Proposing an Educational Scaling-and-Diffusion Model for Inquiry-Based Learning Designs

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Education cannot adopt the linear model of scaling used by the medical sciences. “Gold standards” cannot be replicated without considering process-in-learning, diversity, and student-variedness in classrooms. This article proposes a nuanced model of educational scaling-and-diffusion, describing the scaling (top-down supports) and diffusion efforts (bottom-up innovations from teachers and schools) in Singapore’s education landscape. For educational innovations that focus on explicit knowledge, scaling is mechanistic (“roll-outs”), while inquiry-based learning designs are connoted as organic (“diffusion of innovation”). Inquiry-based learning designs focus more on process rather than content dissemination, although content and process are intertwined. Roll-outs are generally sound when disseminating content as products, and in the haste of implementation, we inherently partake in the fallacy that process abilities can likewise be taught as content.

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While it appears that scaling and diffusion appear on two ends of a continuum, this article discusses how both concepts are co-dependent at a systems level of analysis.

Introduction

The current model of scaling as informed by medical sciences is inadequate for education. Education, as a contextually nuanced social science, cannot adopt the model of the medical sciences wholesale. “Gold standards” are not possible for process-in-learning (for example, student-centered pedagogies) especially if the essence of scaling requires teachers’ embodied tacit understandings more than mere execution of explicit or procedural knowledge. “Gold standards” can only be replicated when the context where transfer occurs is either identical or little varied.

Unfortunately, many “roll outs” in education, framed from a replication model of scaling, have resulted in the lack of teacher agency in classrooms and an insufficient emphasis on understanding teachers’ adaptations of practices in lieu of the centrally advocated program. As education moves towards a more student-centered, non-didactic instructional model, student variation and teacher autonomy are key. These tenets are important for inquiry-based, problem-based, and other embodied, dialogic forms of learning designs. Process and interactions are integrative, while maintaining the foundations of content understandings. Prescribed and rigid curriculum with minute specifications of instructional goals is deemed overly constraining for inquiry-based classrooms. The implication for educational scaling is that innovations regarded as successful cannot be replicated wholesale into another classroom, because we value diversity and student variedness. Adaptations to teacher performances, curriculum resources, and differentiated instruction for learners are considered today’s good instruction. Hence, the model of scaling used in medical sciences does not apply to education.

In addressing this gap, we argue that replication is problematic to educational translation and scaling. We propose a way forward focused on a nuanced model, which we argue applies to education, to describe the scaling efforts in Singapore’s education landscape. Such an understanding is important because it frames policy expectations of various intervention projects in schools and classrooms from the Office of Education Research (OER) at the National Institute of Education (NIE) in Singapore. While most studies on educational scaling are from local interventionist perspectives, this article proposes a framework for scaling-and-diffusion (applied to education) at the systems level of analysis.

Diffusion adopts the underpinning assumption that inquiry-based learning is cultivated locally, and spread is initiated from local instantiation. Tacit knowledge is emphasized as teachers enact and re-contextualize innovations in classrooms. We advocate both top-down and
bottom-up strategies to seed and grow innovations and people capacity throughout the system. The Ministry of Education (Singapore) provides top-down structures to enable bottom-up innovations, translate kernel-core designs into different contexts, and harvest innovations for diffusion. We seek a sufficing standard in the form of a kernel-core design reified in terms of design principles that deeply describes how the innovation occurs in a particular context. Intentional translation and subsequent diffusion is taken up by the Ministry of Education (MOE) with a more systematic approach to develop resources and case examples for other contexts.

**Educational Scaling Is Not Identical to Medical Sciences’ Model of Scaling**

In the natural sciences, including that of the medical field, scaling and translation from research to everyday practices is a linear and staged process (Boet, Sharma, Goldman, Reeves, 2012; McGaghie, Issenberg, Petrusa, & Scalese, 2010; Rubio et al., 2010; Woolf, 2009). Stage 1 of the translational research (T1) focuses on testing in laboratory settings, with the aim of developing new methods for diagnosis, therapy, and prevention (Boet, Sharma, Goldman, & Reeves, 2012; McGaghie, Issenberg, Petrusa, & Scalese, 2010; Rubio et al., 2010; 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.

