools (but not to the whole system)
We envisage that the data for scaling or knowing what is happening as far as scaling interventions’ attempts are concerned can be integrated with systems’ wide quantitative, baseline research conducted by NIE and MOE in the future. When we are able to understand local phenomena and spread, we can further optimize the efficiencies and cost effectiveness such that subsequent instantiations can be done more economically, without compromising the core or kernel sufficing standards.

5 Conclusion and future work
Educational settings differ across classrooms and contexts. In the milieu of student-centered pedagogies and designs, the celebration of diversity in student learning and participations is desired. Hence, there is no one-size-fits-all solution for scaling. Instead, we propose an ecological model of scaling. In this proposition paper, we advocate top-down supports for bottom-up initiatives, where flexibilities and adaptivities occur throughout the system with sufficing standards (as largely determined by teacher readiness, leadership supports, and infrastructural adequacies) as target goals at each local instantiation. While celebration of diversity is at local levels, the system keeps tab of this growth and spread of innovations with system’s wide quantitative, baseline data in order to identify gaps, future work, and initiatives needed.
The proposed ecological model of scaling is aligned to the centralized decentralization view adopted in Singapore. Our thesis is to emphasize a balanced approach and create an ecology where centralization enables control and decentralization enables efficiency for scaling innovations. The Singapore education landscape similarly attempts to balance decentralization and centralization to achieve efficiency and effectiveness of governance. Centralization strengthens control over strategic agenda and educational outcomes, while decentralization helps achieve tactical implementation of efficiency (Ng 2013; Tan and Ng 2007). Balance is important because there may be propensity to move away from the existing system in pursuit of diversity and innovation. Rather than moving radically toward a different paradigm, the education system must recognize that what it has achieved is worthwhile (Ng 2008b, 2010). The proposed ecological model of scaling attempts to consider this paradox and be cognizant that any initiative has to be centrally driven and balanced rather than free-flowing and radical.

This paper is insightful for other developing countries to highlight the delicate balance between qualitative and quantitative dimensions; conformity to procedures and diversity.

While we emphasize that we are proposing an ecological model of scaling from a system’s view and attempt to unpack the sufficing standards and structures that may enable different innovations to spread, we are also cognizant that ours is a theoretical model. We acknowledge that scaling innovations are a complex agenda that needs to consider different issues, such as educational policy and implementation, accountability, cultural context, and government-school relationships. Scaling and sustaining innovations are more than just compliant implementation of structures and policies. Structural changes alone are insufficient (Ng 2008a). Thus, it is valuable that the proposed ecological model recognizes both qualitative and quantitative dimensions, top-down and bottom-up efforts. More than just aligning school resources and systemic structures to enable scaling, it is important to empower school leaders to chart direction for teachers. School leaders need to encourage dialog and participation among teachers to generate buy-in and develop teachers’ reflective capacity to delve deeper where sustaining innovations change mindsets and their
approach to education (Ng 2008a). However, these issues are beyond the scope of this proposition paper.

Moving forward, NIE is probably the best place to work among in-service teachers in bringing basic research ideas to the classroom. These could include new areas of learning theories informed by the learning sciences, neural sciences, and others. Taking basic research to the classroom is anything less than straightforward. It involves both researchers and teachers painstakingly implementing these ideas with evidence to support their work trajectories, trail blazing in “messy” classroom situations, till the innovation succeeds.

Qualitative dimensions such as school-based professional learning communities (PLCs) and cluster-based communities of practices (CoPs) can be leveraged to monitor and mentor teachers on their teacher- and school-led pathways. NIE researchers and their innovation/intervention projects should also be integrated into teachers’ existing PLCs and CoPs. Through these partnerships, more concerted efforts can be made to advance 21st century pedagogies and literacies throughout the system.

MOE should be careful not to overly expect system roll-outs to be particularly high in fidelity and to be concerned if perception survey results show that these schemes and initiatives are working well. The tacit nature of educational settings requires time for interventions to take root, and for teachers to experiment and to change pedagogies. We need to acknowledge that teachers believe in what they do, and for very good reasons, and hence change and reform take time. The system should also know the “good work” that is happening at each local level before assuming that change is always for the better. Hence, the need for local and system’s level data is imperative, going forward. Unpacking the sufficing standards at each local instantiation and supporting the spread of educational innovations would be a productive means to enable the system to optimize.

With the above instantiations, and with sufficient time, a natural, healthy ecology, and culture of innovations across schools in Singapore will develop in a gradual, evolving manner. MOE, NIE, and schools will
undertake research and development efforts to further understand and implement the scaling process with a view to leveling up the base of 21st century learning and literacies, for all stakeholders, across the Singapore education system.

