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School Leaders' Learning of Diffusion of Innovation through Agent Based Modeling

- Coupling Modeling and Simulation Process with Learners' Interaction with Diffusion System

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Abstract: If school diffusion of innovation is viewed as complex adaptive process, how shall we prepare school leaders to be effective diffusion decision makers? Coming from the epistemological belief that knowledge is subjective and embodied, this paper proposes to use Agent Based Modeling (ABM) for learning by focus on learning to "do" diffusion of innovation rather than learning about diffusion of innovation. We therefore recommend to engage school leaders in iterative agent based model development process and to couple it with their interaction in real world diffusion system. With feedback from real world system used for iterative model calibration and validation, the affordances of the agent based model allow school leaders to participate, experience, appropriate, perform and therefore to learn to make effective diffusion decisions in their schools.

Keywords: Learning, diffusion of innovation, agent based modeling, complex system

1. Introduction

With Singapore Ministry of Education (MOE) launch of the Third MasterPlan for ICT in Education (MP3), the government seeks to extensively integrate ICT into curriculum, pedagogy and assessment to enhance learning [1]. The challenge to school leaders is how to foster pervasive and sustainable diffusion of innovations [2] in their schools so as to capitalize the affordances of ICT in learning. While the top-down strategies work well in the first two MasterPlans which is mainly for hardware-driven adoptions and teacher professional development [3], the MP3 endeavor on ICT infused pedagogical adoptions requires a different approach so as to encourage the bottom-up adoption and innovation customizations [2]. How to prepare school leaders for the innovation diffusion in this new educational terrain remains to be an underexplored challenge.

This paper adopts a social cultural perspective of learning and proposes a coupled approach to prepare school leaders to be effective diffusion decision makers. This paper is organized in the following sections. In Section 2, we discuss the phenomena of diffusion of innovation in schools as a complex adaptive process; Section 3 unpacks learning of complex adaptive system. Section 4 discusses the affordance of Agent Based Modeling for learning of complex adaptive system, and in Section 5 we match the learning of complex system with a proposed design that couples Agent Based Modeling with social interactions. In the last section we propose some future research directions.

2. Diffusion of Innovation in School as a Complex Adaptive Process

Huang and Kapur suggest to view the school diffusion of innovation using complexity lens [4]. In school innovation diffusion, teachers are viewed as a heterogeneous agents

interacting with their near peers in their school social networks and act on local information with bounded rationality. The diffusion of innovation is deemed to be complex and adaptive with multiple unpredictable diffusion trajectories. Huang and Kapur [4] characterize the diffusion phenomenon as: (1) diffusion in spatial-temporal landscape; (2) diffusion as an emergence; (3) multiple possible diffusion trajectories that are unpredictable.

3. Learning of Complex Adaptive System

Fostering change in a complex adaptive system requires a different approach as compared to simple linear systems [5]. Mason suggests that the focus is shifted from seeking universal principles to understanding the contextualized complex wholes with emerging contingents [5]. The implication in education is a case of generating momentum for change in a new direction by attending to various factors at the same time [5].

Complexity theory challenge learning at two levels: (1) nature of knowledge; and (2) approaches for learning.

3.1 Nature of Knowledge

Radford [6] suggests that in complex educational situations, attempts to find evidence for prescription is illusory, and learning in complex system is understood as descriptive and explanatory within a range of interpretative possibilities. We take the Social Cultural perspective [7], and regard knowledge not as our internal representation of the external world, but our ongoing interpretation of the world and our appropriation in the world [8]. We view learning as an ongoing iterative appropriation process that emerges from our social interactions and our capacity to understand [9]. With the view that knowledge is local, embodied, embedded and provisional, Social Constructivist is more concerned with the consequences of knowing [10]. We therefore take a pragmatist stance [11] that learning is learn to be capable in doing things, rather than learning about something.

In school leaders' learning of innovation diffusion, the focus is not about what needs to be known about innovation diffuse, but more importantly about how to make diffusion decisions and facilitate the diffusion process in a social system.

3.2 Approaches for Learning of Complex Adaptive System

Jacobson and Wilensky [12] name four challenges in learning about complex system: anticipating emergence, reasoning of nonlinearity, random-determinism confusion and effect of positive feedback loop. They also suggest that learners need to experience complex phenomena and learn through collaboration, discussion and reflection [12].

Such suggestions are not in conflict with the Social Cultural [7] approach for learning, which argues that learning is experiencing and therefore is embodied [9]. Learning therefore needs to be fashioned in the following ways: (1) learning as iterative interpretation [10], (2) authenticity in learning [9], (3) learning through participatory appropriation [8], (4) learning is narrative [9], and (5) learning as discursive process [13].

4. Employing Agent Based Modeling for Learning

Agent-Based Modeling (ABM) is a computer simulation method that use computational models to simulate actions and interactions of autonomous individuals in a network, with a view to assess their effects on the system as a whole [14]. The process is characterized as the emergence from local level interactions to higher level emergence. It simulates the

simultaneous operations of multiple agents, in an attempt to re-create and to explain the complexity of phenomena [15]. ABM is starting to be widely used in social studies [16, 17].