Stage 2 of translational research (T2) is about translating results from clinical studies into clinical practice and decision-making (Boet, Sharma, Goldman, & Reeves, 2012; McGaghie, Issenberg, Petrusa, & Scalese, 2010; Rubio et al., 2010; Sung et al., 2003; Woolf, 2009). 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 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 to everyday practices (Boet, Sharma, Goldman, & Reeves, 2012; McGaghie, Issenberg, Petrusa, & Scalese, 2010; Rubio et al., 2010; Westfall, Mold, & Fagnan, 2007; Woolf, 2009). The focus here is on how interventions work in real-world settings.

Medical research moves linearly from laboratory to mass market. The default model is to look for a "gold standard" of an innovation and bring this through the T1 to T3 processes. This dominant thinking is also found in programs such as the i3 (Innovation through Institutional Integration) model of the USA National Science Foundation (NSF) (The National Science Foundation, 2006).

The educational contexts of classrooms differ significantly. Educational proponents, such as Anderson and Shattuck (2012), Dede (2006), Penuel, Fishman, Cheng, and Sabelli (2011), and Sternberg et al. (2006) recognize that decontextualized experiments set up in laboratories and controlled settings may not always generalize to the varied nature of classrooms. Instead, there is the recognition that educational research should begin in classrooms. This is especially true for inquiry-based learning designs, for example, seamless learning (Looi et al., 2010; So, Kim, & Looi, 2008; Wong, 2012), where process literacy and inquiry emphasize teachers' in-situ facilitation and responses from students' questions and voices. Hence, instead of a product replication perspective, which emphasizes tacit knowledge, developing people capacity to enact the phenomena of change is crucial. Products are important, but of greater importance is process. This is especially true for inquiry-based learning designs, which are contextually nuanced. The educational model of scaling proposed in the subsequent sections attempts a non-linear approach to scaling, yet incorporating some of the T1 to T3 stages as top-down supports for bottom-up innovations.

**An Educational Model of Scaling-and-Diffusion**

**Mechanistic to Organic Continuum**

Since context is sensitive for inquiry-based learning designs, and considering the varied nature of classrooms, we recognize that every undertaking of educational interventions or innovations is a translation. That is, it occurs from the onset in a local classroom and not in a decontextualized laboratory. If we extrapolate this assumption, it means that every context transferred is a re-contextualization rather than a replication of the innovation. There will only be T2 translation research.

Thus, scaling or replication of a "gold standard" may not happen, because each context differs. Scaling in education is about re-contextualization and transfer, adopting a sufficing standard and kernel-core design. Policy-makers would find this assumption difficult to comprehend, as it goes against an intuitive sense that we learn from history, then generalize. Subsequent iterations become more optimal. We will address this issue in later sections.

Instead of a "gold standard," we argue for a sufficing standard and kernel-core design for educational innovations, before considerations are made to support its diffusion. Critiques might suggest that not all educational innovations need to be oriented to inquiry-based learning. There are many examples of learning which can be...
efficiently achieved by didactic learning. Adopting a systems perspective and to make our proposed model more robust, we allow for exemplars along a mechanistic-to-organic continuum (see Figure 1).

For educational interventions, or innovations that focus on explicit knowledge with high levels of prescription, scaling is connoted as mechanistic ("roll-outs"). On the other end, innovations associated with inquiry-based pedagogies and designs are connoted as organic ("diffusion of innovation"). Diffusion suggests a bottom-up approach in contrast to a hierarchical and top-down philosophy. Diffusion happens when innovations are cultivated locally, and spread is initiated from that local instantiation. Tacit knowledge is emphasized, as teachers' understandings arise from interpretations, dialogue, and embodied experiences enacting innovations in classrooms.

Seeding Innovations: Populating the System with Bottom-up Innovations

This article also advocates a "populating of innovations" approach (see Figure 2) throughout the system rather than "roll-outs" of any successful intervention from a centralized agency. "Roll-outs" should be kept to a small number, while teacher/classroom-led and school-led innovations should be supported and encouraged throughout the system. Aligned with a systems view, it is necessary to learn from each local experience and endeavor for cost-effectiveness and efficacy at each subsequent instantiation. Moreover, keeping a systems data-driven analysis to understand scaling and diffusion across schools and districts is advocated.

In other words, we adopt a bottom-up strategy to seed and grow innovations and people capacity developed ground-up. If we can do this throughout the whole system, we develop teachers' embodied experiences of
inquiry-based pedagogical designs and heighten teacher professionalism.

