Learning Innovation Diffusion as Complex Adaptive Systems through Model Building, Simulation, Game Play and Reflections

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Abstract: To effectively foster innovation diffusion, school leaders need to learn innovation diffusion as Complex Adaptive Systems (CAS). In this study, two school leaders formed a dyad to learn both the knowledge about innovation diffusion and the knowledge in fostering innovation diffusion. Agent-based model building, model simulation, game play of a simulation game and reflections were designed as learning activities in this study. In the learning process, the learners developed the following understanding in innovation diffusion: teachers’ adoption decisions are based on limited rationality and local information; teachers have nonlinear influence on each other through social networks; teachers are heterogeneous agents; and diffusion is a process of emergence. The learners also learnt to leverage on social networks to foster effective innovation diffusion. While agent-based model building faces challenges for learning CAS in the social science domain, this study shows that engaging learners in reflection activities helps to overcome the challenges.

Innovation Diffusion in Schools: Learning Challenges That School Leaders Face

The past decade saw many education innovations, but the diffusion (Rogers, 2003) of such innovations has yet to receive adequate attention in education research (Christensen, Horn, & Johnson, 2008; Surry & Ely, 2001). For school leaders to effectively diffuse innovations, it is essential that they (a) understand innovation diffusion as Complex Adaptive Systems (CAS) (Dooley, 1996; Holland, 1995), and (b) learn how to foster diffusion.

Need to learn innovation diffusion as CAS: Rogers, Medina, Rivera and Wiley (2005) conceive innovation diffusion as CAS, a sub-set of Complex Systems (Bar-Yam, 2003). Different from Complex Systems, CAS has multiple semi-autonomous agents (such as human beings) (Holland, 1995) whose decision-making is based on limited information and limited rationality (Gigerenzer & Selten, 2002). The agents are constantly evolving and adapting to what the other agents are doing by interacting with other agents (locally) so as to maximize their fitness in the environment (globally). The structures and patterns of a CAS tend to be emergent (Holland, 1995). Huang and Kapur (2007) regard innovation diffusion in school as a result of many teachers (who are seen as semi-autonomous agents in a CAS) interacting with each other in school social networks. As teachers adapt and change (similar to how agents self-organize in a CAS) over time, innovations are re-invented and adopted over time and space in a school.

However, there is a strong top-down tradition in innovation diffusion (Niehaves, 2007), which maintains that imposing a top-down mandate in a school for a sufficiently long period will result in sustainable and pervasive adoption of innovations among teachers (Christensen, et al., 2008; Looi, Lim, Koh, & Hung, 2005). This perspective takes a mechanistic view rather than a CAS view on innovation diffusion.

Need to learn how to foster innovation diffusion: There are differences between the knowledge about innovation diffusion (“knowledge-about”) and the knowledge in fostering innovation diffusion (“knowledge-in-doing”). Using swimming as an example, the “knowledge-about” swimming includes the concept of buoyancy which can be used to describe and explain swimming whereas the “knowledge-in-doing” swimming refers to the personal knowledge that a swimmer has in the act of swimming. The characteristics of the two kinds of knowledge are summarized in Table 1.

<table>
<thead>
<tr>
<th>Knowledge-about</th>
<th>Knowledge-in-doing</th>
</tr>
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<tbody>
<tr>
<td>Knowledge to describe and explain a phenomenon</td>
<td>Action dependent knowledge in changing a phenomenon</td>
</tr>
<tr>
<td>General and abstract</td>
<td>Situational and embodied</td>
</tr>
<tr>
<td>Relatively static</td>
<td>Temporal and dynamic</td>
</tr>
<tr>
<td>Explicit; can be described by the knower</td>
<td>Mostly tacit; cannot be totally reduced to mere words, but can be acted out in situations</td>
</tr>
<tr>
<td>Evidenced by descriptions, artifacts and description-oriented actions</td>
<td>Evidenced by interpretations of actions and reflections towards actions</td>
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Innovation diffusion as CAS is a form of “knowledge-about” which is different from the knowledge in fostering innovation diffusion (“knowledge-in-doing”). There is a need for school leaders to learn both.

