

TRANSFER AND SCALING OF KNOWLEDGE BUILDING PRACTICES: A JOURNEY FROM DIFFUSION APPROACH TO SITUATIVE KNOWLEDGE CREATION COMMUNITY APPROACH

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This paper reports a 12-year journey of bringing knowledge building practices into Singaporean classrooms and scaling up related pedagogical practices to more classrooms. It started with a linear diffusion approach, through a researcher (the author) who introduced the pedagogy to selected classrooms. In the mid-term, a collaborative learning approach was adopted which involved both researchers and teachers in co-designing lessons. The current approach can be regarded as a situative knowledge building community in which the teachers assume agency, not only in enhancing effectiveness of pedagogical practices in their classrooms, but also in spreading the practices to other classrooms and schools. The researchers facilitate teacher learning by helping the teachers to reflect and intentionally create knowledge artifacts that capture their advancement in understanding of their knowledge building practices. This journey has implications for the field of research on transfer and scaling of innovation. Rather than restricting to a categorical choice of specific approaches, it suggests an evolving trajectory that is dependent on the contextual conditions of the recipient sites and therefore, a need for an amalgamation of approaches at different phases of the journey.

Keywords: Transfer; scaling; technology; knowledge building pedagogy; situative approach.

1. Introduction

This paper reports a journey of transfer of technology-mediated pedagogy, knowledge building (Scardamalia & Bereiter, 1996, 2006), which originated in Canada, to Singaporean schools. Knowledge building refers to the continual production and improvement of ideas useful to a community through the collaborative efforts of its members (Scardamalia & Bereiter, 2006). The term “journey” is used as it spans a history of more than a decade and it involves trials of a few approaches. Typically, technology transfer refers to “the development of a technology in one setting which is then transferred for use in another setting” (Markert, 1993, p. 231) whereas diffusion of technology emphasizes the utilization of a technology in a new setting (Rogers, 2005). Johnson, Gatz, and Hicks (1997) held that transfer and diffusion are so intricately intertwined that they should be considered together – “both the movement of technology from the site of origin to the site of use and issues concerning the ultimate acceptance and use of the technology by the end user” (p. 35). Despite this effort to combine the two concepts, transfer and diffusion typically shows a clear power differential – from

the technology originator to the end user in another setting. This paper documents our journey, from a linear diffusion approach, to a bi-directional enterprise that engages the users at the target site to take on agency to contribute knowledge to the larger technology innovation community.

2. Models of Technology Transfer – From Traditional to Social Constructivist Approach

Technology transfer is a complex process, involving multiple stakeholders and multiple issues. This paper focuses on the approaches of transfer. Our experience can be framed by the categorization of approaches suggested by Tenkasi and Mohrman (1995), who reviewed three traditional models: The Appropriability Model, the Dissemination Model, and the Knowledge Utilization Model. The Appropriability Model relies on good technology and quality of research as its natural marketing strategy. It is the customers who pursue the innovation communicated through technical reports or journals. The Dissemination Model uses experts to transfer knowledge to the willing receptor. Shifting the focus to the receptor's end, the Knowledge Utilization Model focuses on successful applications of knowledge at the recipient's setting. However, Tenkasi and Mohrman (1995) argued against the linear bias of these models that entailed "a one-way transmission of information, from source to destination or from originator to receiver." (p. 149). More importantly, they argued against the epistemological assumptions of these three models: "Knowledge can be objectively determined and will be objectively consumed", "knowledge is applicable across contexts" and "knowledge is complete" (p. 150). In fact, the term "transfer" connotes the transmission metaphor where nicely packaged knowledge can be transmitted one-way from the innovator to the recipients. The knowledge utilization model uses two-way processes but still subscribes to the notion of objective knowledge.

