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| Author(s) | David Hung, Azilawati Jamaludin & Yancy Toh |
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Apprenticeship, Epistemic Learning, and Diffusion of Innovations in Education

David Hung
Contributing Editor

Azilawati Jamaludin
Yancy Toh

Issues of innovation diffusion and its related tractability in schools remain key challenges in education research. At the Office of Education Research in Singapore, the authors have been working to develop a research program leveraging upon a school cluster system with the view to experimenting on the centralization and decentralization structures of Singapore's education system to enable scaling or the diffusion of innovations to occur. They posit that underpinning the structural aspects of diffusion is the notion of apprenticeship learning among teachers for epistemic change to occur. In this article, they define and outline how epistemic learning can occur at the teachers' level, articulating how leaders can provide

David Hung, a Contributing Editor, is Professor of Education at the National Institute of Education, Singapore. His research orientations are largely social-cultural in nature and applied to student learning and cognition. His more recent research projects involve studies into communities of practice, scaling, and diffusion of innovations, and how school leaders support the work of teachers (e-mail: david.hung@nie.edu.sg). **Azilawati Jamaludin** is a Research Associate at the Office of Education Research, National Institute of Education, Singapore. Her research interests are in progressive pedagogies and institutional innovations, game-based learning, embodied knowing, immersive environments, argumentative knowledge construction, and learners' trajectories of *becoming* (e-mail: azilawati.j@nie.edu.sg). **Yancy Toh** is a Research Scientist at the Office of Education Research, National Institute of Education, Singapore. Her research interests are in school change, educational leadership, innovation diffusion, complex systems, seamless learning, and technology integration (e-mail: yancy.toh@nie.edu.sg).

the necessary socio-technological infrastructure to spread and sustain epistemic shifts for pedagogical change. To this end, they explore the use of the cluster system as an alternative approach and a proximal vehicle to build teacher capacity and to promote epistemic change in a more optimal manner in the context of innovation diffusion in education.

Introduction

A key issue in educational research concerns the sustainability of pedagogical and curricular innovations in attempts to introduce improved ways of teaching and learning in schools. While innovations are usually, in principle, welcomed in schools, concrete attempts to sustain and scale innovations often involve resistance among participants and entrenched institutionalized traditions. Such resistance may be characterized as "benign neglect, failure to engage, reluctance, withdrawal, criticism, or even open conflicts" (Sannino, 2010, p. 61). In fact, even innovations that may initially be embraced often wither from the lack of sustained cultivation (e.g., Carnine, 1997; Clark, 1989; Cohen *et al.*, 2007; Elmore, 1996; Greenwood & Abbott, 2001; King-Sears, 2001; Kozma, 2000; Sannino, 2010). Consequently, few school-based innovations achieve sustainable tractions.

As a response to the intractability of educational innovations, the Office of Education Research (OER) at the National Institute of Education in Singapore aims to work with schools to seed, sustain, and scale innovations. In line with OER's efforts to bring research interventions to scale, we have been working to develop a research program leveraging upon a school cluster system* with a view to experimenting with the centralization and decentralization structures of Singapore's education system (Tan & Ng, 2007), thereby enabling scaling or the diffusion of innovations to occur. The research program hinges upon the following motivations, at the respective layers of analysis (see **Figure 1**):

- how diffusion of innovations occurs as a system (i.e., macro-system);
- how design interventions can be carried out in schools—which we hope to derive from the macro-system's identified gaps and the theoretical bases for how learners learn;
- what kinds of social, technological, and structural affordances, as unpacked at the meso-level of analysis, have facilitated or impeded diffusion of innovations; and

*Within the Singapore education system, all schools are grouped into zonal clusters, and each cluster is facilitated by a Cluster Superintendent. The Cluster Superintendents develop, guide, and supervise the school leadership teams to ensure that schools are effectively run. See <http://sis.moe.gov.sg/SchoolClusters.aspx> for the zonal clusters of all schools in Singapore.