References


Appendix A


Appendix A


The National Science Foundation. (2006). Innovative Technology Experiences


Appendix B


Chapter 3

Scaling from the Perspectives of Policymakers and Practitioners from Singapore

David Hung · Shu-Shing Lee · Laik Woon Teh

Abstract

In many countries and regions, education authorities have shown interests in promoting new education initiatives or innovations. With the hefty investments, they are keen to see that their initiatives are well received by the various stakeholders, namely, national leaders, district-level leaders, school leaders, teachers, students and their parents, and can be successfully scaled and improve learning. However, are the perspectives and expectations of policymakers and practitioners with regard to education innovations and their scaling necessarily the same as those of the researchers? Some of these stakeholders may expect a linear model of scaling, i.e. innovations can be translated into ready intervention packages which can be replicated mechanically by all the practitioners and consequently uplifting learning outcomes within the nation. Others may expect extensive adaptation to be allowed for any education innovations accepted for scaling. This chapter describes an eco-logical model for scaling that allows for a productive tension due to the differences in stakeholder perspectives. Based on scaling practices and considerations that operate in Singapore, the lessons about how scaling can be advanced at the systems level, which may be relevant for school districts, regions or countries similar in size to Singapore, are drawn. The paper also attempts to distil underlying scaling principles that can provide some directions to help analyse or shape scaling strategies across a hierarchy of much larger scale levels.
Appendix B

Introduction
Many high-performing education systems are concerned with a change reform agenda, especially towards student-centred pedagogies and away from conventional teacher-centred models. These efforts aim to reach out to all students in the system rather than just disparate change efforts. The Singapore education system has over the last decade invested in classroom research to transform the conditions for how this change occurs, policymakers have been more concerned with how these understandings can be applied to transform the whole system. This chapter describes an ecological model for scaling (Hung et al. 2014) that allows for a productive tension due to the differences in stakeholder perspectives. It also draws on scaling practices and considerations that operate in Singapore from perspectives of Singaporean policymakers and practitioners who are involved in mobilising knowledge, i.e. creating, mediating and utilising knowledge (Hogan 2011; Teh et al. 2013). The underlying scaling principles and heuristics that can provide some directions to help analyse or shape scaling strategies across a hierarchy of much larger scale levels are then surfaced. In the discussion and conclusion sections, we also attempt to delineate the role of research and researchers and that of practice for practitioners and policymakers in this scaling agenda.

Background
Singapore is a small and highly urbanised city state. It has a total population of 5.399 million with a population diversity of 7,540 per sq km in 2013 (Department of Statistics, Singapore 2014). Today, based on the latest official estimates, Chinese, Malays and Indians make up 74, 13 and 9 % of the Singapore resident population, respectively. The remainder is classified as ‘others’, including ‘Eurasians’ (those from European and Asian descent). The diversity and size of the Singapore population are mirrored in its education system. Singapore has a small education system with a relatively short history and an ethnically diverse school population. There are about 180 primary schools (grades 1–6), 170 secondary schools (grades 7–10) and about 20 junior colleges, centralised institutes and specialised schools that offer academic preuniversity curriculum (grades 11–12). All these publicly funded schools employ English language as the medium of instruction and cater to almost all Singaporean students of schoolgoing age.
Prior to 1978, besides English medium schools, there were vernacular schools where lessons were taught primarily in Chinese, Malay and Tamil. Today, all the publicly funded schools are organised into 28 school clusters, each with 12–14 schools. Each cluster is headed by a cluster superintendent who supervises and advises the school principals. Currently, principals have substantial autonomy in managing the learning programme of the schools within the Ministry of Education (MOE), Singapore guidelines.

Even after three decades of reorganisation, rationalisation, consolidation and reformation, the Singapore education system remains highly centralised and regulated (Gopinathan 1985; Hogan and Gopinathan 2008). Its instructional system has been honed to a level that maximises efficiency and minimises costs. In spite of (or perhaps because of) Singapore’s success in international studies such as the Progress in International Reading Literacy Study (PIRLS), the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), since the late 1990s, Singapore has stepped up the refining and reforming of its education system since the late 1990s. In 1997, then Prime Minister Goh Chok Tong announced that:

_The old formulae for success are unlikely to prepare our young for the new circumstances and new problems they will face … we must ensure that that our young can think for themselves, so that the next generation can find their own solutions to whatever new problems they may face._ (Goh 1997)

Since the launch of Thinking Schools, Learning Nation (TSLN) in 1997, educational policy in Singapore has been dominated at the broadest level by a vision of ‘a nation of thinking and committed citizens capable of meeting the challenges of the future, and an education system geared to the needs of the 21st century’ (Dimmock and Goh 2011). In 2011, Singapore Ministry of Education further articulated its vision for education being values driven and student centric (Heng 2011). With an increasing shift made towards soft skills, dispositions and student-centred pedagogies, teachers are encouraged to innovate and embrace interventions to meet their students’ needs. Nevertheless, this strive
for innovations in Singapore is undertaken in a context where there is a more ‘tightly coupled’ system of instructional governance than many other systems (Hogan and Gopinathan 2008; Hogan 2011).

**Scaling and Translation Research: From Medical to Educational Fields**

Scaling and translation of a successful laboratory experiment is one of the typical approaches policymakers in all sectors (e.g. public, non-profit, private and commercial) considered first when they wanted to improve practice at the systems level. Most policymakers also typically assumed that a traditional replication perspective is an appropriate one to adopt to achieve scaling. For example, it has been a common practice for policymakers in the education sector to attempt to focus on replicating the infrastructure, materials and procedures of interventions which work in one setting to others. The assumption appears to be that translational work can be centrally planned. That is all the permutations of curricular materials and forms of teacher preparation can be tested and planned in a relatively controlled environment. This optimised package can then be organised and subsequently rolled out across the entire school system. Unfortunately many roll-outs have resulted in teachers’ lack of agency on the ground in local classrooms and an insufficient emphasis on understanding teachers’ own practices in lieu of the centrally advocated programme (Glennan et al. 2004; Peurach and Glazer 2012). The outcomes of traditional replications have been, in most cases, discouraging.