What Tenkasi and Mohrman (1995) subscribed to is a social constructivist epistemology (Denzin, 1989). From this perspective, knowledge is socially constructed and sanctioned by members in a community; it is also subjectively consumed because the recipient community has its unique interpretive perspective. Due to the unique meaning system in the recipients' community, knowledge needs to be reconfigured within the new context. Thus, it is not a simple adoption of an imported technology or innovation, but an appropriation process depending on the interpretive schemes, the norms, and power relationships in the new context. Finally, the notion that knowledge is "incomplete" (p. 156) is critical because it is distributed throughout society and it is subject to improvement. The consequence of blind adoption is what Brown and Campione (1996) termed as the trap of "lethal mutation", where the intended meaning and structure of the original materials are violated. In other words, the appropriation process necessarily involves creative synthesis of new conceptual knowledge of the innovation and the practice-based knowledge of the recipient's community. Based on these assumptions, Tenkasi and Mohrman (1995) suggested transfer as contextual collaborative knowledge creation, through which "distinctive individual knowledge,

meanings, assumptions, and beliefs are exchanged, evaluated and integrated with those of others” (p. 159). No concrete example, however, was provided to illustrate this approach.

This paper uses the categorization by Tenkasi and Mohrman (1995) to frame our approaches of introducing knowledge building pedagogy to Singaporean schools. Three approaches will be shared, with more emphasis on the latest approach: the teacher knowledge creation community. This approach involves technology transfer through the effort of a teacher-researcher knowledge building community, which is an emerging model of technology transfer through which the users at the target site engage in knowledge creation effort to improve the practices at the local schools, and at the same time, contributing back to the field of research on knowledge building.

First, let us look at knowledge building pedagogy and the technology that are intended to be transferred.

3. Knowledge Building Pedagogy

The following is an example of a knowledge building episode in a classroom. Understanding what knowledge building looks like and the characteristics of knowledge building is essential as it provides some clues to the challenges of introducing this pedagogy. More importantly, the current approach (teacher-researcher knowledge building community) relies on the same key principles.

The following example happened in a 4th Grade Singaporean classroom in a typical elementary school located in a suburban town in Singapore. The topic of instruction was “Energy”. One of the laboratory activities prescribed in the workbook adopted by the school was the activity called “Why the Spiral moves?” In this activity, a candle was lit and a paper cut into spiral was hung above the burning candle. The spiral would move, as if turning in a circular manner. In a typical laboratory session, the students would conduct the experiment and provide a two-line explanation. A typical answer would be “the burning candle produces heat energy that makes the spiral moves.” In this lesson, the teacher used the candle activity as a trigger, and asked the students to draft their initial thoughts as notes in Knowledge Forum (Figure 1), an online forum.

In one of the display options in Knowledge Forum, the notes could appear as linked square icons. Upon double click of a note, the note screen will appear. Of significance is the left panel that provides the scaffolds as sentence opening cues (e.g. My theory, I Need to Understand). These are important thinking cues, customizable by teachers, to engage students in productive epistemic discourse that focuses on reflecting on ideas and improving ideas.

To illustrate idea improvement, the following excerpt of discussion was extracted from notes appearing in one of the threads of interactions. The words in the square brackets are scaffolding phrases the students pulled from the note panel in the Knowledge Forum.

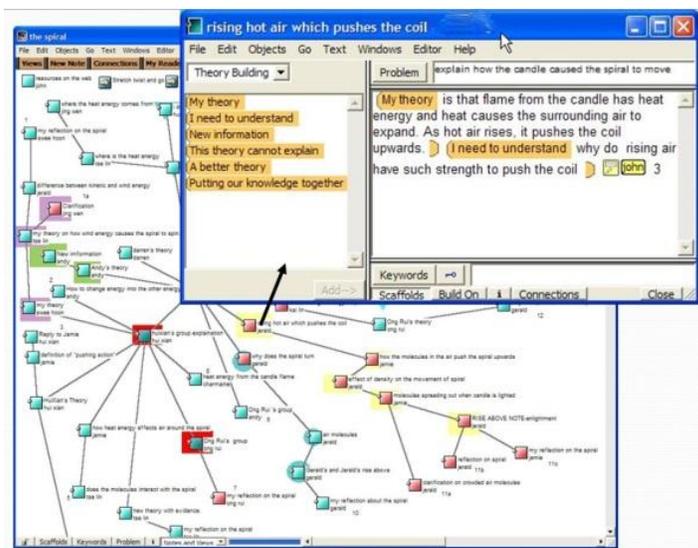


Figure 1. A screen shot of the students' notes in Knowledge Forum, an online forum.

