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An Ecological Model for Scaling and Translation: Maximizing the impact of Research and Development Interventions

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Abstract: Scaling and translation constitutes essential challenges for educational fields. Gold standards are not possible in education because student-centered processes assume variability in different situations rather than adopting a 'one-size fits all' form of instruction. This paper proposes a more nuanced ecological model to describe the scaling efforts of educational innovation within the Singapore context. In this model, innovations "flourish" under different conditions with various structural supports depending on their complexity. The spreading of educational innovations from a centralized agency would be limited. Instead, teacher/researcher-led and school-led innovations would be encouraged and supported throughout the system. By going through multiple local instantiations of innovations, efficiency and cost effectively issues are addressed and teacher agency is nurtured through professional learning communities and communities of practice. System-wide baseline data is encouraged to keep tab of the growth and spread of innovations, identify gaps, and recognize areas where nudging and further supports are needed.

Keywords: Scaling and Translation, Golden Standard, Sufficing Standard

1. Introduction

The education research funding in Singapore spans two time periods (2002-2007, 2008-2012) accumulating to an approximate amount of 150 million Singapore dollars. In the first period (2002-2007), the budget from the Ministry of Education, Singapore (MOE) focused on establishing research centers at the National Institute of Education (NIE). Another goal was to change and enact new pedagogies; focusing 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 had begun to play an inevitable role in the change-reform process. These research efforts brought about various successful educational innovations, such as Group Scribbles (Chen and Looi 2011), Seamless Learning (Wong and Looi 2011), Productive Failure (Kapur 2010), in schools. These examples and many others, both from MOE and NIE, have laid the foundation for a rich and diverse culture of innovation in the schools and across the Singapore education system. Furthermore, it has also enabled the recognition of Singapore's educational innovations amongst international research communities, practitioners, and policy makers.

With a relatively large investment on research in the last decade, the development of educational innovations in the Singapore context has reached a stage where some fundamental and pragmatic questions are raised:

- How do we "repeat" or "replicate" successful implementations of educational innovations, albeit not necessarily in identical ways, but in more economical and efficient ways?
- How can some "top down" support be provided for bottom up (researchers and teachers initiated) innovations to enable more efficiencies and cost effectiveness, and hence spread the benefits of research to other schools?

This paper proposes to address the above two questions by first arguing that the idea of "replication" is problematic to educational translation and scaling. Second, the paper proposes a way forward focused on the provision of a more nuanced ecological model, which we argue applies to

education, to describe the scaling efforts in the Singapore education landscape as exemplified by various types of existing research projects from NIE.

2. Scaling and Translation Research: From Medical to Educational Fields

2.1 Linear Modes of Scaling and Translation

In the natural sciences, including that of the medical field (see Figure 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 with the aim of developing new methods for diagnosis, therapy and prevention (Woolf 2009). In T1 research, clinical 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 translation 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. 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. 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, Mold, and Fagnan 2007). The focus here is on how interventions work in real world settings. Medical research, as described from the stages, moved linearly from the laboratory to the mass market. The default model is to look for a 'gold standard' of an innovation and bring this through the T1, T2, and T3 processes. 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 Figure 1.

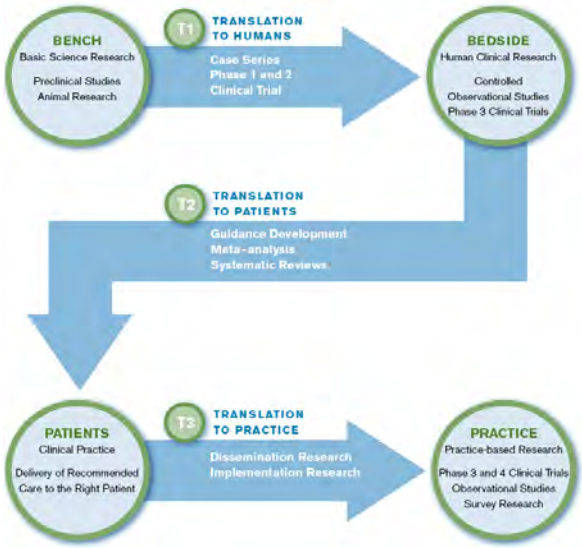

Figure 1. Linear translation model in medical research (University of Miami, 2013).