This underlying assumption is aligned to the scaling and translation practice in the natural sciences, including that of the medical field (see Fig. 3.1), where research to everyday practices follows largely a linear and staged process (Woolf 2009). Stage 1 of translational research (T1) focuses on testing in laboratory settings with the aim of developing new methods for diagnosis, therapy and prevention. In T1 research, clinical and medical scientists are working in laboratories with supportive infrastructures within the institution. This research occurs in community and ambulatory settings. The Institute of Medicine’s Clinical Research Roundtable states that stage 2 of translational research (T2) is about translating results from clinical studies into clinical practice and decision-making (Sung et al. 2003).
In T2, research moves out of the laboratory into real-world settings. This is the first attempt to bring T1 research to public settings and contexts. T2 research yields knowledge about efficacy of intervention in various controlled real-world settings. It focuses on how infrastructure, resource constraints, human behaviour and organisational issues affect the efficacy of interventions. It begins to recognise that translating interventions is a socially complex phenomenon. Stage 3 of translational research (T3) is about disseminating the intervention from controlled real-world settings to the general population. In T3, researchers explore ways to apply recommendations into everyday practices (Westfall et al. 2007). The focus here is on how interventions work in real-world settings.

Medical research, as described from these stages, moves linearly from laboratory to mass market. Within the T1, T2 or T3 stages, innovations
are adjusted and refined, and only those that achieve ‘gold standard’

Appendix B

can progress to the next stage and to be scaled up subsequently. This
dominant thinking is also found in major funding pro- grammes such as
the i3 (Innovation through Institutional Integration) model of the National
Science Foundation (NSF) (The National Science Foundation 2006).

Although different educational studies have discussed what ‘scaling’
means and what it entails (e.g. Klinger et al. 2013; Fullan 2000; Coburn
2003; Hargreaves and Fink 2000; Bocconi et al. 2013), we posit that
the underlying unstated assumptions which undergird many actual
attempts of scaling by many governments remain characterised by a
linearity towards diffusing an innovation from one context to the masses
(Klinger et al. 2013; Sternberg et al. 2006). Such a construal aligns
itself with the ‘gold standard’ dissemination approach within medical
sciences, perceiving continuities and assuming trivial irregularities
when diffusing innovations across contexts. In precluding the complex
behavioural world of education and its attendant to ‘context-dependent
interaction effects and insubstantial correlations among events’
(Shweder 1980, p. 77), we argue that linear models of scaling remain
inadequate in addressing (1) the variability when foregrounding student-
centred processes, (2) the dynamic interrelations and social context
complexities in educa- tion settings and (3) a systemic perspective in
making meaning of how the scaling of education innovations may be
made more expansive and widespread.

Variability When Foregrounding Student-Centred Processes

In the twenty-first-century learning, much of the focus is on cultivating
student-centred process in learning such as inquiry and knowledge
building. Student-centred processes thus ensure substantial variability
in learning situations, and this makes the adoption of a ‘one-size-fits-
all’ form of instruction untenable. Based on this assumption, we posit
that attempts to scale, if consistent to student centeredness, should not
be mere replications of the goals, structures and procedures from the
original intervention, but substantial and meaningful variations should
be allowed to occur based on differences in student profiles, curriculum,
teacher dispositions and others. Nevertheless, to maintain the integrity
and identity of the innovation, the core design principles or the kernels
of the intervention should be upheld.
Dynamic Relations and Context Complexities: Imperative Tacit Knowledge in Education Settings

In the medical field, research starts in laboratories in a context vastly different and abstracted from the real world where a successful product will be consumed. Transfer of innovations to everyday practices is fixed on a set of procedures. In educational science, the social context is more complicated (Clarke and Dede 2009), characterised by interrelations between not only teachers and students but also researchers, administrators and other stakeholders, at the local, regional and national levels. The education environment is inherently varied and socially messy because learning is a sociocultural process (Beach 1999). Conceptualising the scaling agenda in such dynamic interactions between teachers, students and the situated context where learning and instruction arise necessitates a focus on tacit knowledge (Polanyi 1967; Murnane and Nelson 1984; Nonaka and Takeuchi 1995; Hargreaves 2000; Fullan et al. 2006) that will shift dimensions of abstracted learning akin to abstracted laboratory procedures into contextualising and authenticating knowledge applications to real-world settings. We argue that the linear models of scaling, moving from laboratory to the mass market through T1, T2 and T3 processes, remain perfunctory to the importance of tacit knowledge in education settings. The assumption that figuring out what worked there and then for the others is the best, or perhaps the only, way to find out what is most likely to work for me here and now is probably a lot less valid in the twenty-first-century education setting.

The process of large-scale adoption of innovations is concerned, therefore, not simply about ‘rubber stamping’ the same programme into multiple contexts but on empowering teachers in the design process of student-centred lessons, fitting and adapting for local circumstances (Barab and Luehmann 2003) and others. There is not just one model for successful implementation – there are probably as many models as there are the unique contexts (Wylie 2008). The articulation of a number of core design principles or kernels, or explicit knowledge, that are relevant in these contexts will nevertheless heighten the likelihood of the teachers internalising these principles into their practice (e.g. tacit knowledge) and successfully designing effective learning experience for their students.
Appendix B

An Expanded Conception of ‘Scale’

Considerations of ‘scale’ are therefore a key challenge for education reform. Definitions have traditionally been focused on an innovation-oriented perspective that emphasises the expanding number of schools or quantitative dimensions reached by an intervention or innovation. There are, however, complex challenges of reaching out broadly while simultaneously cultivating the depth of change necessary to support and sustain consequential change. Coburn (2003), Dede (2006) and Clarke and Dede (2009) contribute to an expanded conception of scale that has five interrelated dimensions: depth, sustainability, spread, shift and evolution in reform ownership to the teacher and school. To elaborate:

• Depth looks at the nature or degree of change, whether change is effected by the organisation’s beliefs, whether individual beliefs and thereafter practices have evolved or whether these changes are merely superficial.