Student 1: [My Theory] is that flame from the candle has heat energy, and heat causes the surrounding air to expand. As hot air rises, it pushes the coil upwards. [I Need to Understand] why do rising air have such strength to push the coil.

Student 2: [My Theory] Perhaps as the heat from the flame continues burning for quite some time, the expansion of molecules in the air will increase, and as they accumulate, they rise in an upwards direction towards the spiral, pushing the spiral up ...

Student 1: [My Theory] is that the heat does not cause the molecules to expand but the heat from the candle flame makes the surrounding air less dense and will cause the air to rise/float ...

...

Students 1 and 2: [Putting our knowledge together] Chemical potential energy in the candle wax is converted into Heat and Light energy when the candle is lit. The heat energy is then converted into kinetic energy when the air molecules spread out and rise upwards. As the hot air rises, the kinetic energy in the rising hot air will then "do work" to push the spiral upwards ...

From this short excerpt, we can see that in the second note, the student had proceeded beyond the observable to the non-observable (the particulate nature of matter) and explained the phenomenon from the molecular perspective. After some interactions, the final "rise above" note by both students shows that the students not only invoked the theory of particulate nature of matter, but also the concepts of kinetic energy and

potential energy. This depth of scientific knowledge demonstrated far exceeds the typical two-line answers found in many students' workbook.

There are a few key characteristics of knowledge building pedagogy:

- (1) Idea centeredness. Getting students to put forth their ideas is critical so that different ideas are made available to all the students. These ideas are captured as knowledge artifacts (notes in an online forum) which reify the ideas and make these ideas visible to others. It usually starts with questions of understanding about the world (in the above example, why did the spiral move?)
- (2) Knowledge building practices. Getting students to collaboratively improve their ideas is important. In a group setting, the students need to appreciate other's perspectives and use productive knowledge building discourse that applies epistemic criteria to improve the quality of the ideas. Mercer and Littleton (2007) suggested the use of "exploratory talks", which are characterized by active listening, appreciating of alternative views, constructive challenging of ideas, and collaborative improvement of ideas. In the process of ideation and idea improvement, external authoritative sources of knowledge (e.g. textbooks) are used, but they are used critically and constructively in service of illuminating the issue being discussed.
- (3) Epistemic agency. Ability to engage in knowledge building discourse means that the students are able to use epistemic criteria to assess the quality of their ideas. Such assessment practices are an integral part of the knowledge building (assessment for learning and assessment as learning), rather than a separate end-of-learning activity (assessment of learning).
- (4) Collaborative culture. Knowledge building practices are different from prevalent classroom practices that focus on individual cognitive gains and demonstration of knowledge or skills in separate assessment activities. Students need to assume collective cognitive responsibilities in improving knowledge artifacts in a classroom environment that democratizes knowledge contribution rather than one that privileges just the teacher or specific group of learners. The students need to work collaboratively, rather than competitively, towards improving artifacts that will benefit all in the group.
- (5) Collaborative technologies. Technologies such as an online forum play a critical role in knowledge building because they afford a tool for creation of knowledge artifacts, a tool for collaborative interactions, and a tool to capture the artifacts and trace the advancement of the ideas captured in the artifacts.

4. Early Approaches – Appropriability and Dissemination Approaches

Earlier attempts to bring in knowledge building pedagogy to Singaporean classrooms started in 2001. Tan (author of this paper) was attracted to the potential of the knowledge building pedagogy and applied for a research grant to implement this in Singaporean schools. It is an Appropriability approach in that based on the publications by the innovators (e.g. Scardamalia, 2002; Scardamalia & Bereiter, 1996, 2006), it was the researcher at the recipient end who initiated the transfer. Such innovation was then

introduced by the researchers to several schools in Singapore, which is effectively a Dissemination approach (Rogers, 2005).