Linear models that assume replicating a gold standard are challenged for their appropriateness in education. Different educational studies discuss what "scaling" means and what it entails (see for instance, Klinger et.al, 2013; Fullan 2000; Coburn 2003; Hargreaves and Fink 2000; Bocconi, Kampylis and Punie 2013). On the surface, scaling as defined in education seems to bear some resemblance to the medical sciences -- scaling is about diffusing an innovation from one context to the masses (Klinger et al. 2013; Sternberg et al. 2006).

2.2 Variability Due to Student-centeredness

Scaling and spreading innovations in education is different from the medical field. In education, the focus is on cultivating student-centered process-in-learning such as inquiry and knowledge building. Student-centered processes thus assume variability in different situations rather than to adopt a 'one-size fits all' form of instruction. Based on this assumption, we posit that attempts to scale, if consistent to student-centeredness, should not be mere replication from the original intervention, but variations should be allowed to occur based on differences in student profiles, curriculum, teacher dispositions, and others. To maintain the integrity and identity of the innovation, however, there should be core design principles or core fundamentals that should be upheld.

2.3 Educational Settings are Socially Messy and Tacit Knowledge is Needed

In medicine, research starts in laboratories in a context vastly different from the real world when 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), and hence socially messy. The education environment is varied and learning is a socio-cultural process (Beach 1999). This necessitates tacit knowledge due to the dynamic interactions between teachers, students, and the situated context where the learning and instruction arises. This is in essence the student-centeredness which MOE is advocating.

2.4 Educational Models of Scaling are Lacking from a Systemic Perspective

Current literature discusses on issues about scaling educational innovation and possible ways to address them (Elmore 1996; Bodilly et al. 2004; Clarke and Dede 2009; Klinger et al. 2013). These discussions mostly take the respective innovation or project as the focus. Although they provide detailed accounts about scaling individual local level innovations, this level of analysis lacks the bird-eye or systems' view of scaling. Understanding scaling at the systems' level is essential to inform policymakers of different scaling patterns, help policymakers understand teachers' and students' needs on the ground, and allocate resources more efficiently.

Policy makers, practitioners, researchers, and other educational related agencies are, however, largely uninformed about how effective innovations can be made more widespread. A literature scan has not found profound theories or sound models for scaling up research that can accumulate into generalizable findings. The process of large-scale adoption of innovations is concerned not simply about "rubber-stamping" the same program into multiple contexts, but on empowering teachers in the design process of student centered lessons, fitting and adaption 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 (Leusner, Ellsworth and Goe 2008).

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 innovations to improve student learning in design-based research by taking into account the interconnected relations between curriculum standards, curriculum materials, learning activities, formative and summative assessments, professional development practices and educational leadership (Looi, So, Toh and Chen 2011; Pea and Collins 2008), as well as taking into account the aspects of organizational learning (Spillane, Gomez and Mesler 2009).

Considerations of "scale" are a key challenge for school reform. Definitions have traditionally been 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. 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 reform, spread and (out)reach of an innovation from a system-wide perspective which is inherently more complex and non-linear. The above criteria is however important when considering local level interventions at respective schools.

3. Proposing an Ecological Model for Scaling and Translation

3.1 Overview

In the education context of Singapore, unlike the medical model, the path towards a greater adoption of educational innovation is complex and cannot be assumed to be linear. Instead we envision a model where various types of innovations (see Figure 2 below) happen concurrently. These innovations "flourish" under different conditions with various structural supports. There is a need to acknowledge that innovations have varying levels of complexities. Innovations 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 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. 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 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. Examples of these teacher-led projects can be found in MOE-NIE initiatives such as eduLab. eduLab is designed to surface and push ground-up Information and Communication Technology (ICT)-enriched pedagogical innovations across schools (eduLab 2009).