The rest of the paper is organized into four sections. Section 1 synthesizes the literature and concludes that the literature on learning Complex Systems and learning innovation diffusion rarely focus on the development of “knowledge-in-doing”, and the learning processes are largely uninvestigated. This section further draws design conjectures for learning innovation diffusion as CAS. Section 2 outlines the research methodology in this study: the interpretivist paradigm and the case study method, and the learning design framework which includes agent-based model building, model simulation, game play and reflections. Section 3 reports the four learning trajectories identified in the learning process: teachers’ adoption decisions based on local information and limited rationality; teachers’ nonlinear interactions through social networks, teachers’ heterogeneity, and diffusion as a process of emergence. The last section discusses the affordances and limitations of Agent-Based Modeling (ABM) and reflections for learning CAS in the social sciences domain.

1. Review of Literature

The review of literature is divided into three parts. The first part reviews the literature of learning Complex Systems: the literature focuses primarily on learning the knowledge about Complex Systems in the science domain, where the processes of learning are rarely investigated. The second part reviews the literature of learning innovation diffusion. The literature lacks of evidence of learning outcomes and understanding of learning processes. The third part reviews the design principles from the two bodies of literatures and draws four design conjectures: to activate learners’ prior knowledge, to provide opportunity for exploration and experimentation, to encourage collaboration and to provide opportunity for reflection.

Learning Complex Systems

Learning Complex Systems has proven to be difficult (Hmelo-Silver & Azevedo, 2006; Jacobson & Wilensky, 2006), and Kapur and Jacobson (2010) regard learning as an emergence. The research on learning Complex Systems is still at the emerging stage (Jacobson & Wilensky, 2006).

Almost all the empirical studies (Azevedo, Guthrie, & Seibert, 2004; Levy & Wilensky, 2008; Son & Goldstone, 2009) measured students’ “knowledge-about” Complex Systems or CAS, in particular the concepts of emergence, nonlinearity (such as the “butterfly effect”) and self-organization (Jacobson & Wilensky, 2006). These concepts are difficult to learn because they are counterintuitive or conflict with learners’ existing beliefs (Wilensky & Resnick, 1995). Very rarely do studies focus on the learning in changing CAS (“knowledge-in-doing”).

There is also inadequate understanding on the process of learning Complex Systems. Many empirical studies (e.g., Azevedo, et al., 2004; Son & Goldstone, 2009; van Bilseb, Bekebrede & Mayer, 2010) adopt quantitative methods or mixed methods to analyze the students’ learning outcomes. Most of them are preliminary and only emphasize primarily on students’ learning outcomes.

While many empirical studies (see Wilensky & Reisman, 2006) engaged learners in learning Complex Systems in the science domain, such a learning design has limitations in learning CAS in the social science domain (e.g., in innovation diffusion) because human society is more complex. Currently, only one empirical study (van Bilseb, Bekebrede, & Mayer, 2010) had examined the learning in the social science domain. The researchers engaged port management professionals to learn port development as CAS and asked the learners to self-report their learning gain. The learning outcomes and the learning processes were largely not investigated.

In summary, the existing studies generally engaged learners in learning the concepts of Complex Systems. Three main literature gaps are identified: (a) the need to have greater emphasis on learning the “knowledge-in-doing” in Complex Systems, (b) greater understanding of learners’ learning processes is desired, and (c) there is a lack in literature about learning CAS in the social science domain.

Learning Innovation Diffusion

At present, the learning of innovation diffusion is still at its infancy stage with few studies examining it. For example, Hallinger (2009) engaged part-time master students in learning innovation diffusion using a simulation game. Within the period of 2001-2005, a total of 50 classes and 1,221 students participated in the learning activities. However, Hallinger (2009) did not make any assessment on the students’ learning outcomes. The only paper proposing a measurement on students’ learning is a conference paper abstract by Ng and Hallinger (2000). Nevertheless, the paper did not report students’ learning outcomes.

