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Sustaining Research Innovations in Educational Technology Through Communities of Practice

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The diffusion of innovation is critical to societal progression. In the field of education, such diffusion takes on added significance because of the many stakeholders and accountabilities involved. This article presents the argument that efforts at diffusion which are designed from a top-down perspective are not sustainable over the long term because such a perspective does not sufficiently acknowledge the importance of tacit knowledge in the successful adoption and adaptation of innovations. Using examples drawn from the trialing and implementation of a suite of research innovations in the Singapore education system, the argument is made that tacit understandings of any given innovation are attained through dialogue and embodied practice within authentic contexts, and that these very contexts and opportunities for dialogue are precisely the affordances of Communities of Practice. The article draws some tentative conclusions about systems-level moves and strategies which might nurture the dialectic of theory, practice, and epistemology by leveraging existing social structures.

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Lessons Learned from the Recent Seeding of Educational Technology Innovations in Singapore

When an innovation is mature, attempts are usually made to translate that product into use benefitting the masses. Such an approach adopts a linear upstream to downstream flow of innovation diffusion. We argue for an alternative and non-linear conception of the diffusion of educational technology by adopting a more ecological metaphor to this issue. We argue why such an ecological approach is possible due to communities as networks of people, thereby enabling this diffusion. We also posit that the Communities of Practice (CoP) approach is a more sustainable innovation diffusion strategy, as the crux of innovation is the leveling up of human capacity to adopt the innovation appropriately.

Over the past seven years, the Ministry of Education (MOE) in Singapore has generously supported the research efforts by awarding the National Institute of Education (NIE) a five years' block of funding amounting to around US$10 million dollars per year. Many of these projects study the baseline states of current teaching and learning practices, both in local schools and the teacher education practices, and another significant allocation goes to intervention projects in the schools. ***Table 1*** shows the research grants and the clustering of projects we have done through our analysis of these grants. The analysis is done based on data we have collected from the principal investigators of the grants, where we sought data relating to years of implementation and the specific intervention for a particular year; the funding amount supported; the schools involved; and the nature of the research work with respect to research methodology (for example, design research) and teacher professional development issues. Interviews were also conducted with the research teams when more information was needed with respect to their interventions.

From the data collected from over 250 research projects, consisting of a wide range of educational issues across the system and with differing methodologies, we categorized these projects into 12 research clusters or themes. The 12 clusters are: (1) applied cognitive development, (2) bilingual language development, (3) scaling and professional development, (4) user generative designs, (5) values and 21st century learning, (6) special needs, (7) early childhood, (8) learning by inquiry, (9) teacher education, (10) problem solving, (11) systematic studies, and (12) international benchmarking.

The projects are placed in ***Table 1*** according to the nature of the research: basic, applied (schools and teacher education), and evaluation/implementation (local system and international benchmark comparisons).

Table 1. Classifying research projects into clusters.

<table>
<tr><th></th><th>Basic research</th><th>Applied research on schools</th><th>Applied research on teacher education</th><th>Evaluation/ Implementation of local system</th><th>Evaluation/ Implementation with international benchmark comparisons</th></tr>
<tr><td rowspan="5">Research Clusters</td><td>Applied cognitive development</td><td>User generative designs</td><td>Teacher education</td><td>Systematic studies (for example, leadership of school principals, baseline studies of teaching and learning practices)</td><td>International benchmarking (for example, TIMSS and PISA)</td></tr>
<tr><td>Bilingual language development</td><td colspan="3">Values and 21st century learning (in and out of school)</td><td rowspan="4"></td></tr>
<tr><td rowspan="3">Scaling and professional development</td><td>Special needs</td><td rowspan="3">Problem solving (in Mathematics)</td><td rowspan="3"></td></tr>
<tr><td>Early childhood</td></tr>
<tr><td>Learning by inquiry (for example, applied to teaching and learning science)</td></tr>
</table>

Not all projects had an intervention orientation, but the whole range of studies would provide us with the context to understand the sustainability of the research. One major criterion we observed in research projects having the potential to scale up was that projects had a sustained historical development and resulted in an active dialectic between theory, practice, and epistemology. These studies would typically have adopted varying methodologies, from baseline studies to interventions, and, to some extent, have done some degree of scaling. A second important consideration is that these studies, which have a sustained trajectory, would also have built up strong human capital and teamwork both among the researchers and with schools and teachers.