The researcher approached several school leaders and made a presentation to the leaders and teachers about the potential of this pedagogy. At least three schools agreed for the trial. In one of the schools, the trial ended after two weeks, when the teacher experienced technical problem with Knowledge Forum, the online forum that supports knowledge building. As the earlier version used a server-client technology, technical difficulties could not be resolved within a short period of time. Decision was made by the teacher to end the trial. In the second school, one teacher tried out the pedagogy in his class for students conducting a science project. It was a time when internet-relay chat (IRC) was highly popular. The students were found to engage in social chats using the Knowledge Forum, rather than engaging in productive epistemic discourse. Often, the students posted short notes that discussed about the procedures of doing science project (e.g. who is responsible for which tasks), rather than the science topic being investigated. Disappointed by the outcome, the project was abandoned after about three months. A small breakthrough was finally found in the third school. This school offered science inquiry class as enrichment lessons for selected students. These classes were conducted once a week in the afternoon. The researcher offered to co-teach the lessons with the school teacher for 12 weeks. After the intervention, the experimental group was found to performed better in some aspects of scientific inquiry (defining variables and stating hypothesis) and the achievement test results (Tan, Hung, & So, 2005). The intervention, however, stopped with the end of the science inquiry enrichment classes at the completion of the semester. In other words, the transfer was short-lived. The earlier attempts lasted from 2001 to 2004.

4.1. *Challenges and values of Appropriability and Dissemination Approaches*

The pathetic outcomes of the earlier attempts highlighted one key challenge to the transfer of knowledge building pedagogy to Singaporean schools: acceptance of new pedagogy and technology. Even though publications that show the values of knowledge building pedagogy in international context (e.g. Scardamalia & Bereiter, 1996) are easily available, there are several related factors that could inhibit acceptance by teachers and students. Rogers (2005) suggested several factors related to the appropriateness of technology, including relative advantage, compatibility, complexity, triability, and observability. The fact that the three schools agreed to try out the pedagogy suggests that they were at least convinced of the potential of the relative advantages of the new pedagogy. The technical difficulty experienced by the first school, however, rendered the technology not viable and experimentation could not be continued. In the second school, the predominant culture among the students (social chats using IRC) was not compatible with the productive knowledge building discourse. The third school saw some extent of successful implementation, but it highlighted one major disadvantage of the linear model of transfer, the issues of buy-in and agency. While the co-teaching of the researcher helped to achieve to some extent the desired outcomes, it was not a viable

option for long-term implementation, nor was it feasible to integrate the pedagogy to the mainstream curriculum.

There are, however, valuable outcomes from the earlier attempts. First, the researcher gained first-hand experience about the challenges faced when introducing the innovation to the local context. Second, research publications in local schools were generated from the third attempt, which could serve to inform other schools in future. Third, some degree of “knowledge transfer” was achieved. In the third school, for instance, one of the teachers completed her Master thesis based on the intervention in the school. It was a way to build teacher capacity to continue with the intervention without the researcher. The researcher also supervised three other Master students through his university program and thus began the journey to build up a local community of educational researchers who might be interested in this pedagogy.

5. Mid-term Approach - Collaborative Learning Approach

Following the earlier attempts, more researchers collaborated in the subsequent research projects introducing knowledge building pedagogy to Singaporean schools. This phase of intervention happened roughly between 2005 and 2009 at two research sites (see Ow & Bielaczyc, 2008; Tan & Seah, 2011; Yeo & Tan, 2011). Departing from the linear approach, the strategies used are similar to the collaborative learning model (Tenkasi & Mohrman, 1995), where emphasis was on the refinement of the pedagogical applications involving both researchers and the teachers. From the researchers’ perspective, design experiment (Brown, 1992; Cobb, Confrey, deSessa, Lehrer, & Schauble, 2003) was the key methodology adopted.