The review of the literature on learning Complex Systems and learning innovation diffusion revealed two main research gaps: (a) the need to develop both “knowledge-about” and “knowledge-in-doing”, and (b) the need to understand the process of learning. These literature gaps will be addressed in this paper.

Design for Learning

By synthesizing Jacobson and Wilensky’s (2006) design principles for learning Complex System in general and the six empirical studies on learning CAS in specific, four design conjectures for learning CAS are identified: (a)
design learning activities that allow learners to activate their prior knowledge, (b) provide opportunities for learners to explore and experiment in CAS using tools that make the CAS emerging process explicit, (c) encourage collaboration, and (d) provide opportunity for reflection.

Agent-Based Modeling (ABM) (Axelrod & Tesfatsion, 2006) and first-person role-play simulation game (Gee, 2004) are widely used as tools for learning CAS. Axelrod (2006) summarizes that ABM is particularly helpful in making the CAS emerging process explicit; supporting students’ reasoning capacity and aiding their intuition on CAS. In view of the challenges in learning CAS, all the six empirical studies engaged ABM to help students explore, experiment and experience CAS. This design conjecture is consistent with Jacobson and Wilensky (2006)’s design principles for learning Complex Systems as well.

Although “learning” and “doing” in the real world are not the same as “learning” and “doing” in a simulation game, Jarvis (2004) argues that a first-person role-play simulation game potentially has the power to engage learners in creating the impression of learning through primary experiences and to transpose their real-life experience and knowledge into a simulation game (White & Cornu, 2010). Consequently, the experience and knowledge developed in a simulation game can potentially be transposed to the real world. As such, first-person role-play simulation games are often used to learn the “knowledge-in-doing” innovation diffusion.

Reflection (Schon, 1987) challenges learners to critically examine the current situation, question the validity of the prior knowledge, and make sense of the experience. Reflection promotes metacognition (Kujawa, 1995). Metacognition has three basic elements: developing a plan of action, maintaining/monitoring the plan and evaluating the plan (Kujawa, 1995). Accordingly, reflection can also be categorized in three directions: reflection-for-action (Fitzgerald, 1994), reflection-in-action (Beck & Kosnik, 2001) and reflection-on-action (Fitzgerald, 1994). Reflection-for-action has a central role in achieving self-regulation (Zimmerman, 2000). Jacobson and Wilensky (2006) also regard self-regulation as a design principle for learning Complex Systems.

The literature comparison reveals that none of the empirical studies reviewed follows all the four design conjectures. Two main design gaps are identified: (a) the researchers either engaged learners in reflection-on-action or did not engage learners in reflection at all. They rarely engage learners in reflection-in-action and reflection-for-action. One exception is the study by Klopfer, Yoon and Um (2005). The researchers engaged students in reflection-in-action during the task-based interview and reflection-for-action to plan for the next sessions; (b) sufficient opportunity to activate learners’ prior knowledge was not given in some studies.

2. Research Methodology

Under a broader framework of an interpretivist paradigm (Burrell & Morgan, 1976; Cohen, Manion, & Morrison, 2000), a case study method (Sorin-Peters, 2004) is adopted in this study. The purpose is to provide a descriptive interpretation of the process in which school leaders learn innovation diffusion as CAS.

Learners: School leaders with innovation diffusion experience voluntarily took part in this study. There were a total of five dyad groups and only one dyad group is presented in this paper. This dyad group consists of a school principal (P1) and a Senior Teacher and ICT Mentor (P2) from a neighborhood secondary school. Prior to his appointment as Principal, P1 worked as a teacher, an ICT Department Head and a Vice-Principal in other secondary schools. He also worked as an Education Technology Officer in the Ministry of Education (MOE) before. P2 is a Senior Teacher in the English Department. He is the only ICT Mentor in the school appointed by the MOE. P1 and P2 had joint experience in diffusing iPad for learning in their school.