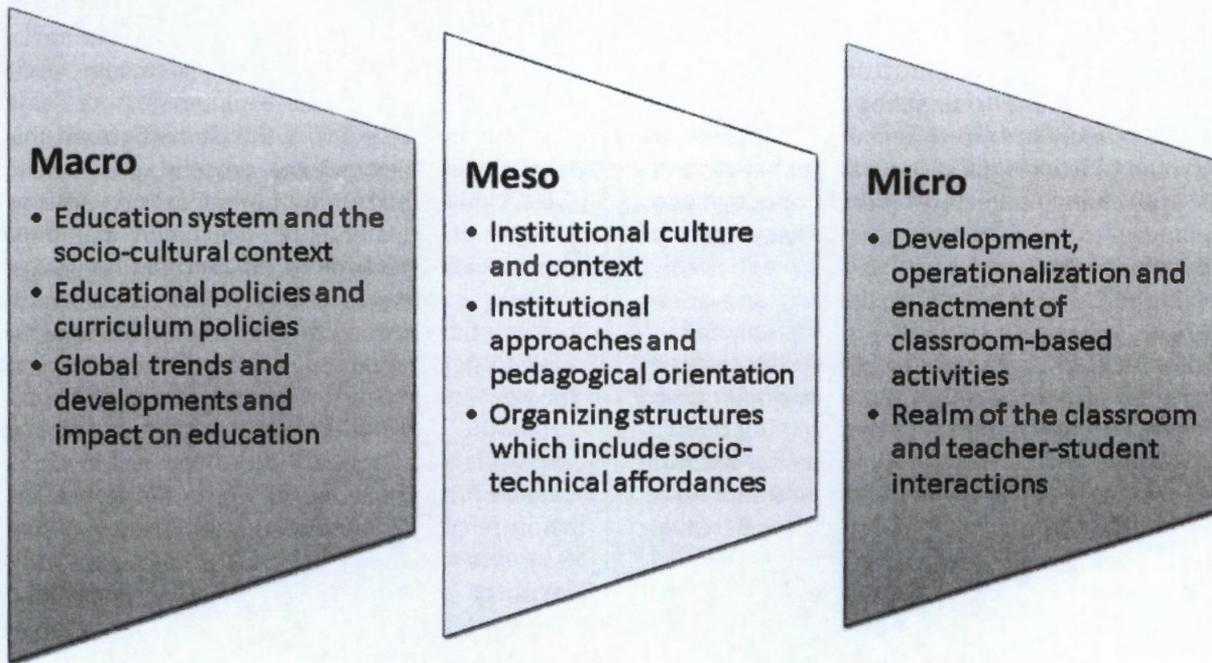


Figure 1. Analytical layers of research program.

- what kinds of learning gains and outcomes (from both teachers and students) are attained at the micro-level of analysis.

Since the introduction of the ICT Masterplans* in Singapore's education, OER has systematically introduced inquiry-based learning, mediated by technologies. In the implementation of these inquiry-based practices, the overarching goal aligns itself with the thrusts of the ICT Masterplans, that is, to leverage on ICT for seeding students' abilities to engage in '21st century competencies.' These include competencies such as questioning, argumentation, knowledge-building, problem-solving, critical-thinking, creativity and imagination, aesthetics and design thinking, imagination, and other processes. Thus far, the kinds of research interventions we have conducted in OER have included innovations within domains of both formal and informal learning, such as social studies inquiry (through the Critical Web Reader), knowledge

*The use of technology in Singapore has been emphasized by MOE since the inception of the ICT Masterplan in 1997. Masterplan 1 (MP1) focused on laying the foundation for the use of ICT in education through capacity building of teachers and procurement of IT equipment, while Masterplan 2 (MP2) focused on seeding innovation and integrating the use of ICT into the curriculum. In the third ICT Masterplan (MP3, 2009–2014), the espoused vision was to ensure a greater level of technological integration in curriculum, assessment, and pedagogy so as to equip students with critical competencies (IT, communication, self-directed and collaborative skills) to succeed in the 21st century.

building (through the Knowledge Forum platform), seamless learning (through using mobile devices), game-based learning, and others.