The following case example is taken from one of the two research sites. From 2006 to 2008, three iterations of research cycle were implemented and evaluated. In this case, the school was interested in enacting a problem-based learning approach. The researchers were approached to collaborate on the research project. In the first cycle, the team of physics teachers designed and implemented their problem-based lessons, while the researchers (including the author) acted as ethnographers. Using Cultural Historical Activity Theory or CHAT (Engeström, 1999) as a framework of analysis, the researchers found that the espoused motive of implementing PBL was not achieved but rather, the PBL was the mediating tool towards achieving the traditional goal of imparting science knowledge. The researchers discussed the findings with the teachers and suggested shifting the focus back to problem solving as the object of the activity system. The second intervention revealed some unexpected findings. The students were motivated and oriented towards finding the solutions, but in some cases, used simple heuristics and trial-and-error method rather than tackling the problems with the relevant physics principles. The researchers suggested to the teachers to include a knowledge building phase in their PBL to engage the students in deep learning of the relevant physics concepts and principles, before proposing the solutions. In addition, to support problem solving processes, the school engaged a vendor to develop Knowledge Constructor, a computer-supported collaborative learning (CSCL) tool. Similar to

Knowledge Forum, Knowledge Constructor is an online discussion forum with a graphical interface. It uses icons to represent different types of ideas, thus constrains the ways ideas can be represented and discussed. After the third intervention, there was a better balance between the dual goal of achieving better understanding of subject knowledge and developing the students' problem solving skills. The researchers left the research site in 2008 but to this date, the school continued with their problem-based framework.

This collaborative learning approach resembles the "learning study" approach proposed by Marton and Pang (2006). Learning study hybridizes the Lesson Study and Design Experiment methods. Lesson study (Yoshida, 1999), which means "research lesson" in Japanese, focuses on improving classroom teachings through joint planning by teachers on a particular learning goal, followed by peer observation and focused discussion based on the video recording of the lessons. It is practice-oriented and focuses on improving classroom practices. Design experiment (Brown, 1992; Cobb et al., 2003), on the other hand, is research oriented and focuses on advancing theories about the process of learning of a particular domain, and ways to support this learning process. Similar to lesson study, it has similar focus on observing classroom practices, but it brings in additional goal of improving educational theories guiding the design of the lessons. It is thus both reflective and prospective in that it assesses how well a theory-based intervention works, and generates ideas for further experiments.

5.1. *Challenges and values of the Collaborative Learning Approach*

In contrast with the Appropriability and Dissemination model, one distinct difference of the collaborative learning approach is the equalization of power differential between the researchers and the teachers. In this case, the recipients (teachers) displayed agency right from the commencement of the project: They initiated the first pedagogical framework and they initiated the research. In addition, the researchers worked closely with the teachers throughout the intervention. Findings were presented and discussed with the teachers, but the teachers were the owners of the curriculum. They led the design of the lessons and implemented the lessons. Another distinct feature of this approach was the iterations of intervention design. Although the pedagogical design started with PBL, the final pedagogical framework was a hybrid between PBL and knowledge building. It is a contextualized knowledge creation effort that leverages the distributed expertise between the researchers and the teachers. The researchers played their roles as researchers – collecting data, interpreting results and sharing their findings – but also extended their roles as co-designers of the lessons. The teachers played their roles as teachers – implementing the lesson plans and guiding the students – but also extended their roles in creating a hybrid model of pedagogy. Perhaps the most distinct feature of this approach is that the innovation (PBL and knowledge building) are used as a mediating tool to achieve an authentic outcome (more effective student learning), yet the outcome also included an improvement to the innovation.

While overcoming some limitations of the earlier linear approaches, one of the key limitations of this collaborative learning approach is the localized effect. The researcher-teacher coupling works well in a school – pedagogy is refined and a new hybrid model is created – nevertheless, the impact is confined within the school, or perhaps within the few classrooms involved in the project. In sum, the teachers assumed change agency only for their own classes.