• Sustainability is about endurance: how long will the change endure and what strategies are in place to assure sustainability of the change.

• Ownership is the attempt to shift reform ownership in terms of knowledge and authority to implementers, the schools who should ultimately 'own' the process.

• Evolution is about how users’ adaptations for the innovation in localised contexts can be learned and used in rethinking the innovation’s design model.

We see the first three dimensions of scale as focusing on the explicit spread and reach from an innovation-oriented, local-project instantiation point of view and the next two dimensions as more aligned to a system-wide perspective as it requires a genuine understanding and internalisation of the innovation and the knowledge associated with it, from explicit to tacit, which involves an inherently more complex and non-linear process. Scaling from a system-wide perspective must therefore make considerations about the issue of ownership and evolution as the core of the scaling effort, and not as an afterthought,
that is pursued after the first three dimensions of scaling have been secured. We note, however, that all the above criteria are important when considering local-level interventions at respective schools.

**An Ecological Model: Non-linear Approach to Educational Scaling**

Given the above discussion, we would like to introduce a non-linear scaling model where innovations that are analogous to those conceptualised in medical research, of T1, T2 and T3 stages, can take place without a specific order (see Fig. 3.2). This non-linear model is appropriate because in most of the education interventions, unlike the medical model, the path towards a greater adoption of educational innovation is complex and cannot be assumed to be linear. The model stresses that educational scaling is not just about scaling the innovation to the masses (explicit knowledge). It is essential to develop school cultures and build teacher capacity (tacit knowledge) to take ownership and sustain the innovations in practice. Educational scaling is an organic evolution, balanced approach where top-down (centralised) structures are available to scale innovations to school-wide and system-wide levels. Yet, structures are loose enough to enable teachers to initiate and adapt innovations for their contexts (i.e. decentralised innovations).

![Fig 3.2 Non-linear model of educational scaling](image)

A more detailed description of this model is given in Hung et al. (2014). The essence of this ecological model is that instead of viewing stages, which are analogous to those conceptualised in medical research, of T1, T2 and T3 as stages to be enacted linearly, we reframe:
Appendix B

- **T1 as Tb** – teacher oriented (innovation units are at the teacher level)
- **T2 as Tc** – school oriented (innovation units are at the school level)
- **T3 asTd** – system oriented (innovation units are at the system level)

Teachers and researchers can also take a theoretical idea (Ta) and work around it in classroom (or equivalent) settings and these become Tb (teacher-oriented) innovations. More importantly, all four types of innovations must happen concurrently for a healthy ecology to occur in any education landscape. Growth and spread of innovations happen locally, and the state of play can be understood according to Coburn’s (2003) and Dede’s (2006) frameworks and criteria. See Table 3.1.

Consistent to this ecological model, we attempt to describe the roles and levels of innovations to enable a healthy ecology for innovations to be scaled throughout the system.

<table>
<thead>
<tr>
<th>Role in ecology</th>
<th>Level of innovation</th>
<th>Description of the innovations’ spread</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Seeding’/populating bottom-up innovations</td>
<td>Teacher-oriented/ supported innovations</td>
<td>Translating learning theories into classroom practice</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ownership shifts from researcher to teacher or shared by both</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Innovation is driven by teacher’s initiatives, for example, action research</td>
</tr>
<tr>
<td>‘Spreading’/growing innovations from teacher to school level</td>
<td>School-oriented/ supported innovations</td>
<td>Diffusing teacher-led innovations to the school-wide level</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Creation of school’s microcultures for sustaining the innovation</td>
</tr>
<tr>
<td>‘Dispersing’ innovations to more schools with system supports</td>
<td>System-oriented/ supported innovations</td>
<td>An innovation that is successfully adopted by several schools to system-wide diffusion</td>
</tr>
<tr>
<td></td>
<td></td>
<td>System structures considering both the innovation’s characteristics and school profiles are needed to ascertain support and resources needed</td>
</tr>
<tr>
<td></td>
<td></td>
<td>System-wide dispersals should be kept to a minimal, for example, basic literacies</td>
</tr>
</tbody>
</table>

**Table 3.1 Growth of innovations**
Appendix B

Teacher-Oriented Innovations (Tb)
There is a need to acknowledge that innovations have varying levels of complexities and therefore ‘flourish’ under different conditions with various structural supports. Teacher-oriented innovations (Tb) are usually simple interventions that can be easily adopted with available resources. Teachers develop contextualised understandings as they enact the innovations. Those that can more easily spread and scale would be those that have an established and socially accepted core kernel design. When such innovations are implemented in different situations, the resources are well disseminated and the sociality of teachers is built around it, such as professional learning communities (PLCs) or communities of practices (CoPs), we can expect more of such innovations to be taken up by teachers for implementation in their classrooms.