Learning Design Framework: The learning design framework adopted in this study is articulated in Figure 1. Three learning activities are engaged in sequence: (a) model-building − building an agent-based diffusion model; (b) simulation of researcher’s model − simulating an agent-based diffusion model provided by the researcher; and (c) game play − playing a first-person role-play innovation diffusion simulation game which is also agent-based. In each learning activity, reflections and dialogs between the two learners are facilitated by the researcher. The three activities are selected in order to maximize the learners’ opportunities to activate prior
knowledge and to explore innovation diffusion as CAS. The sequence is proposed to given opportunities to activate the learners’ prior knowledge. The learners make explicit their assumptions in model building and they further activated their prior knowledge when justifying the model they built. Taking model building as the first activity would prevent the researcher’s model in limiting or directing the learners’ model-building towards some preconceived directions (Kapur & Bielaczyc, 2012). Asking the learners to simulate the researcher’s model after their model building activity allows the researcher to build a model that is relevant to the learners’ context and diffusion needs. The researcher’s model includes social network effects which are missed in the learners’ model. It better represents the CAS process in innovation diffusion. By comparing and contrasting between the simulation of their own model and the researcher’s model and by reflecting on their real world experiences, the learners further activate their prior knowledge. Game play was scheduled as the last activity as it not only enables learning but also allows observing learning transfer.

Research Procedure and Instrument: A total of nine sessions were conducted. Session 1 and 2 were pre-learning interviews with P1 and P2 respectively. Session 3 involved a pre-learning collaborative interview. In session 4, the researcher shared the ABM concept and engaged the learners in building the model. Session 5 was the simulation of the learners’ model and Session 6 was the simulation of the researcher’s model. Session 7 involved the game play. Finally, two post-learning interviews were conducted in sessions 8 and 9 respectively. Session 1 to 8 were conducted over 3 months and Session 9 was conducted 3 months after Session 8 to verify whether the learning developed had an impact on the learners’ diffusion strategies in their school context.

Anylogic (XJ Technologies, 2008) was selected as the ABM tool in this study due to its robustness. It allows for defining agents’ local network connections and enables more complex diffusion strategies to be simulated. The learners were required to dialog and reflect before, during and after each modeling action in order to enhance and promote reflection-for-action, reflection-in-action and reflection-on-action. To address the time limitations in providing opportunities to activate learners’ prior knowledge, sufficient time was given to the learners for model building. The learners were also cautioned not to alter the model design to achieve certain desired simulation outcome without considering the sensibility and reality of the alteration in the real world.

The learners’ model was then further enhanced by the researcher for a better model representation of innovation diffusion as CAS. This allowed the learners to see the differences from their own model and create learning opportunities. Dialogs and reflections were carried out during the simulation process.

Frick, Ludwig, Kim and Huang (2007)’s Diffusion Simulation Game (DSG) was used in the game play activity. DSG uses an agent-based approach to simulate a school context. The design of DSG includes heterogeneity of social connections (Rogers, 2003), heterogeneity of adopters (Rogers, 2003) and Concern-Based Adoption Model (CBAM) (Hall, Hord, Huling-Austin, & Rutherford, 1987) to represent agents’ adoption decision-making. The game allows players to select both bottom-up diffusion strategies (e.g. seeking help from people who are socially connected) and top-down diffusion strategies (e.g. organizing site-visits and information-sharing meetings) to achieve the desired diffusion goal. The game is widely played with nearly 9,000 game-plays between late 2006 and 2009 (Lara, Myers, Frick, Karabacak, & Michaelidou, 2009). Although CBAM is only one approach to model teachers’ adoption decision-making, the game is calibrated using real school data and the players self-reported that it is a realistic representation (Frick, et al., 2007).