While ABM simulations are used for learning about some subject matters[18, 19], we feel that the ABM has the following unique affordances for learning of complex system:

- ABM enables the modeling of nonlinearity and emergence as a result of heterogeneous agents making bounded decisions. It is therefore suitable for building and representing complex system such as diffusion of innovation [4];
- ABM is process oriented which allows the simulation of diffusion evolution process over space and time [4]. It provides rich context for learners to experience.
- ABM allows learners perform by playing with "what-if" scenario and adjusting multiple parameters at the same time so as to generate the desired momentum in the system [4];

5. A Coupled Social Technical System: Research Design

A model is not the internalization of the external world, but the modelers' re-construction to represent their appropriation of the real world [8]. To allow deep learning to take place, we propose to couple the model building, model simulation with learners' interaction with real world as one social technical system for learning. In this approach, the development of one part will couple with the development of the other part. Agent based model is designed as both the representation of learners' understanding and the simulation tool for learners to collaboratively experience, perform and reflect. With this approach, model and learners are developed together through the coupling process.

In the following part, we first discuss the design of the social technical system informed by the learning paradigm adopted, and then propose how to evaluate learning in this approach. We also discuss about the data collection that can be used to demonstrate the manifestation of learning.

5.1 Design of Social Technical System

To best capitalize learning that is coupled with agent based model development, the social technical system for learning is proposed in Table 1. The following are proposed to be included in the design:

- Modelers: School leaders from the same school will be selected to form a team to participate in the model development and learning. A few such teams are recommended so as to compare the commonalities and differences of the learning dynamics.
- Modeling tool: Agent based modeling tool AnyLogic [20] is recommended as the tool for modeling. The researcher who is familiar with the tool will assist the modelers in the programming part.
- Intersubjectivity [21] between researcher and the modelers: In order for the discursive process and the dynamics of the model development process be well captured and interpreted by the researcher, we proposed that the researcher interview the school leaders, develop the initial model and then pass it to the modelers for critiques and further improvement.
- Model development: Each team is recommended to conduct 3 rounds of iterative model development in one year duration. Each round includes model building, model simulation, and collaborative reflections. After each round of model simulation, school leaders will interact with their school innovation diffusion for certain duration before they collaborative reflect and start the next round of model building.

Table 1: Social Technical System Design

Learning	Social Technical System Design
Learning is iterative process	Through the iterative process of model building, simulation, interaction in the real world, and reflection.
Learning is authentic	By engaging school leaders as the modelers, the model is calibrated and validated through their interaction with the real world diffusion of innovation.
Learning is narrative	Agent based model can emerge the diffusion phenomena through the simulation of the diffusion process. School leaders by participating and performing in the simulation, narrate the symbolic world in which their purposive actions have consequences. Such narrative provides a contextual framework through which action in simulation have meaning.
Learning is discursive	Three levels of discursiveness exist: discursiveness between model and individual modeler, discursiveness among modelers, and discursiveness between modelers as a whole and model
Learning through participatory appropriation	By allowing the school leaders jointly participate in model building, experience and perform in the simulation, and reflection process.
Fit the learning developmental trajectories	By coupling the iterative model development with learners' learning and interactions with the real world system

5.2 Evidence: Manifestation of Learning

Shaffer [22] suggests that learning is to learn the way the professionals use to see the world, solve problems, and justify their answers. It is along with the development of skills, knowledge, and values with which one puts the epistemology into practice. Epistemic Framework [22] suggested by Shaffer evaluate learning based on skill, knowledge, identity, value, and epistemology.

Rogoff suggests that the evaluation of learning from the perspective of transformation of participation should not focus on their search for the mechanisms of acquisition or the nature of the internalization, but to look directly at learners' efforts and those of their companions and the institutions which they constitute and upon which they build [8]. He [8] proposes the following areas to focus on: (1) the role people play with what fidelity and responsibility; (2) their changing purposes for being involved, commitment to the endeavor; (3) their flexibility and attitude toward change in involvement; (4) their understanding of interrelationship of different contributions to the endeavor and readiness to switch to complementary roles; (5) the relation of the participants' role in this activity to those in other activities; (6) how their involvements relates to changes in the community's practice.

While Shaffer takes a holistic view of learning, Rogoff gives an operational framework to evaluate learning of participatory process.

5.3 Multimodal Data for Triangulation

In conjunction with the evidence for manifestation of learning proposed above, the following multimodal data are to be collected: models as artifacts; discourse process; questionnaire and interviews, and observation of behavior change in school leaders' diffusion of innovation practices.

The research findings can be triangulated by multimodal data, which makes the manifestation of learning and the research findings more reliable and convincing.

6. Considerations for Future Research

With the research design proposed above, the future research will focus on the review and the selection of research instruments so that the evidence for manifestation of learning can be further unpacked, identified and captured. We are also interested in finding reasons that contribute to the convergence within each team and among teams. We think this can help to further our understanding of the differences in their learning.

In summary we propose to couple the school leaders' experience and performance in agent based models with their interactions in real world diffusion of innovations. With this approach, the rich discursive process can be unpacked for school leaders to negotiate and learn collaboratively so as to be effective in making diffusion decisions.

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