While we engage in such efforts, we need structures and mechanisms to ensure that teachers' and schools' ground-up efforts are indeed 'innovative' and approximating inquiry-based learning designs. Partnerships with researchers are an expensive solution. We know that such a process of learning is not straightforward. We need to find alternative structures, such as enculturation and learning in Professional Learning Communities (PLCs) and Communities of Practice (CoPs)—by optimizing on these system structures in lieu of researcher-teacher partnerships. However, we make the assumption that these PLCs and CoPs have teachers and/or facilitators who deeply understand and appreciate inquiry-based learning designs and pedagogies.

**Top-down Support for Bottom-up Innovations**

In Singapore, the Ministry of Education (MOE) plays a top-down supporting role for bottom-up initiatives. The key issue is: how can we optimize and accelerate the trajectory of the whole system by benefitting from understandings of local innovation instantiations? Since we do not subscribe to linear models of scaling (the replication of products), how can we do the equivalent in education, where we can accelerate and level up the base of inquiry-based learning? Or, how can there be MOE's top-down support for bottom-up initiatives?

We propose an approach for identifying and scaling bottom-up innovations through the following processes (see **Figure 3**):

1. seed and identify note-worthy innovations;
2. "fertilize" them or undergo a "translational" process, where we attempt to apply the ground-up innovation and situate it in more contexts (according to student demographics, other subject areas, and grade levels); and
3. harvest and scale these innovations out with proper products and process, and these can be termed as *bicycles, cars, and buses*.

To further describe the above processes, we adopt a metaphor of *bicycles, cars, and buses* in a country's transport system. As typically envisaged, buses carry more passengers to destinations but have inherent constraints, whereas bicycles are mostly individualistic vehicles that are portable and flexible in terms of terrains for travelling. Cars are in-between buses and bicycles. Analogously in our scaling-and-diffusion model, buses are connoted as system-led supports, cars as school-/cluster-led supports, and bicycles as teacher-classroom-led supports. As supports move from bicycles to buses, the degrees of prescription in terms of top-down support increases, and flexibilities from teachers and schools decrease. Buses imply that more stakeholders can benefit from such a support. Cars are such that schools have more lee-way in terms of adapting the innovation.

According to our characterization, bicycles, cars, and buses are all "scaling" efforts, which are supported with top-down infrastructure—harvesting successful innovations and enabling them to be spread out for others' benefit, without compromising the original thesis for a non-linear *modus operandi*. Bicycles, cars, and buses are

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**Figure 3. Top-down structures for bottom-up innovations.**
Top-down Structures for Harvesting Innovations into Bicycles, Cars, and Buses

Bicycles are scaled-up or harvested teacher-classroom-led innovations—that is, these can be handled by the teacher in his or her classroom with relatively little assistance, provided the infrastructure is available. We conjecture that these innovations are more prescriptive innovations, which require mentoring and scaffolding teachers as they implement them in classrooms. These innovations focus on inquiry or process literacies, which require adaptation to contexts and cultivating students’ inquiry and participations. Teachers have to be adaptive and situate practices in their respective contexts. For example, if MOE decides that a particular game-based learning program is to be used by teachers across the system to help grade seven students learn citizenship, MOE may work with NIE or with the academies such as Academy of Singapore Teachers (AST) to provide adequate training and onsite mentoring on this bicycle innovation.

Cars are school-led innovations—that is, these can be handled only at the school/cluster level, with relevant leadership supports. We conjecture that cars are innovations which MOE deems to be best suited and implemented at the school or cluster level, because flexibility and support are appropriate at this level. These projects are usually mid-way between prescription and proscription, as some degrees of optimization has already been worked out. The kinds of school-cluster-led infrastructure that MOE provides are product and process access and professional development for teachers. The cars innovation can be supported by schools’ PLCs or even at CoPs within the school clusters. MOE ensures that on the ground—at the school and cluster level—there are sufficient teachers and school leaders with deep and tacit understandings of the innovation, who will support the innovation.

Buses are system-led innovations—that is, these can be handled only by MOE, where system-led infrastructure provisions are provided massively and “rolled out” to schools. Buses should be few, and only if prescription to ensure consistent implementation is possible. MOE is not unfamiliar with this concept. Based on our postulations, we caution that buses should be adopted for innovations that are less process inclined but primarily procedural in knowledge. We envisage such innovations to address basic literacies of reading, writing, and arithmetic.