3. Key Findings

The process of learning was analyzed using open coding content analysis method (Charmaz, 2006; Strauss & Corbin, 1998) which was also triangulated by the learning artifacts generated. Four key trajectories were identified: teachers’ adoption decisions based on local information and limited rationality; teachers’ nonlinear interactions through social networks, teachers’ heterogeneity, and diffusion as a process of emergence that is complex and adaptive. The four learning trajectories were related to the four characteristics of CAS, namely: semi-autonomous agents’ limited rationality, heterogeneity of agents, network and nonlinearity in interactions, and emergence. The four learning trajectories were not developed in isolation but were interrelated and co-constructed. An interview conducted three months after the learning activities revealed that the learners made corresponding changes when diffusing innovations in their schools. This section provides a descriptive interpretation of the four learning trajectories. As the agents in the agent-based models represent teachers in schools, the agents are referred to as teachers in this section.

Understanding the Limited Rationality in Teachers’ Adoption Decision-Making

During the pre-learning interviews and the agent-based model building sessions, the learners acknowledged teachers’ autonomy in decision-making but assumed that teachers make adoption decisions with full rationality (initial “knowledge-about”). This is manifested in the model they built where teachers needed to “see value” in innovation. The learners elaborated that teachers “must see the rationale” of the innovation. Under this assumption, teachers’ adoption decision-making was regarded primarily as an information processing process and the diffusion strategy (initial “knowledge-in-doing”) was to (a) make correct information available through school and departmental-level sharing; and (b) train teachers to increase their information processing ability.
Development in model building: The simulation of the learners’ model showed that innovation that works will be adopted fast among agents. The researcher then asked why the superior DVORAK keyboard is not able to replace the inferior QWERTY keyboard over the past 40 years (to promote reflection-in-action). P2 responded confidently that “if the DVORAK keyboard is mandated, especially if it is mandated among the new users, it will overtake the inferior QWERTY keyboard”. P1 concurred with P2. While this response revealed some slight shifts from a rationality model of decision-making (initial “knowledge-about”), the learners’ “knowledge-in-doing” was not well aligned with regards to innovation diffusion as CAS.  

Development in simulating the researcher’s model: The researcher made two modifications on the learners’ model; firstly, the social networks (e.g. friends in the school and colleagues in the same department) which the teachers were connected with and secondly, the spread of positive and negative opinions through the social networks. During the simulation, the learners encountered a simulation scenario whereby all teachers connected in a social network tend to be resistant to innovation diffusion. Even when the learners made attempts to convert some teachers in that social network, it was more difficult to convert them as compared to converting teachers who were not connected to any social networks. During reflection-in-action, the learners acknowledged that adoption decision-making is not just based on information, but also largely influenced by peers (developed “knowledge-about”). As such, the learners started to intentionally leverage on social networks to influence teachers’ adoption decision-making (developed “knowledge-in-doing”).  

Development in game play: In the game play session, the learners were fully aware of the social network effects and were actively engaging social networks to persuade adoption among teachers.  

Understanding Social Networks that Connect Teachers
During the pre-learning collaborative reflection session, the learners were directly asked if the social networks had any effects on diffusion. P1 responded that he “(did) not think they have a large impact on diffusion”. P2 added that “frankly we did not consider social networks in diffusion... Even it is impactful, how can we control them?” The reflection suggested that the learners initially regarded social networks as irrelevant to innovation diffusion (initial “knowledge-about”) and they had no intention to tap on social networks for effective diffusion (initial “knowledge-in-doing”).

Development in model building: During the reflection on the model built by the learners (reflection-on-action), the researcher asked the learners to compare and contrast between innovation diffusion and the spreading of rumors. The reflection activated the learners’ prior knowledge on virus infection and through their experience on virus infection, the learners’ prior knowledge on rumor spreading and innovation diffusion were connected. However, the learners still did not think that they can leverage on social networks for diffusion.