This article is organized in the following manner: First, we define and outline how epistemic learning can occur at the teacher level (micro); next, we articulate how leaders can provide the necessary socio-technological infrastructure within schools to spread and sustain epistemic changes (meso); and, lastly, we explore the use of the cluster system as an alternative approach and a proximal vehicle to build teacher capacity and to promote epistemic change in an optimal manner (macro).

Apprenticeship Learning for Epistemic Change

Underpinning the structural aspects of diffusion is the notion of apprenticeship learning among teachers for epistemic change to occur. Epistemic change includes *skills* and *cognition*, where teacher *beliefs* with respect to inquiry-based learning occur. For inquiry-based models of pedagogy to be enacted in schools, epistemic change has to occur in stakeholders who hold on to traditional mindsets. While scaling and diffusion (or spread) may connote some passivity on the part of the recipient, our work on epistemic change calls for the 'appropriate' to adopt a stance of struggle and dissonance before the appropriation and internalization of the new perspective take root. Such a process is consistent with the humanistic model of scaling and diffusion. We hold that this concept of apprenticeship learning for epistemic change in teachers, within the

larger frame of diffusion of innovations, is unique, as it ties together the:

- socio-technological infrastructure—leverages the cluster system and the schools involved in a centralized-decentralized manner afforded by alignment of leadership in innovation change; and
- epistemic change trajectory—design of activities to promulgate cultural change via the enactment of role performances by the actors.

In seeking to bring established research innovations to scale, our hypothesis is that fundamental change stems from the teacher. As documented in our research studies around apprenticeships, we have documented case accounts of how teachers fail in enacting innovative pedagogies, and how the apprenticeship learning process occurs through peer-modeling, role-modeling, competency-modeling, and performance under guidance (Hung, Lee, & Wu, 2015).

Within the OER research interventions, as researchers embarked on interventions in inquiry-based learning in schools, we have observed the performance of the apprentice-master to the teachers working with them as apprentice-disciples. In a subsequent iteration of the research intervention, the apprentice-disciples, having acquired the relevant epistemic shifts, became apprentice-masters to still other teachers, but this was not always achieved intentionally, as not all research interventions had a distinctive design for scaling. For example, in one of our research studies, on the spread of an innovative seamless learning pedagogy from one school to five schools (Wu, 2014), it was through a developmental trajectory of recognizing teachers as 'champions' of the innovation that the school leaders began to support the movement towards 'open classrooms.' Apprentice-disciple teachers were able to observe 'apprentice-master' teachers who had established inquiry-based cultures in their classrooms.

In another research study, where we traced how innovations get diffused from one school to more than 80 other schools (Jamaludin & Hung, in press), we observed how teachers were facilitated through leadership modelling of a systematic process of organizational development to design unique paths toward powerful learning for its learners, while affording adaptations of locally-appropriate forms of pedagogical practices consistent with this approach. At the teacher level, we observed that in making the curricular innovation adaptations to their classrooms, teachers went through an 'apprenticizing' process of exploring the potential 'value' of the curricular innovation. As they do so, they evaluate the 'results' of their exploration in terms of 'impact' (e.g., recognition from reporting officers, students' manifestation of skills). This exploratory-evaluative process does not only inform teachers' subsequent course of action, determining how they proceed next with the

innovation, but it also entails a process of recognizing the full worth or value of the innovation through 'appreciating' the response from the social and structural environment.

In our interventions, we have recognized that when teachers experienced the process where their beliefs were challenged during the innovation implementation journey, they gained the realization that the change process was much more difficult and intransigent than initially expected. However, as accountabilities are designed as part of the process of learning, teachers have to stay committed to the endeavor. It is crucial that the peer apprenticeship learning process is supported by providing adequate apprenticeship support and appropriate structure for these teachers to undergo the change process (Hung, 1999). In Singapore, while the Ministry of Education is not short of producing resources for teachers to use, there is a pertinent need to focus on the socio-technological infrastructure that enables learning to take place, encouraging teachers' epistemic change to occur. In this regard, these resources have to be intentionally brought into the workflow, and appropriated in the apprenticeship process that may be facilitated by structures such as school based professional learning communities. Through our interventions, we also see that when we put teachers around an actual intervention, where they have to work together, they seek help among the more experienced colleagues when they encounter difficulties.