6. Current Approach – Knowledge Creation Approach

Extending from the Collaborative Learning model, our current approach uses the Knowledge Creation community model. This community involves teachers from five different schools. In each school, professional learning team (PLT) involving about four to six teachers meet regularly to discuss intervention in their respective schools. Each of these PLTs is led by a teacher who has more experience in the knowledge building pedagogy. The leader acts as a facilitator to discuss about students' work, as well as a mentor for new members who are new to the pedagogy. A reflection by one of the PLT leaders gave a glimpse of what went on in her PLT and the observable impact on students:

I used my P5 Science class as a discussion focus so that none of my teachers felt pressured nor stressed that they have to adopt something new and might take up more time. Thus, it took my members one full term of Term 1 before they garnered enough courage to venture into KB for lesson on Environment. Their main concern was that these classes are graduating classes and time was a constraint. It was indeed true that instead of spending 2 weeks on Environment, we stretched it to between 3 to 5 weeks and left only a couple of weeks for teaching Adaptation. As members, we were very motivated to find a shorter and effective way to complete the syllabus but of course we used KB on Adaptation. Not that we need to, but the students demanded it by requesting and even refusing to pay attention to teacher talk. We incorporated CL (collaborative learning) strategies into Adaptation topic and viola! Teachers reported that the students taught themselves and we had very little voice in class – through sharing and building onto others' knowledge or queries, we only had to do consolidation of the entire topic using 2- 4 periods. Results showed they were none the worse.

Each week, at least the leader of PLT in each school will meet with a researcher from the Ministry of Education to share and discuss some issues faced in their intervention. About once in every four months, a special event will be organized – to attend a meeting involving researchers from universities, a study trip overseas, or a conference. For example, a study trip was organized in March 2013 for the teachers in the community to interact with teachers and researchers in Hong Kong. The Hong Kong community (Chan, 2011) has also evolved over the years with their unique journey of scaling of innovation. They discussed various issues related to the implementation of

knowledge building and co-taught some of the lessons there. The event spurred the teachers' motivation further. Their discussion on the Knowledge Forum sustained from March to July (Figure 2).

Below is an excerpt on one of the threads that begins with a question by one teacher on ways to diffuse the innovation to more teachers.

Teacher 1: [I need to understand] how to enthuse more teachers to use knowledge building?

Teacher 2: [My Theory] KB is not new, as we reflect on the 12 principles, we can identify with some of them and as a matter of fact, some teachers are already doing it ... If the teachers do not see KB as something NEW and it is really about what they are already doing, they might be more willing to try it out?

Teacher 3: I think the key factor that makes KB different than other pedagogy is that it's based on students' idea, improving idea and putting ideas together. I think idea is what that makes it authentically KB.

Teacher 4: [My Theory] I see that I can repackage my SIOs (Specific instructional objectives) so that students approach it from another angle. Instead of teacher being the transmitter of (our sometimes limited) knowledge and facts, the teacher instead "masterminds" the lesson, playing the role of facilitator to guide the students to discover the knowledge themselves, and hence "own" the knowledge. This is central to the constructivist mode of learning.

From this short excerpt, we could see how a question triggered different ideas to tackle the issue: clarifying the pedagogical characteristics of knowledge building,

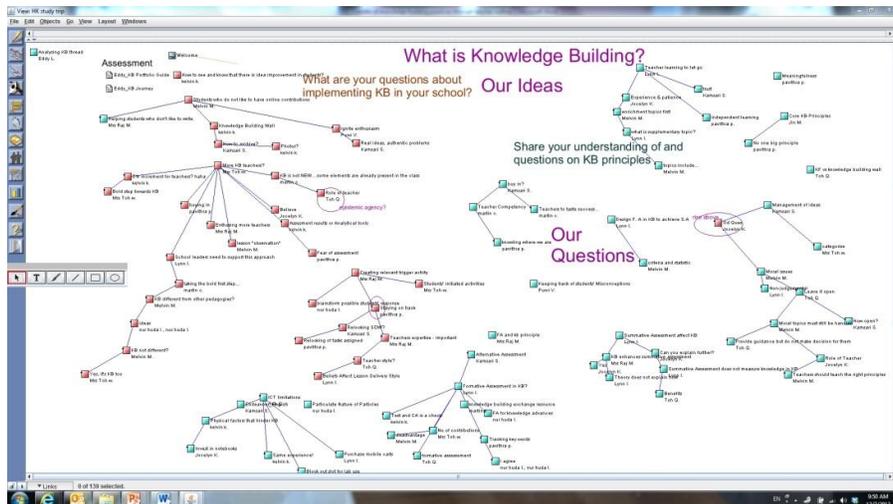


Figure 2. Teachers' discussion initiated during their study trip to Hong Kong.

starting from what some teachers are already doing, and elaborating on the constructivist aspects of knowledge building. Perhaps what is more impactful is the motivation behind this thread of discussion. The teachers have moved beyond the immediate concern of their own classrooms, and assuming agency to influence other teachers toward the adoption of the pedagogy.