School-Oriented Innovations (Tc)
There are currently a considerable number of teacher-oriented projects (with researchers’ support) populated throughout the Singapore education system, for example, java simulation design for teaching and learning (eduLab 2010). Some projects have been more successful in spreading across different classrooms and moving towards a school-oriented innovation while others have been less successful. This could be due to the complexity of the innovation and the readiness of teachers. As school-oriented innovations are happening on a larger scale, they require additional support and structures, such as resources, technical expertise, funding and more professional development for teachers. School-oriented structures from school leaders or management are needed to create the school’s culture for sustaining innovations (Mulford 2003).

We posit that Singapore (with collaboration between Ministry of Education, MOE, Singapore, and National Institute of Education, NIE, Singapore) stand ready to engage teachers to spread these teacher-led innovations across schools. We envisage that innovations that are less complex would require less support. To a certain extent, if the sociality built around the innovation is strong, the innovation could continue to grow. Of course, if school-based supports are given, the spreading could happen more quickly at the school-wide and
Appendix B

across school levels. We refer to these as school-oriented or school-supported projects (see Fig. 3.2).

Singapore also recognises that more complex innovations could require higher levels of support to enable it to spread. Such innovations would require the commitment of schools and principals to rally school-based support from more teachers and to make resources available in order to better support such innovations to grow. Likewise, school principals who opt to undertake these more challenging innovations will be supported by MOE and partnered with NIE researchers (in specific instances). Given the more complex nature of these projects, a richer partnership is envisaged.

System-Oriented Innovations (Td)

Another kind of innovation could be for projects that grew from teacher levels or school levels to system-wide levels. This would also include projects or initiatives that MOE initiates which are intended to be implemented system wide and/or intended to have system-wide impact. Appropriate system structures considering both the innovation’s characteristics and school profiles are needed when working towards system-wide diffusion. Ideally, system-oriented supports are provided by MOE because schools may find it difficult to collaborate and tackle complexities of the innovation at the system’s level of scale. To ensure teacher ownership, sustainability and evolution, system-oriented innovations must be adaptive so that they can be locally relevant and meet local needs without changing principles underpinning the kernel of the innovations.

With the three types of innovations (teacher-, school- and system-oriented innovations) populated across the system, we envisage that as teachers and schools adopt, adapt and implement innovations (with MOE’s continued support and other school-based structures), local cultures of innovation would be nurtured. Due to the complexity of innovations and the nature of support required, it would be reasonable to expect an education landscape that is populated with more teacher-oriented (Tb) and school-oriented (Tc) innovations than of system-oriented (Td) initiatives, especially in the milieu of student-centred pedagogies. The more radical and complex and less well defined the
innovation is compared to conventional practices, the greater the need for local instantiation and spread in order to develop and cultivate the tacit knowledge underpinnings of the innovation.

As change, growth and eventual impact of innovations to the community would be gradual, an evolutionary rather than a radical change process should be expected. With this organic approach, teachers and schools can begin the scaling adoption at different starting points. Teacher-oriented innovations relate to experimentations at the local (classroom) level in small instantiations. The focus of these innovations relates to the identification and contextualisation of innovations to meet students’ needs and address issues in classrooms, especially of student-centred pedagogies and designs. Teachers work collectively towards refining innovations, identifying the core/kernel principles and building teaching resources that allow innovations to be implemented in classrooms. Through experimentations and consistent dialoguing, teachers may begin to adapt innovations for use with their own students in different classroom contexts. Teacher-oriented (Tb) innovations and experimentations could grow to influence more people in various local situations. In other words, teacher-oriented (Tb) innovations could be scaled locally to include more subjects, classes and different student profiles and result in eventual ‘promotion’ to school-oriented (Tc) status. Spreading from teacher-led to school-supported status, implementation efforts are locally driven and emerged. These innovations could subsequently be taken up by MOE, and these could be provided with financial and infrastructural supports to ensure innovations’ spread and sustenance with greater efficiencies. As such, these efforts could eventually be system-oriented innovations (Td). Examples of these Td innovations could include the levelling up of the base of core literacies in order to bridge achievement gaps or when local growth models may be too slow for certain policy priorities.

In summary, these are the growth trajectories:

Criteria based on the level that the kernel operates at and not who it is led.

1. Ta → Tb (teacher oriented or supported) – experimentation of theoretical ideas at the local level in a small instantiation.
2. Tb→Tc (school oriented or supported) – Tb experimentation grows and influences more people and in variant local situations in schools, such as increased number of subjects or with different student profiles. These efforts are ‘locally’ school driven or emerged.

3. Tc→Td (system-oriented or supported) – expansions on Tc are encouraged and cultivated further with some structural supports from ‘outside’ the local community, such as system supports.

In other words, to ascertain the degree through which policymakers can decide whether supports should be given to the above efforts in order to proceed to the next steps, indicators such as evidence of teacher uptake, the availability of infrastructure and whether the kernel core idea has been increasingly moved from tacit to explicit forms of knowledge and understanding as existing amongst the teachers in the community need to be shown (see Table 3.2).