The apprenticeship thus serves as a 'becoming' process to enculturate the struggling teachers towards embracing inquiry-based learning epistemology. This process can be facilitated by experienced teachers or researchers who create a visible point-at-able model, which others can see and reference; inject cultural dissonance to challenge teachers to think about new problems of practice; curate resources from teachers (student artifacts, lesson notes, and teachers' reflection notes) to engineer momentum to take place during discussions on how to move students' inquiries forward; anchor teachers within a frame of reflexivity that is concretely comprehensible; assist apprentice-teachers to understand the affordances of technology and propose strategies that would promote meta-cognitive thinking; and develop school-based core expertise at each innovative site so that the innovation can be sustained.

We posit that the notion of apprenticeship thus need not be as structured as traditional craft apprenticeships. Rather, it takes a whole process of teacher-learning, entailing teacher-doing, teacher-enactment, teacher-dialogue, and teacher-reflection, as reflected in the works on apprenticeship learning that we have delved into in the last decade. These include research works that have spanned the aforementioned macro, meso, and micro levels of analysis across various timescales, such as:

- *Individual*: peer to peer formal learning as mediated by learning technologies, e.g., Hung (1999);
- *School*: adaptability of schools as organizations linked to Communities of Practice (CoP), e.g., Hung, Lim, Chen, & Koh (2008);
- *Community*: collective and individual regulatory phenomena, e.g., Jamaludin, Kim, & Hung (2012); and
- *System*: systemic policy of translational research with recommendations of the process of spreading learning innovations (Hung, Lee, & Lim, 2013; Hung, Lee, & Wu, 2015; Lee, Hung, & The, 2013; Toh, Jamaludin, Hung, & Chua, 2014).

Additionally, in our recent book, *Adaptivity: A Disposition for Learning in the 21st Century* (Hung, Lim, & Lee, 2014), we weaved together the issues of boundary crossing, contextuality, identity, and sociability, and how these interwoven constructs relate to authenticity in learning oriented towards a process-epistemology consistent with the epistemic learning shift needed in teachers if they are to enact 21st century, inquiry-based classrooms. As we delved into different levels of analysis beyond the learner, we analyzed micro-cultures of innovation-change orchestrated by teachers and supported by school leaders. Hence, this book connotes the epistemic change level of our work.

Drawing upon the body of research on apprenticeship learning that OER has engaged in, our proposed program recognizes that the issue of scaling/diffusion is an issue of shifting the epistemic thinking of teachers—epistemology being the way the teacher views knowledge. It is an epistemic change in thinking—manifested in terms of a shift from frontal teaching to inquiry-based approaches, despite large class sizes—and we refer to it as epistemic learning.

Leadership for Facilitating Epistemic Change

While we observe that the implementation of ICT mediated school-based innovations create opportunities for changing classroom practices in Singapore schools, these changes in practices are not to be naively construed as changes occurring at the level of classrooms only. At the micro level, teachers' ontological and epistemological beliefs have to change as well. At the meso level, the coverage of syllabus and the pressure of high stakes examinations often require drilling and teaching to the test. Parental pressures also compel schools and teachers to respond in conventional ways that can meet the academic aspirations of stakeholders. As such, knowing how to navigate within acceptable boundaries to experiment with new designs and pedagogies without failing too badly becomes a pivotal concern.

For teachers, being responsible to every child and ensuring they do well in the current assessments are palpable preoccupations; and these are understandably

necessary and legitimate concerns of a teacher in a classroom. From the teachers' perspective, they are less inclined to adopt a high-risk intervention due to accountability towards their students and parents. How then do teachers become adaptive to both academic performances and the innovation introduced? To this end, we posit that teachers need to be supported with the appropriate socio-technological infrastructure, from which the culture for experimentation is cultivated, when engaged in these endeavors.