This approach shares the key characteristics of knowledge building pedagogy discussed earlier: Idea centredness, knowledge building practices, epistemic agency, collaborative culture, and collaborative technologies. It has, however, a slightly more complex nested activity structure: it is a teacher knowledge building community that works on improving implementation of knowledge building pedagogy among students. There are dual goals of making an impact on students' learning, as well as achieving teacher learning. At times they discussed about students' ideas, thinking about ways to help students advance their ideas. In the teacher-researcher community, they discussed about their own ideas that reflected on their learning, as well as influencing other teachers. This toggling in focus between students' ideas and teachers' learning is a powerful mechanism, in that it demonstrates the teachers' epistemic agency not only in guiding their students to engage in knowledge work, but also in reflecting and creating in-situ teacher's knowledge about the pedagogy. Scardamalia (2002) suggested that pupils with epistemic agency will deal "with problems of goals, motivation, evaluation, and long-range planning that are normally left to teachers or managers" (p. 79). Extending the concept to teachers, we could view teachers' epistemic agency as a key attribute of their productive participation in a knowledge creation community. The teachers display their epistemic agency by engaging in productive discourse involving reasoning and reflections, and through volitional, sustained effort, create real impact on students' learning while advancing their teacher knowledge.

This knowledge creation approach ventures beyond the concept of transfer and adoption of innovation, and signifies a scaling of innovation by the end-users. The teachers' actions thus demonstrate some of the key aspects of scaling of innovation suggested by Coburn (2003). There is *depth* of changes in the classrooms, as shown by the teachers' nuanced understanding of the pedagogy; there is *sustainability* as the pedagogy has been practiced in at least three of the schools for more than three years; there is *spread* of pedagogy within the schools, and within the larger education community in Singapore; there is also a *shift* from external agenda to internal ownership as evidenced in the teachers' epistemic agency.

7. A Reflection on Our Journey

Steve Jobs (2005), in his commencement address to graduates in the Stanford University, reflected on his earlier life journey and offered this serendipitous remark: "you can't connect the dots looking forward; you can only connect them looking backwards." Likewise, the journey we have taken to bring knowledge building pedagogy into Singapore classroom is not a premeditated endeavor. The framing using various transfer and adoption models is a post-hoc reflection. Nevertheless, it helps us to reflect on the

processes and offers some insights into the outcomes. Table 1 summarizes some of key aspects of change.

The collaborative learning approach and knowledge creation approach involve community comprising both teacher-practitioners and educational researchers in a synergistic relationship: the teachers contribute their expertise in contextual knowledge about their schools and classrooms and their practical wisdom in teaching specific topics; the researchers contribute their respective expertise in learning theories and specific knowledge about the knowledge building pedagogy. In the community, the teachers implement the lessons, reflect on the lessons, and suggest specific actions to take to help students advance their knowledge building. The researchers facilitate teacher learning community by helping them to reflect on and construct their pedagogical knowledge. Such practices preserve the agency of teachers in making pedagogical improvement and with the participation of the researchers, help to liberate the teachers from their deeply entrenched culture, by bringing in ideas from researcher communities. It generates a symbiotic relationship that could help to improve classroom practices, and provide an authentic context to test and improve educational theories. The key difference between the second and the third approach lies in the extent of teacher agency and their impact.

Table 1. Summary of key changes.