In terms of scaling up, the research projects which conceptually took into account scaling considerations from the onset stood a higher chance of success. These projects often began as 'blue sky' research (Braben, 2004, 2008) and worked their way through years of implementation in schools. Such research with strong theoretical underpinnings was more successful with respect to scaling up. All the research grants that experienced success with scaling up had the schools as their partners in research engaged from the beginning, although there were projects with varying degrees of teacher ownership and agency involved.

Table 2 shows a sample of educational technology and inquiry related innovations from projects undertaken—which were mainly oriented towards interventions. Projects in ***Table 2*** had demonstrated success in diffusion among schools because partnerships with schools were established in early stages of the research.

The design research approach used on educational innovations—in which teachers and researchers worked in partnership in Singapore schools—have succeeded because the journey was taken long-term over three to seven years. There was sustained research interventions of learner-centered designs and pedagogies seeded in many local schools. The research journey had processes to make sure that when things did not work well, researchers were always around to ameliorate the situation until it became a productive learning experience. Thus, it was a hands-on approach to research. It was challenging for researchers to work with the schools, and these challenges were mitigated when the school principal was supportive; teachers were given resources and time to participate in innovations. The innovation could subsequently spread from one class in a level to the entire level, followed by multiple levels in a school to multiple schools in a district.

The key value of having researchers and teachers work together is that there is diversity of perspectives and skills. This enables them to think in out-of-the-box ways, and diversity drives innovations. Using an ecological perspective creates incremental evolutions towards 21st century practices. If CoPs are used as a

Table 2. Analysis of intervention projects.

Intervention projects	Number of schools	CoPs	Intense ownership by teachers	Courses infusion	Sustained	Translation efforts
Seamless collaborative learning	20	Yes	Yes	Yes	Yes—team is stable; funding is also stable	Yes
Games for learning	5	No	No	Yes, but gradually introduced	Not stable—no stable co-PIs; funding not stable	No
Constructive activities	4	Yes	Yes	No	No—no succession planning	No
Learning in virtual worlds	17	Yes	Yes	No	Yes—team is stable; funding is also stable	Yes
Storytelling	2	No	No	No	No	No
Science inquiry	3	No	No	Yes	No—no succession planning	No
Historical inquiry	5	Yes	Yes	Yes	Yes—team is stable; funding is also stable	Yes
Math problem solving	10	Yes	Yes	Yes	Yes—team is stable; funding is also stable	Yes

resource for diffusion and a mechanism to encourage dialogue among teachers and principals in different schools, the entire education system may slowly progress towards 21st century literacies.

Scaling up issues and sustainability cannot be divorced. In fact, we argue that they are two sides of the same coin. For research projects which have been sustained, the presence of CoPs (or some form of professional learning community, whether in schools or in our teacher-education institution) was evident. Within the CoPs, teachers:

(1) had much ownership working closely with researchers on authentic tasks and real practice in the classrooms—integrated as part of the teachers' professional life;
(2) were also heightening their professional practice by presenting their work in conferences and in school and cluster sharings; and
(3) were recognized for what they contributed.

Discussion: The Pipeline Versus an Ecological View of Innovation Diffusion

The traditional way of thinking about scaling innovations has been from the pipeline perspective (Godin, 2006). Researchers conceptualize innovations, and these are tested out in constrained laboratory settings and then rolled out. As discussed earlier, these creations are not authentic to the original innovations because they foreground the product over process.

In this article, we have sought to introduce an alternative view of innovation diffusion from an ecological metaphor. Such a view is more consistent with the concept of CoPs. It is based on creating CoPs to support innovations as they get seeded. CoPs are formed in parallel with these seeding efforts. Tacit knowledge (Polanyi, 1967) involving the social and interactional dimensions is exercised *in situ* with the development of the innovation. CoPs are groups of people gathered around a common interest and interacting in a sustained manner to dialogue and engage in meaningful activities around the issues at hand (Lave & Wenger 1991; Wenger 1998; 2000; Wenger, McDermott, & Snyder 2002). Lave and Wenger (1991) brought to prominence this concept and began to probe further into why learning in CoPs work. The prominence of such theories arose as a contrast to

school-based learning, which was criticized as less authentic due to the de-contextualized nature of how the latter represented knowledge.