<table>
<thead>
<tr>
<th>Level of innovation</th>
<th>Criteria for supporting innovation to the next step</th>
</tr>
</thead>
<tbody>
<tr>
<td>System-oriented/ supported innovations</td>
<td>Innovation is fundamental that all students in the system can benefit</td>
</tr>
<tr>
<td></td>
<td>Tacit knowledge can be translated to explicit knowledge</td>
</tr>
<tr>
<td></td>
<td>Teachers are generally ready</td>
</tr>
<tr>
<td></td>
<td>Infrastructure is available</td>
</tr>
<tr>
<td>School-oriented/supported innovations</td>
<td>School supports with infrastructure</td>
</tr>
<tr>
<td></td>
<td>School leadership has provided resources and time for teachers to redesign curriculum</td>
</tr>
<tr>
<td></td>
<td>Trust has been established between school leaders and teachers</td>
</tr>
<tr>
<td></td>
<td>Other teachers from school commit to the innovation</td>
</tr>
<tr>
<td></td>
<td>Teachers from other schools join in community</td>
</tr>
</tbody>
</table>

Table 3.2 Supporting criteria for taking projects to the next steps

Discussion

**Instead of ‘Gold Standard’, Scaling Can Begin When Conditions Are ‘Sufficing’**

One fundamental difference between conceptualising the spreading of innovations in ecological ways and not purely a mechanistic way is that we do not seek to ask if a ‘gold standard’ has been achieved before allowing for the spread to occur. Instead, besides having established the evidence that the innovation can deliver the learning outcomes that
Appendix B

it is designed to achieve at the classroom, school and system level, we also seek to ask if the teachers are enthused, committed and ready about the innovations and if the teachers are able to take innovations to their respective classrooms (or equivalent) and implement the core ideas or kernel of that intervention/innovation. Moreover, are resources to support these subsequent take-ups available, or can they be mobilised at the school, cluster or MOE levels to support the spreading? Are school leaders willing to support these teachers to experiment and permit possible implementation gaps to happen, if any? And are teachers able to collect evidence-based data for their experimentation to exemplify some form of rigour and monitor their experimentation?

We connote the above questions as important to the issues around a sufficing standard for spreading of innovations, rather than a gold standard. Some possible indicators of spread could be the adoption of school-led innovations by other schools, an increasing community of teachers involved around an innovation, more dialogue and sharing between schools and others.

To reiterate, the use of ‘sufficing’ standard as opposed to ‘gold’ standard is adopted and argued for here to shift the focus away from expecting and deriving a par excellence model which can be considered ripe and optimal as a gold standard to be rolled out to the system at large. This is because, given the substantial varying and evolving environment and context, even if a ‘gold standard’ can be identified there and then (and many will argue otherwise), it is not likely to be the ‘gold standard’ for here and now. In this shift towards a sufficing standard, we underscore that the thinking of policymakers should shift closer to that of understanding how to support teacher, school and system innovations (i.e. to build up the tacit knowledge within the system) rather than the conventional notion of focusing solely on achieving a gold standard (i.e. explicit knowledge) and replicating this system wide.

In the next phase of the Singapore education system’s focuses on student centeredness, there will be a shift towards enabling teacher-oriented pedagogical innovations and local instantiations in schools to support the spread of education innovations. The Singapore education
system will therefore need to deepen the culture of trust that lets teachers engage in pedagogical innovations as well as develop tacit and explicit knowledge of designing and enacting student-centred curriculum.

Supporting local instantiations would also mean enabling school leaders with the autonomy to provide time and resources to teachers, developing a culture of trust that encourages teachers to experiment and do what is of value to students, building teacher communities to enable professional growth and to initiate and sustain pedagogical innovations and providing recognition to teachers who overcome tensions – such as teaching according to the prescribed syllabus and yet be innovative in their pedagogies. These five critical dimensions (see Fig. 3.3) must be present for an innovation journey to continue.

![Fig 3.3 Tenets for supporting teachers](image)

**‘Mechanical’ and ‘Organic’ Scaling Can Coexist in an Ecological Model of Scaling**

Policymakers usually look at an issue more so from the system’s level and less at the individual student, teacher or school levels. They are more likely to ask ‘how can innovations be spread throughout my system’ and less to ask ‘what are the orientations of the innovations that can be spread’. From the perspective of ecological model of scaling, we argue
that a system that has a healthy ecology of innovations must have a good spread of teacher-oriented, school-oriented and system-oriented innovations and must support both ‘mechanical’ and ‘organic’ scaling.

By ‘mechanical scaling’, we are referring to the more traditional replication perspective of scaling which was discussed earlier. Such a scaling approach is appropriate when, across all schools in the system, (a) the tacit knowledge to be developed and understood amongst teachers has been or can be readily codified, (b) the readiness of the teachers to enact the innovation has been or can be readily enhanced, (c) the infrastructure that is required to support the innovation has been or can be made available and (d) the innovation is so fundamental that all students in the system can benefit. Given that system-level instantiations of innovation will entail substantial transaction costs, a system is only likely to accommodate a small number of ‘mechanically’ scaled innovations, and hence these innovations have to be carefully selected based on benefits and costs considerations.

While the system cannot accommodate too many ‘mechanical’ scaling efforts, within a system there will always be room for individual or groups of schools, classrooms or teachers to try out new interventions and to spread these intervention ‘organically’, i.e. without following a centrally prescribed plan. The ‘organic’ scaling strategy is one that allows teachers the time and space to decide if an innovation is appropriate for his/her classrooms and schools and to develop the skill sets and mind sets to enact the innovation. ‘Organic’ scaling is therefore appropriate for innovations which are not yet ready for ‘mechanical’ scaling (i.e. in the absence of all the four above-mentioned criteria), but these innovations may nevertheless be efficacious in addressing classroom or school problems locally. The kernel of an innovation appropriate for ‘organic’ scaling is therefore less likely to have been clearly explicated, and the support needed for teachers to enact these innovations successful is less readily available. The organic spread of such innovations takes place when teachers or schools share them in network or collaborative learning situations (e.g. PLCs). Besides spreading innovations from one site to another, another important reason why ‘organic’ scaling should be promoted is because
‘organic’ scaling is an effective way of fostering teacher agency and professionalism and of preparing them for successful ‘mechanical’ scaling when the circumstances permit.