Along this vein, we recognize that leadership in support of curricular adaptations is crucial. Teachers need the time and bandwidth to reflect on and challenge the current assumptions of the existing curriculum before enacting innovative pedagogies. The question, then, is how do school leaders create the favorable conditions for the teacher in the classroom to learn together with other peers; and how would this process change the teacher's way of thinking?

In our related study of Future Schools (FS)* in Singapore (Toh, Jamaludin, Hung, & Chua, 2014), we found that school leaders need to create a sustaining culture where teachers are comfortable with experimenting, reviewing, and learning, all at the same time. Building or cultivating a culture of learning among teachers and developing their own lens in inquiry before they can scaffold students in disciplinary ways of constructing meanings is critical. According to these Principles (of FSs), engaging in inquiry-based learning is not a simple substitution for the existing curriculum. It requires a retrospective and critical need to revisit and understand the goals at hand. In addition, teachers need to be supported by more knowledgeable peers during the co-design phase of inquiry lessons, the enactment phase of lessons under challenging and authentic conditions such as large class size, and the reflective phase where feedback and reflections as situated within the context of a larger professional learning community (Teo, 2014).

*The FutureSchools@Singapore program is a selection of a few schools in Singapore that have demonstrated a heightened level of readiness in terms of ICT to create meaningful, engaging experiences for students through technology, pedagogy, and innovative school design. The development of the Future Schools@Singapore aims to enhance the diversity of educational offerings to cater to learners' needs and provide possible models for the seamless and pervasive integration of information and communications technology that includes interactive digital media (IDM). Through additional resources provided to the Future Schools and by harnessing infocomm technology in the education sector through innovative pedagogies and flexible learning environments, it is intended that these schools will be able to achieve not only higher levels of engagement of their pupils who already have an Infocomm-integrated lifestyle, but also as test-bed for innovative pedagogies that may then be scaled up to other schools.

Within such a backdrop, we recognize that the diffusion of innovations is not a straightforward process, where we can replicate experiences of the cultures of learning (from FSs) throughout schools in Singapore. While we can develop resources for both teachers and students, an epistemic shift is needed for inquiry-based learning to occur in teachers within the constraints of current dominant classrooms and their practices. This epistemic shift can be facilitated by leaders if we understand what is needed, namely:

1. Understanding the core kernel design and theory of the innovation at hand and articulating how these are aligned with the experimental school's narrative.
2. Creating socio-technological infrastructure:
 - a. enabling access to resources, facilitating partnerships, and corraling dialogues to encourage a participatory process; and
 - b. establishing structures and building cultures for community (group, peer) support to sustain epistemic change:
 - i. teachers struggling and receiving help through apprenticeship learning; and
 - ii. moving from teacher-generated to student-generated ideas (or a balance of both);
3. Implementing strategies for growing the teacher community (within schools) in the inquiry practices:
 - a. making visible the learning (via open classrooms); and
 - b. cultivating teacher leaders who can scaffold other teachers to foster disciplinary ways of seeing meanings; and
4. Forming lateral networks (across schools) to optimize resources and create apprenticeship learning opportunities for more teachers.

As innovation diffusion is correlated to teacher capacity and the leadership that enables the culture of learning to be cultivated, it is inevitably a *people capacity-building* endeavor. Structures can be set up to facilitate the process, but the 'right people' have to be put in place to enable it. Not only do we need structures and people, we need an interactional and engagement process to encourage teachers to experiment with inquiry approaches in their respective disciplines within an expanded socio-cultural peer/group/community context.

Cluster-Based Research Program for Innovation Diffusion

While effecting epistemic change at the teachers' level can be a protracted process, this can be accelerated by leveraging on a scalable innovation diffusion model at the systems level. We posit that the cluster system is an example of such scalable structure. The cluster system is set up in the Singapore education system to mediate

between the Ministry of Education's (MOE) centralized policies and schools' decentralized goals. While school leadership has been shown to mitigate teachers' demands and responsibilities in terms of teaching and learning, our hypothesis is that clusters—with their sharing and coordinating mechanisms—can aid to better align MOE's demands and a school's contextualized needs. Moreover, many of the interventions require new norms in terms of resourcing and other forms of funding. In our view, the cluster system is poised to coordinate and align demands relating to:

- resourcing (or the pooling of resources);
- teacher capability development; and
- school improvement (in teaching and learning) through interventions.