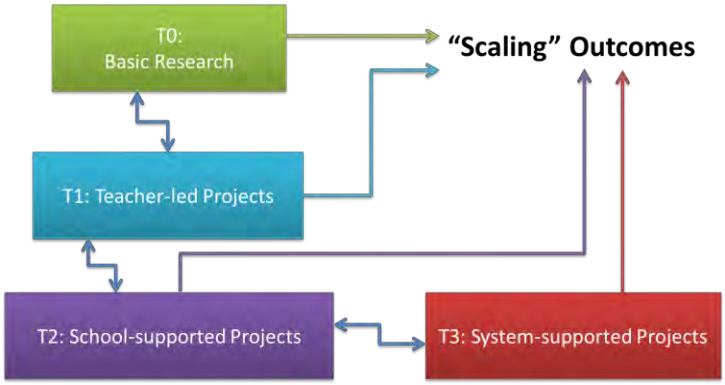

Figure 2. An Ecological Model for Scaling and Translation.

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 continue to 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 Figure 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 certain system-wide projects or initiatives due to the need to regulate local level initiatives or when certain reforms are needed due to a systems' view to narrow gaps in achievement. We thus propose that instead of viewing T1, T2, and T3 as stages to be enacted linearly, we reframe:

- *T1 as Teacher-led;*
- *T2 as School-led; and*
- *T3 as System-led.*

Teachers and researchers can also take a theoretical basis (T0) and work around it in classroom (or equivalent) settings and these become T1 projects. All three types of innovations happen concurrently for a healthy ecology to occur. 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.

3.2 Organic and Evolutionary Growth

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 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 assume that our education landscape would be one which is populated with more teacher-led (T1) and school-led (T2) innovations instead of 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. With this organic approach, 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 towards refining innovations, identifying 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 (T1) innovations and experimentation could grow to influence more people in various local instantiations. In other words, teacher-led (T1) innovations could be scaled locally to include more subjects, classes, different student profiles, and result in eventual "promotion" to school-led (T2) 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 sustain with greater efficiencies. As such, these efforts could eventually be system-led innovations (T3). Examples of these T3 innovations could include the leveling 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.

3.3 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. Instead, we seek to ask if the teachers are enthused, committed, and ready about the innovations, whether teachers are able to take innovations to their own respective classrooms (or equivalent) and implement the core or kernel ideas of that intervention. Moreover, are resources to support these subsequent take-ups available at the school, cluster, or MOE levels to support the spreading of innovations? 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 experimentations to exemplify some form of rigor? We connote that the above questions are 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.

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

To reiterate, the use of "sufficing" standard as opposed to "gold" standard is adopted and argued for in this paper 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.

4. System's Level Data of the Growth and Spread of Student-Centered Innovations

In typical scaling efforts connoted by the sciences, policy makers would roll out to the whole system or nation a certain proven drug or product. In this kind of linear scaling, data would be collected on its implementation efficacies and degrees of fidelity in terms of benefits to the 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, MA, HA in this figure represents low achieving, 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.

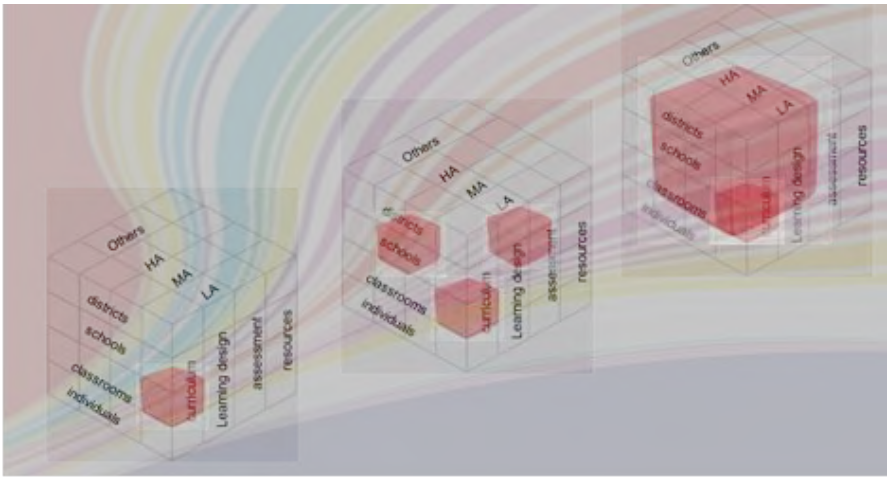

Figure 3. Contexts to consider in scaling education programs.