Approach	<i>Appropriability and Diffusion</i>	Collaborative Learning	Knowledge Creation community
Approximate Period	2001-2004	2005-2009	Since 2010
Mechanism of diffusion	Linear transfer – from innovator to recipient	Situative and collaborative evolvement of local knowledge on implementation of innovation. Iterations in design of the intervention.	Same as collaborative learning. In addition, creation of knowledge generalizable to broader contexts.
Roles of researchers	As experts introducing the new pedagogy - knowledge building. Designer of classroom activities.	As specialists on research methods and co-designer of classroom activities.	As facilitator of teacher professional learning community and broker for connection to other communities
Roles of teachers	As recipients of the new pedagogy	As specialists on classroom practices and co-designer of classroom activities.	As agency of change for own classrooms and spread of innovation to other educators. Involved in creating knowledge in the teacher learning process
Agency of change	Researchers, advice from innovators as consultants	Researchers and Teachers	Teachers and researchers. The teachers demonstrate volitional effort in influencing other teachers in a wider community.
Impact	Limited impact on students and teachers	Changes limited to localized sites.	Teachers lead scaling effort to other teachers and to other sites.

The knowledge creation community brings about intentional codification of the teacher knowledge to generate transferable knowledge that could benefit a greater circle of educators. The teachers also develop and demonstrate their volition in expanding their circle of influence.

While the latter efforts seem to create greater impact, it does not imply that future attempts at transfer and diffusion of innovation could leapfrog using the knowledge creation community. It is noteworthy that the continual effort over the years has helped to develop expertise among teachers and lay the seeds for change. One of the key researcher-facilitator of the knowledge creation community, for example, was a Master student during the beginning phase of the reported journey. She was motivated to implement knowledge building pedagogy in her classroom and completed a Master's thesis based on the outcomes of her classroom intervention. She went on to complete her PhD under the supervision of one of the innovators (Marlene Scardamalia) and upon her return to Singapore, became the key pillar in the scaling effort. In other words, time is necessary for a critical mass of researchers and teachers to develop so that a productive knowledge community could be assembled. This journey, nevertheless, suggests a possible trajectory of innovation transfer, from linear transfer and diffusion, to collaborative and situative involvement of local knowledge, to agentic change and scaling of innovation led by the adopters. Each phase achieves incremental outcomes and strengthens the foundation for the deepening, sustaining, and spreading of the innovation to more educators in the country.

8. Conclusion

This paper is a post-hoc reflection of a more-than-a-decade journey of bringing knowledge building practices into Singaporean classrooms. It was initiated by a researcher (the author) who was convinced of the potential of the knowledge building pedagogy. He introduced the pedagogy to interested teachers in selected classrooms, though with limited impact. Such approach has characteristics of the Appropriability and Dissemination approach, which is linear in nature. In the mid-term, the knowledge building practices were spread to more schools and researchers. It was characterized by a collaborative learning approach which involved both researchers and teachers in co-designing the lessons and interactively improved the lesson design and implementation. The current approach is regarded as a situative knowledge building community in which the teachers assume agency, not only in enhancing effectiveness of pedagogical practices in their classrooms, but also in spreading the practices to other classrooms and schools. The researchers facilitate teacher learning by helping the teachers to reflect and intentionally create knowledge artifacts that capture their advancement in understanding of their knowledge building practices. The journey saw a progressively larger circle of influence and impact and greater agency assumed by the teachers. The power differential between the researchers and the teachers is also reducing as the teachers display stronger agency in spreading the innovation.

This journey has implications for the field of research on transfer and scaling of innovation. While the literature suggests disparate categories of approaches, our journey suggests an evolving trajectory that is dependent on the contextual conditions of the recipient sites. Each phase builds the foundation for the subsequent phases and consequently, we saw an amalgamation of approaches at different phases of the journey. This suggests a possible fusion of the concepts of transfer, diffusion and scaling of innovation; rather than treating them as distinct field of research, we could regard them as incremental methods of seeding an innovation at recipient sites, nurturing contextualized practices, generating situative knowledge, and spreading the practices to similar sites. While the full impact of the current approach is yet to be realized, we hope that the knowledge creation community will be a site where new innovations could emerge such that a full cycle is brought to fruition: the initial recipients become innovators of the future.

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