**The Role of Researchers and Policymakers**

If we accept the ecological framework of scaling as discussed above, we begin to recognise that for an education system to be successfully innovative, it must necessarily promote a more organic bottom-up scaling process with appropriate supports, because ‘organic’ scaling not only encourages teacher-oriented and school-oriented innovations, but it also lays the ground for successful system-oriented innovations and accelerates ‘mechanical’ scaling.

Researchers therefore play at least three roles in an ecological scaling model. First, as in mechanistic scaling, researchers must engage in research to discover theories, translate the theories into interventions and test them in controlled experimentations. Successful examples can then be ‘mechanically’ scaled out subsequently to practitioners if the above-mentioned criteria are met. Second, as in organic scaling which is necessarily ground up, the researchers are also expected to engage in equal partnership with practitioners to improve the teacher-oriented and school-oriented interventions in local instantiations and to support practitioners in incorporating innovations into daily practices and deliberately supporting the shifting of ownership of an intervention to more practitioners. This second role is important for an innovation to spread ‘organically’. To play the latter role effectively, researchers can be more proactively involved in the professional learning communities (PLCs) and communities of practice (CoPs) existing in the school system. The third role of the researchers, besides directly involved in designing and spreading innovations, is to study the patterns of growth, spread and implementation of innovations from a systems perspective, so as to improve the effectiveness of scaling. This role is more appropriate for researchers than for practitioners because the former have generally broader exposure to a variety of contexts and innovations, which is opposed to the deep local knowledge that is the definitive strength of practitioners. Research of this nature will not only collect baseline data that provides policymakers with a systems view of the progress made through (the ecological approach of) scaling, it
will also develop the models, frameworks and criteria for supporting the various kinds and levels of scaling or for deciding whether an innovation is ready to progress to the next phase.

While the above-mentioned roles played by researchers are important to the successful scaling of an innovation, it is important for policymakers and practitioners to recognise that researchers are usually not in the best position to lead scaling efforts, neither is it normally the mandate of researchers to lead scaling. Of course, there will be exceptions when individual researchers, who are well connected, can mobilise resources from different level, have an intuitive deep understanding of the needs and reality of classrooms and schools, are passionate for ground work and can lead scaling work. However, these are exceptions rather than the norm. Furthermore, once these researchers embrace the scaling of an innovation as their primary mission, it can then be argued that they are no longer playing the role of a researcher.

Regardless of the above, the importance of researchers as members of a cross-functional scaling team cannot be overstated. If the primary role of researchers is to create theories and translate these theories into interventions and the primary role of practitioners is to incorporate these interventions into professional practices to improve learning and teaching, then the role to ensure that interventions are scaled across the system must belong to the ‘policymakers’. In this paper, we consider ‘policymakers’ broadly to include both senior political leaders who direct and chart broad education policies and more junior policy officers who interpret these policies and design and implement programmes based on these policies. To optimise the chance for successful ‘organic’ scaling, policymakers’ role is to provide proscriptively (or loosely) supporting conditions for teacher-oriented and school-oriented innovation to seed, grow and spread. These conditions include engendering a vision amongst all stakeholders to initiate or catalyse the momentum for teachers and schools to embrace local innovations, making available resources (e.g. time, materials, manpower) to support and sustain locally instantiated teacher-oriented and school-oriented innovations and playing the important ‘boundary spanning’ (Tushman 1977) role which includes cushioning and protecting teachers and
schools from the unnecessarily external interferences which may disrupt or corrupt the innovation.

In addition to the above, to enact ‘mechanic’ scaling which requires even more deliberate coordination, policymakers will need to do even more. They will need to facilitate informed dialogue amongst all stakeholders (including researchers, practitioners and the public) to establish a shared understanding of the key problems facing the system so as to mobilise resources to research into and develop innovations and to spread these innovations across the system to resolve these problems.

This dialogue will significantly heighten the likelihood of any new knowledge, and the innovations derived from the knowledge, produced and developed to be meaningfully adopted and used by practitioners across the system through ‘mechanical scaling’. This is because such shared understanding is needed to shift the more prevalent supply-driven Mode 1 knowledge production to the demand-driven Mode 2 knowledge production more relevant to practice (Gibbons et al. 1994). Second, the policymakers must put in place a system-wide education knowledge base to capture not only rich and robust baseline data that comprehensively describes the status of teaching and learning in classrooms and schools within the system; this knowledge base must also capture the codification and verification of expert knowledge of teachers who responded to the challenges in classrooms and schools. Finally, with the support of the education knowledge base, the policymakers must identify a shortlist of interventions that can address the key challenges facing the system and have the best chance of being sustained by the system. They must also mobilise the resources and the supports of the various stakeholders to scale/implement them across the system.