Development in simulating the researcher’s model: When simulating the researcher’s model, the learners noticed that the teachers from the same social networks tended to hold the same adoption status. They then made attempts to influence the teachers inside the social network so as to “level up the people in the social networks” (shifted “knowledge-in-doing” during reflection-in-action). They also experienced the difficulty in converting many teachers who were connected in social networks. This suggested their realization of the importance of social networks for innovation diffusion. As P2 mentioned during reflection-on-action, “right now what we’re doing is very structured. But I think we’ve overlooked the informal social interactions, so this is something we can really think about (on) how to use them.” Despite this, the learners had yet to understand the influence of the social network and how to leverage on it.

Development in game play: In the game play session, the learners identified opinion leaders to be their targets for converting as early adopters. This was supported by their developed “knowledge-about” during reflection-for-action: “(in the game, when we choose teachers to convert), we talk about influence and credibility (that the teacher has in spreading the innovation).” When reflecting for innovation diffusion in their own school, the learners showed some developed “knowledge-in-doing”: “when we formed the core-group team for diffusion, we need to identify who the teachers (in the core-group) are and identify the opinion leaders in them (who) can help us spread the innovation to others”.

Understanding the Heterogeneity of Teachers
The learners had an initial concept of who the innovators were. They regarded innovators as teachers who are “new to the school environment or new in education service” and they recognized that the innovators have “creative juice in them”, and always “have new ideas to propose”. The learners also had some understanding of the laggards who are “more experienced, stubborn, resistant and more set in their ways”.

Development in model building: The learners were not aware of the other groups of adopters, such as early adopters, early majority and late majority (Rogers, 2003) (initial “knowledge-about”). Hence, they did not use differentiated diffusion strategy to target these teachers (initial “knowledge-in-doing”).

Development in simulating the researcher’s model: The learners observed the social networks in this session. When the learners failed to convert teachers who were connected in social networks, special attention was paid to teachers who had a higher degree of connectedness in the social network. The learners also realized that opinions leaders are teachers who have centrality in social networks. They influence other teachers and are
concurrently influenced by these teachers (developed “knowledge-about”). The learners tried to convert the opinion leaders directly, which did not yield a productive diffusion outcome (developed “knowledge-in-doing”).

Development in game-play: The learners further developed their “knowledge-in-doing” by targeting different groups of teachers in the different stages of diffusion. The learners first identified innovators from the teachers’ profile (in the game) and worked on these teachers. The learners then selected the pro-innovation opinion leaders as their target group for early adopters. Subsequently, the learners worked on the early adopters both directly and indirectly by leveraging on the social networks to influence targeted opinion leaders. When opinion leaders adopted the innovation, the learners acted “knowledge-in-doing” by engaged them to conduct sharing sessions to influence other teachers (early majority and late majority). The learners also noticed during reflection-in-action that “for those opinion leaders who have already adopted, if we continue talk to them, they will continue indirectly influencing others in their social circle”.

Understanding Diffusion as an Emergence
In the first three learning trajectories, the learners identified a gap and subsequently constructed knowledge consciously over the learning sessions to fill the gap. The fourth learning trajectory did not start with any obvious gap, nor did the learners intentionally develop knowledge in this learning trajectory to address the gap. It is a rise-above during reflections. This learning trajectory is identified when conducting the data analysis.

In the simulation session, P1 observed that a single strategy did not work and that the sequence of the strategies matters (reflection-in-action): “actually the learning point is that, there is no one single strategy (that always works). It is really a multi-form of strategies and like P2 mentioned previously, the sequencing is also important. And sometimes we may need to repeat the strategies after a while. So it’s quite hard to say I do one, let’s say, ICT training throughout. It doesn’t work.” During the game play session, P1 further learnt that the sequence of diffusion strategies had a high impact on the diffusion discourse and the same sequence may not always produce the same outcome. He expressed his frustration (reflection-in-action) in dealing with innovation diffusion as CAS. “I don’t know because sometimes it affects (and) sometimes it doesn’t.” Finally, towards the end of the game play session, the learners acknowledged that innovation diffusion is unpredictable or controllable. They can only “work on the feet”, indicating that the learners developed an intuitive understanding of emergence.