Based on the above characterization, there is the implication that suggests bicycles can be consolidated by MOE to become cars. Similarly cars, when maturity of implementation through the system is attained, can be optimized and benefits distributed to more people by becoming buses. However, it is important to note that not all innovations need to become buses. Some innovations may remain best as bicycles, due to the intents of the innovation as mapped out by the system’s goals for students, teachers, and policy needs.

The process of seeding, fertilizing, and harvesting innovations from a ground-up scaling-and-diffusion process supported by MOE’s top-down structures is as follows (see Figure 3):

1. Seeding innovations (ground-up).
2. Making the innovations visible.
3. Selecting innovations to bring to the next steps.
6. The process of seeding occurs continuously and concurrently while 2 to 5 is being carried out as a top-down supporting structure of MOE.
7. While 1 to 6 are being carried out, MOE continues to support the PLCs and CoPs, including that of NIE’s pre- and in-service teacher training to be in alignment to the made-visible innovations—especially the kernel-core designs which are supported by evidences of learning gains.

Sufficing Standard and Kernel-Core Designs

Since our thesis is that a “gold standard” is not tenable in educational scaling, we are seeking a sufficing standard in the form of a kernel-core design arising from ground-up innovations (see Figure 3). This kernel-core is reified in terms of design principles that deeply describe how the innovation occurs in a particular context, including the infrastructure, teacher competencies, and leadership supports that enable the innovation.

This kernel-core design during the fertilization process (intentional translation) is taken up by MOE with a more systematic approach to develop resources and case examples for other contexts (see Figure 3). However, it must be reiterated that these developed resources are not to be subsequently adopted procedurally or mechanically; otherwise, it contradicts the varying nature of a non-linear proposition.

MOE develops these “packages” (resources and case examples) based on the evidence-based kernel-core design. However, the “packages” have to be worked out in embodied experiences by teachers, and evidences of effectiveness are needed to ensure that re-contextualizations are meaningfully conducted.

The sufficing standard and kernel-core designs, which are re-contextualized and embodied by teachers into real classrooms, apply more to innovations concerned with inquiry-based learning designs, where organic “scaling” considerations are prominent (see Figure 1 for mechanical-organic scaling continuum). This is because, as discussed earlier, context is sensitive in inquiry-based learning, due to teachers’ in-situ facilitation of students’ interactions. These kinds of innovations...
may be more aligned to the cars and bicycles metaphor discussed earlier.

We recognize that not all innovations in education necessarily involve an organic scaling-and-diffusion model, and there are procedural applications, which can probably be "rolled out" as products. These we recognize to be more consistent with the buses metaphor, which we have elaborated earlier.

Besides structures to spread the innovation to benefit more students, structures are also needed to accelerate and level-up the professional capacity for inquiry-based learning (see Figure 3). These structures include:

- PLCs and CoPs;
- NIE’s preservice teacher training core modules;
- knowledge management; and
- teachers with research and data collection abilities.

In essence, after innovations on the ground have been identified and selected to be provided with greater top-down support, these innovations can be intentionally situated into existing PLCs and CoPs in the school system. Moreover, NIE’s preservice modules should also integrate these innovations into the modules offered. These support mechanisms develop the human capacity for implementing and sustaining innovations.

MOE’s top-down support, apart from developing teachers’ proficiencies, should continuously adopt knowledge management strategies to describe and document the knowledge base of teachers’ understandings across the system. Such a knowledge management stance will enable teachers to have access to case examples, practitioners’ written theories and principles, and stories of successes and failures in attempting and experimenting on “translated” innovations.

As the teachers’ competency base increases in the long-term, equipping teachers with basic research and data-collecting techniques will aid them in moving towards an evidence-based approach of classroom experimentations. In this way, teachers would be able to assess whether their implementations of inquiry-based learning designs work in their classrooms.

Conclusion

In this article, we have attempted to postulate that scaling in educational contexts is not about taking a “gold standard” of a product and pushing it out to the mass market. Scaling is instead a process and a structure, put in place to optimize diffusion and accelerate subsequent re-contextualization. Perhaps it is better not to call this scaling but diffusion. However, diffusion does not adequately connote the top-down structural supports of the system.

We have described the top-down support, process, and structure for (more) optimal diffusion as the interplay with bottom-up diffusions, requiring constant balancing and re-balancing between the two. If scaling connotes top-down and diffusion is recognized by the larger community as bottom-up, the process we have discussed is a dialectical interplay of both scaling and diffusion. For the lack of a better term, we have referred to this as an educational scaling-and-diffusion model for inquiry-based learning designs.

References