Moore (2002) has depicted the adoption of innovations as sometimes being stymied by a chasm. For any given innovation, there will be early innovators and early adopters, but some of these innovations may never get out to the masses. Many of the innovations that happen in a laboratory or university are research-based and never clear the innovation chasm. In this article, we argue that innovations that are developed for and by CoPs stand a better chance at crossing the chasm.

It is our position that funding agencies have tended to assume that the provision of hard (that is, policy- and resource-, as opposed to social-) structures would help push the innovation across the chasm. In contrast, from an ecological view, innovations are seeded across society and environment (Kao, 2009; Moore, 1993). In a naturalistic way, the majority of these ideas would likely not gain traction. For those that succeed, more funds are provided to support them further. This can be characterized as the business ecological way of looking at innovations.

A central tenet of this article is that such a business-ecological view cannot be simplistically applied to education. This is because schools and educators are accountable to parents, students, and society. How then might the ecological metaphor be used to enable many more pedagogical innovations to be seeded organically?

In the past, consistent with the industrial age, scaling was synonymous with generalization, and in turn this resulted in much de-contextualisation. Innovations were initiated in the laboratory and then spread to the masses. Today innovations—such as smartphone applications—grow with the ecology and community over time. The collective majority in the ecology is creating and driving the innovation rather then a small minority who creates the innovation in the laboratory. Foundations and tacit knowledge are established right from the onset in the ecology and evolve within communities; such an ecological perspective rejects the stance of waiting until the innovation is tested and proven before attempting diffusion.

The ecological view of educational technology innovations, as argued in this article, is about developing and spreading innovations contemporaneously. If such is the case, few innovations will be left behind. It is the responsibility of the education fraternity to try to enable most if not all of the educational innovations to succeed.

From the ecological view of educational technology innovations, research starts at the school, rather than in a laboratory, using a design research approach, where researchers and teachers work in close partnership right from the onset of the intervention. In other words, these interventions do not originate from the research laboratories but begin as innovations with research rigor on the practice grounds. In this way, they stand a better chance of crossing Moore's (2002) chasm.

For example, the technologically-mediated research projects (such as Chen & Looi, 2011; Lim, 2011; Wong, Chin, Tan, & Liu, 2010) outlined in the first half of this article were all co-designed with practitioners because teachers were willing to work with researchers to create innovations and change. The researchers did not conduct non-participatory research or sideline observations. They walked the journey with the teachers through three to five years of research interventions. They worked with teachers until the latter felt sufficiently confident to conduct the interventions on their own. In turn, by having walked the entire research journey with teachers, the researchers were confident that teachers could sustain these innovations by themselves, as they had appropriated the tacit dimensions of the innovation. In order to sustain the innovation in a particular school, the knowledge about the innovation was dialogued among the CoP members there. If that same innovation were to be diffused to other schools, the CoP would grow and evolve with it.

Whenever there is some degree of success in seeding educational technology innovations, the response from policy-makers is to focus on how to scale up. This usually defaults to an issue of how to generalize the principles involved in the educational technology innovation and to create some policy imperative to roll out the innovation to more schools and also to the system as a whole. We argue that this thinking is flawed and under-estimates the process-oriented nature of knowledge.

Conclusion

We therefore wish to conclude this article by highlighting the following areas in which further work is needed.

First, the readiness of schools with respect to innovations in educational technology needs to be articulated. While schools should remain as the primary elector for the respective innovations, there should be a matching of the readiness of a school and the complexity of the innovations proposed. In our past years of innovation seeding, we had research agendas from complex situated games which required a radical redesign of curricular and other technologies that could be more readily infused into curricula but would require lessons to be more collaborative and inquiry-based.

Second, we need to develop a framework for translating and scaling (or diffusing) research such that subsequent iterations remain authentic to the design principles. This requires attention to be paid to how innovations might be

adopted and adapted across different demographics, disciplines and organizational levels.

Third, efforts in teacher professional learning—both by the MOE and the NIE—have to close the loop by infusing case studies of successful research innovations which have been sustained in schools. Although teacher education/training programs are not the ideal ways to encourage tacit knowledge developments, they are nevertheless possible avenues to prepare the minds of teachers and their knowledge base. In Singapore, the MOE conducts a holistic curricular review for the school system every six to seven years. These new curricular redesigns should also be part of the holistic review process.

It is our hope that with these three systemic strategies, educational innovations would be spread more successfully, and students in the school system would benefit and be enculturated into 21st century literacies and dispositions. □

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