This in turn will create lateral networks of schools (around interventions) which can scale and sustain inquiry-based learning practices. Hence the cluster system enables the optimization of resources (both tools and teacher work) with economies of scale. As diffusion cannot always be sustained by research funding, structures within a cluster can be leveraged to optimize time and resources from the teachers' point of view. By forming school-to-school partnerships, transfer of (teacher) learning can be facilitated. As such, we need to develop teacher leaders to work across schools within the clusters. These teachers are particularly specialized in curricular and pedagogical dimensions of the innovation at hand.

Hence the central hypothesis for our research program in OER foregrounds (see **Figure 2**):

- cultivation of teacher leaders in championing innovations across the cluster;
- optimization of resources and hence the sharing of them across the cluster; and
- harnessing leadership as facilitated by the cluster structures (cluster superintendents, school principals, and other key personnel) to coordinate and align competing demands in the diffusion of innovation.

Conclusion

The scaling or diffusion of innovations in education cannot be divorced from the need to grow the capacity of teachers. Along these lines, we can create networks of learning within and across schools, in order to spread these disciplinary ways of thinking. But an epistemic shift is needed, as current classroom 'walls' are hard to tear down. Consistent with the applied learning emphasis, teachers need to undergo an embodied learning process. Teacher learning should not just be dominated by listening and doing some workshop activities, as in typical professional development, but instead they must be involved in learning through apprenticeship. Epistemic change requires both skills and cognitive change. Teacher epistemologies must be