**Conclusion**

Educational settings differ across classrooms and contexts. In the past, when resources were wanting and when teachers were less prepared, Singapore embraced a more traditional ‘mechanical’ scaling approach to spread innovations across the system. This probably contributed to the substantial improvement in learning and teaching and in student performance in international studies that occurred between the mid- to late-1990s (Teh 2014). As the Singapore education system develops
further, more and more attempts are made to more ‘organically’ scale innovative pedagogies that emphasise student-centric learning and diverse learning outcomes. Singapore’s Teach Less, Learn More initiative is one obvious example (MOE 2008). In a natural fashion, not all innovations attempted by the schools will succeed and scale. However, that does not mean these attempts are unproductive because valuable lessons can be learnt by teachers, researchers and policymakers to enable future instantiations. Such initiatives also help develop a culture of trust and experimentation amongst students, parents, teachers, researchers and policymakers that education endeavours which do not yield immediate measurable results can be critical and productive. This also empowers teachers to do what they think is profession-ally needed to develop students to the fullest potential, and such professionalism is key to any successful adoption and adaptation of student-centric innovations, whether through ‘organic’ or ‘mechanical’ scaling.

What we have described above are some experience of and considerations for the scaling of innovations across classrooms and schools of Singapore. We are keenly aware that Singapore is a highly urbanised East Asian city state with a centralised education system that is characterised by its ‘tightly coupled’ instructional governance. What is sensible for Singapore may therefore not work for other systems which are contextually different. Nevertheless, we believe that some principles could be distilled from Singapore’s experience and these principles could be relevant to other systems.

First, in the milieu of student-centred pedagogies and designs, Singapore has recognised that the celebrations of diversity in student learning and participations are highly desired. If Singapore, which is more centralised, tightly coupled and strategically aligned in terms of policy, research and practice than many other systems, is reasonable in recognising that one-size-fits-all solution for education challenges is hard to come by, then it is the quest for ‘silver bullets’ of other larger and more loosely coupled jurisdictions ought to be substantially more difficult. Hence, we believe that it is important for education systems which strive to promote and enhance the quality of student-centric learning, and teaching should invest substantially on structures to
provide top-down support for bottom-up (i.e. classroom and school) initiatives and innovations to address local problems. Support provided would include opportunities for teacher learning to enhance teacher readiness, empowerment for school leadership to support local initiatives and infrastructural and material support to sustain local innovations. More importantly, while there is celebration of diversity at local levels, the system has to keep tab of the growth and spread of innovations with systems’ data in order to identify gaps or concerns where nudging is necessary for some localities and to identify if future work and initiatives are needed.

Second, the experience in Singapore as in other systems shows that the tacit nature and rich interactions of educational settings require time for interventions to take root, for teachers to experiment and change pedagogies, if the interventions are to be deep and sustained, and for the practitioners to take over the ownership. The system must therefore acknowledge that teachers need to believe in what they do, for very good reasons, and hence genuine and meaningful change and reform take time. Even with the trust that teachers and schools are doing what they should, the system should still closely monitor what is happening at each local level before assuming that rolling out interventions will result in change and that change is always for the better. This monitoring must be systematic and as nonintrusive as possible. In Singapore, this is carried through the baseline data collected by NIE’s Core Research Programme funded by Singapore Ministry of Education (see Hogan 2007, 2011; Hogan et al. 2013). We would therefore like to argue the merit for the other systems to also invest in the collection of local- and system-level data so that the system, as well as the subunits, can continually and critically reflect on issues related to scaling and spreading of innovations to improve education practice based on rigorous and valid data of what happens in classrooms and schools. The collected data will also allow the unpacking of the sufficing standards at each local instantiation and of the supporting structures necessary for moving an innovation to the next level.

Third, the ecological model, proposed in this chapter, is informed by the need for continuous iteration and responsiveness to the ground, yet envisioned by consensual need for progressive changes in specific directions. This model is largely based on Singapore’s
experience of experimenting with scaling over the last few decades
As belaboured before, one of the most distinguishing features of
Singapore is its small size and the small number of key actors amongst
policymakers, researchers and practitioners. The ‘smallness’ creates
opportunities for these actors to develop a broad understanding of the
institutional imperatives and interests of multiple stakeholder groups.
This substantially facilitates the alignment of institutional goals and
practices. We believe that this strategic alignment is a critical factor
of successful scaling efforts, especially of ‘mechanical’ scaling which
requires substantially more system-level transactions, coordination and
trusts across multiple parties and multiple stakeholders groups.

Because of our experience (both success and failure, but more the
latter) in scaling innovations, we are inclined to believe that it will be
significantly more difficult to establish such a level of alignment in a
system that is substantially larger than Singapore. Hence, a possible
approach of applying the proposed ecological model of scaling to an
education system that is larger in size is to consider it as a collective of
relatively autonomous sub-ecological systems, say, innovation zones
that comprise about a few hundred schools each. The boundary of
these innovation zones (e.g. school districts, education authorities)
should be co-constructed by the stakeholders (especially the local
actors) so that there are geographical, social, historical and educational
similarities within the zones, as these similarities are crucial in
facilitating the forging of the above-mentioned strategic alignment.
Each innovation zone should then be empowered and supported by
the higher jurisdiction(s) to enact its own ‘mechanical’ and ‘organic’
scaling efforts and to promote a healthy ecology of teacher-oriented,
school-oriented and system-oriented innovations within each innovation
zone. We hypothesise that allowing these innovation zones, within a
larger jurisdiction, to autonomously scale innovations is more likely
to be productive than trying to dictate a rigidly defined scaling policy
throughout this jurisdiction in the absence of strategic alignment
between policy, research and practice.

References
curriculum: Acknowledging and accommodating local adaptation. Science


Appendix B


Appendix B