The concerns of policy makers are valid nevertheless. However, the strategy we are advocating in this paper is for the contextualization of pedagogy and designs to be developed and capacity of teachers to be built to enact student-centered inquiry and facilitation to be cultivated locally. Since teaching requires the interplay of tacit knowledge and developed resources, enabling teachers to have the space and time to work collaboratively with fellow teachers on crafting the lessons would be a great way forward towards fostering teacher agency and professionalism.

Nevertheless, if we were to argue for this bottom up approach of scaling with top down support (for example, from MOE), policy makers would still want to know a systems' view of what is happening with respect to the various (reframed) T1, T2, and T3 innovations grown locally and supported at the various levels of the system. MOE would also want to know, for example, the number of schools across the system which has these innovations, the kinds of innovations and on which subject domains, the grade levels in which they have been implemented, and the local spreading that have occurred or otherwise, the number of teachers involved, the number of local teacher communities, and other such data. Data for the spread of innovations across school clusters and zones is another example of system-wide data that is useful for policy makers and NIE plays a role in providing such data.

As to data collected from 2009 to 2012, NIE's intervention research projects have spread across Singapore in primary school, secondary schools and junior college (as shown in Figure 4 and 5). To provide a more concrete example, NIE's research landscape has constituted an array of T1 (teacher/researcher-led) and T2 (school-led) projects (see Figure 6 below). NIE does not have system-led projects as yet. Categorizing each innovation into one of the T0/T1, T1/T2, and T2/T3 stages and allowing for natural "growth" may be sufficient to create a diverse and rich culture of innovation in our schools.

- *T0/T1 means that the researchers have worked with teachers to bring basic research ideas into the classroom, for example, Knowledge Building (Ng, Looi and Chen 2008) abn Productive Failure (Kapur 2010).*
- *T1/T2 means that the classroom intervention has moved to the school level.*
- *T2/T3 means that the school's innovation has spread to other schools (but not to the whole system)*

Figure 4. NIE's Intervention Research in Primary Schools across Singapore in 2009 – 2012

Figure 5. NIE's Intervention Research in Secondary Schools and Junior Colleges across Singapore in 2009 – 2012

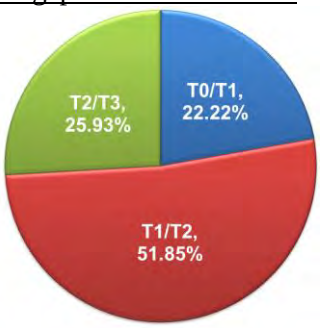

Figure 6. Distribution of NIE's Interventions

We envisage that the data for scaling or knowing what is happening as far as scaling interventions' attempts are concerned can be integrated with the systems' wide 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 and kernel sufficing standards.

5. Discussions and Conclusion

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 are desired. Hence, there is no one-size-fits-all solution for scaling. Instead, we should have a top down support 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 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 wide baseline data in order to identify gaps, concerns where nudging is necessary for some localities, and to identify if future work and initiatives are needed.

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, trailing blazing in "messy" classroom situations, till the innovation succeeds. 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. 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.

Policy makers should also be careful not to overly expect system roll-outs to be particularly high in fidelity and to be also concerned if perception survey results show that these schemes and initiatives are working very 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 also 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 systems' 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 and healthy state and culture of innovations across schools in Singapore will surely develop in a gradual and evolutionary manner. Policy- makers, researchers, 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.

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