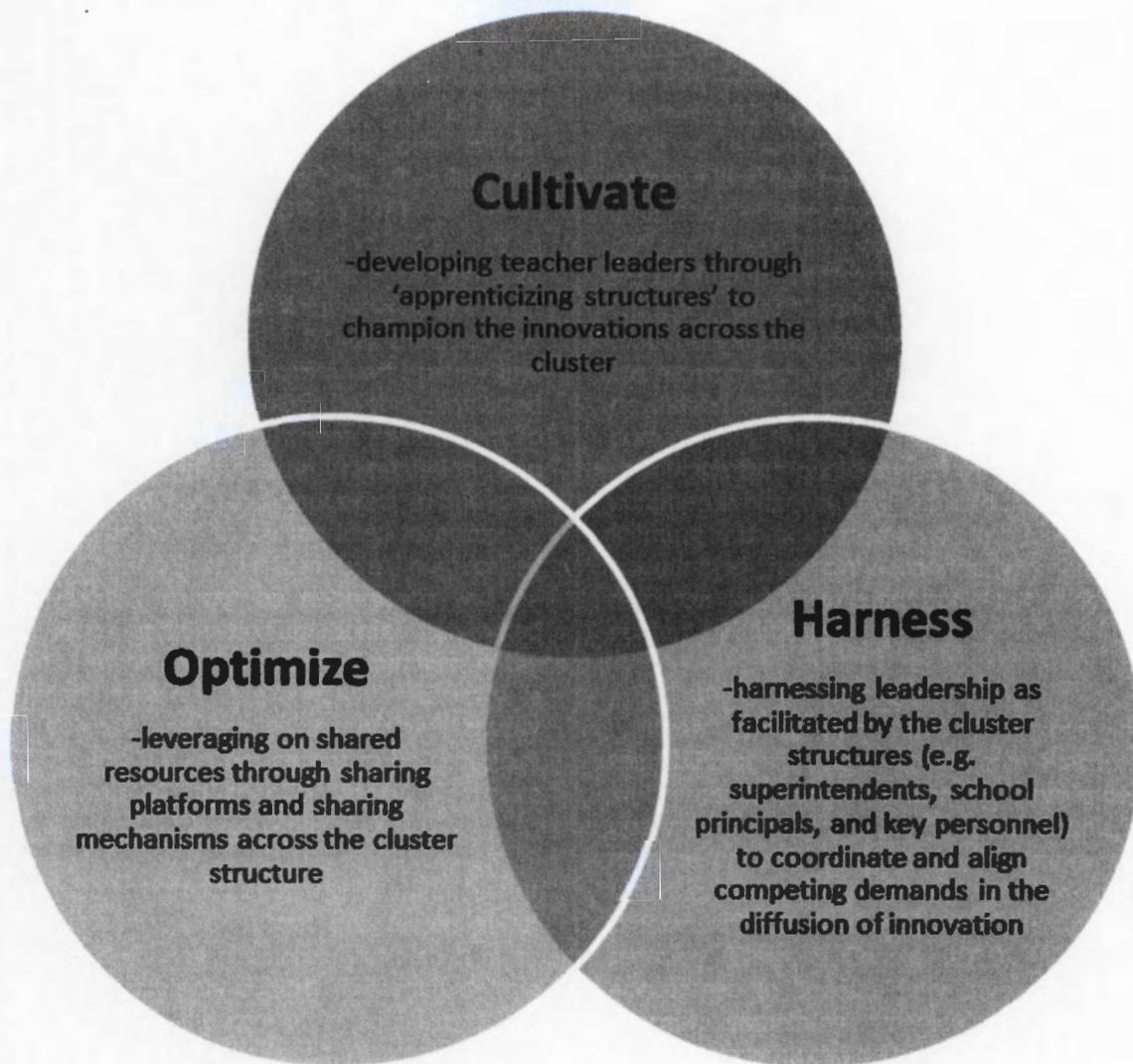


Figure 2. Operational tenets of OER's research program.

accompanied by relevant skills and knowledge required for disciplinary-enacted performances.

Concomitantly, school leadership is needed to create the socio-technological infrastructure to facilitate the change process and to sustain the culture for inquiry-based learning. Reward systems must align with the efforts made by teachers and provisions of time and space for experimentation. Moreover, school leaders have to collaborate with other schools and partners to pool resources and manpower. The growth of teacher leaders ('champions') to sustain innovations within and across schools will reinforce the socio-technological infrastructure for innovations to take root over time.

Finally, scaling up of inquiry-based learning, which we have argued as a teacher change in epistemology, cannot be hastened. It takes a cultural change. The journey toward inquiry-based learning is a change in the larger ecosystem of education. □

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How Do We Train Instructional Designers? Instructional Design as Negotiation

So Mi Kim

There have been many efforts to re-define instructional design (ID) competencies, models, and curriculum to reflect complex and dynamic real-world contexts. As part of such efforts, this article conceptualizes instructional design practice as negotiation between an instructional designer and under-stated constraints that multiple stakeholders convey. A conceptual framework that connects ID and the negotiation process is offered, along with implications for ID training programs.

The Challenges

Paul's primary responsibility is to collaborate with college instructors in their endeavors to (re)design, develop, and implement technologies in classrooms. He describes his working with instructors as "living on two separate planets." Instructors tend to have their own priority in course design with which Paul often does not agree. Mutual understanding is far beyond reach. What is to be done?

More than two decades ago, Lucy Suchman (1987) challenged the common assumption behind human-computer interaction design that human action follows pre-designed or planned procedures (e.g., how Xerox machines should be utilized). Human action is rather situated in a context (e.g., the context tells users how to operate the machines). Greeno (1994) asserted as well that human action is not simply reactive but proactive within a context. Accordingly, humans selectively and intentionally interpret and respond to context, accord-

So Mi Kim is a post-doctoral fellow at the University of Missouri–Columbia. Her research interests include scaffolding design and evaluation, supporting information-based problem solving in new media environments (e.g., game, social media, and open educational resources), and helping teachers, students, and lay people to learn to solve unfamiliar problems independently (e-mail: cotton93@gmail.com).