To summarize, for the case presented in this paper, learning innovation diffusion through agent-based model building, model simulation, game play and reflection is effective. The preliminary analysis of the case data clearly showed that the learners developed some intuitive understanding of innovation diffusion as CAS (“knowledge-about”), such as the limited rationality in teachers’ adoption decision-making, the socially connected teachers and their interactions, the heterogeneity of teachers, and diffusion as an emergence. The learners also learnt to be more effective in fostering innovation diffusion (“knowledge-in-doing”), such as differentiating their strategies for heterogeneous teachers and leveraging on social network effects for influencing and persuading teachers.

4. Discussion
Compared to previous studies (e.g. Slotta & Chi, 2006; Wilensky & Reisman, 2006) which engaged learning Complex Systems in the science domain, this study showed that agent-based model building alone is not effective in helping learners learn CAS in the social science domain. This is probably due to the complexity of the CAS in the social science domain (Eidelson, 1997) and the arbitrariness in setting numeric parameters when building ABM models.

Manifested in the learning process, the learners were sometimes confused about how much they can trust the model they built for reasoning and learning. The learners’ reflection in the post-learning interview revealed that when an unfamiliar phenomenon emerged in the model simulation, they were “not sure whether it is due to their limited or biased observations in their real world diffusion work, the fallacy of their assumption and reasoning; the over-simplification of model; or the inappropriate value assignment of parameters”. The challenge is not due to the limitation of ABM as a tool, but the complexity nature of CAS. Even with this challenge, ABM is still very helpful in learning CAS. The case data in this study showed that ABM allowed the learners to activate and articulate their prior knowledge. It also allowed the researcher to better understand innovation diffusion in the learners’ context so as to build a diffusion model that is meaningful for the learners to simulate. These are important for learning CAS.

Nevertheless, the challenges were addressed largely through reflections, which were crucial in this study. The reflections were facilitated in two areas: (a) the fallacies of the learners’ initial knowledge identified through the pre-learning interviews and the agent-based model building session; and (b) other CAS phenomena the learners may be familiar with, such as the spreading of rumors, the iPhone bandwagon effect, the failure in promoting the DVORAK keyboard, etc. The three forms of reflections, especially reflection-in-action, had proven to be effective and how they enabled learning will be unpacked further in future data analysis.

With reflection as a critical design for learning CAS in the social science domain, the role of the researcher becomes controversial. The learning is no longer a function of learners and the learning activities; the
researcher forms part of the learning environment. As the researcher learns in the learners’ process of learning, he constantly becomes a changing agent in the learning environment. As such, the researcher’s ability to learn in the learners’ learning process, the researcher’s knowledge on innovation diffusion and CAS, and the researcher’s facilitation skill will affect the learners’ learning process and learning outcome. Hence, in this dynamic learning process, can the researcher be independent and is this study valid?

To answer this question, Guba & Lincoln (1989) propose to use “trustworthiness” rather than “validity” to assess the quality of a qualitative study. Flyvbjerg (2004) maintains that trustworthiness needs to be coped within research design and research process, and not by following an inflexible set of standards and procedures. One strategy adopted by this study to improve the trustworthiness is by engaging the researcher in a self-reflexive process so that the researcher is positioned as a self-conscious, critical and participatory co-participants (Fine, 1992). As such, the role of the researcher will be dealt with by engaging the researcher in the self-reflexive process and make his assumptions and intervention decisions overt to the readers (Morrow, 2005).

Findings from this study are preliminarily as only one of the five cases are analyzed and discussed. A framework for understanding the learning of “knowledge-about” and “knowledge-in-doing” will be developed to describe, interpret and compare the learning trajectories within and across cases. The role of researcher in the learning environment as well as in the data analysis process will be dealt with in a self-reflexive process and made known to the readers in future reports.

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