Multiple Mediator Models of Educational Reform: Organizational Learning as Persistent Change

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Abstract

Educational reform is a complex, dynamic process that has proven difficult to model. In this paper we will present multiple mediator models for representing educational reform, which uses a multi-agent simulation system to capture the complexities and dynamics of successful and unsuccessful educational reform. We have built qualitative models of educational reform using qualitative case study data of a particular educational reform, data driven decision making, in a number of diverse schools. We analyze educational reform as a kind of organizational learning that is represented as "persistent change" captured by multiple mediator units with "tipping points". We then present some of the implications of our models for the successful implementation of educational reform, and the potential of these multiple mediator models for representing learning more generally.

Introduction

Educational reform is a focus of much of educational research. Both the content and the organization of education need to adjust to changes in society. However most attempts at educational reform lead only to temporary changes and are not sustained in the structure and culture of a school. In this paper, we explore ways to model educational reform as a kind of organizational learning. As with learning more generally, some

efforts to create persistent change succeed, while others fail. We present some models where the intended changes only last as long as extra resources go into supporting them, but which disappear when those extra resources disappear. We also present other models in which extra resources to implement a reform perturb the educational system beyond a tipping point, at which point the system reorganizes into a new configuration which persists even when the extra resources cease.

These multi-mediator models are implemented as computer simulations, built within a multi-agent computer modeling framework, a relatively new tool for educational research. We describe why we selected this approach to modeling, what our specific models look like, how we built them based on qualitative data, and how we are evaluating and utilizing them to connect back to educational practice. Finally, we describe some preliminary attempts to apply this multi-mediator model approach to learning at different scales of analysis.

Why do we use multi-mediator models?

Many educational reform efforts implicitly rely on a "dissemination" model of organizational learning, which is similar to the "transmission" model of teaching and learning. In this simple model, educational reforms are developed by educational experts (e.g., at the district or design team level), and then those reforms are disseminated to those who are to adopt the reforms, usually in a top-down hierarchical way. This "dissemination" model is linear and mostly unidirectional, with the only information flowing back to the developers being how well or how poorly the reform is being implemented.

Many studies of educational reform have documented the shortcoming of this model (Berman & McLaughlin, 1974, 1978; Datnow, Hubbard, & Mehan, 2002; Hubbard, Mehan, & Stein, 2006; Datnow, 2008). Some recent educational researchers have described instead the "co-construction" of educational reforms, especially more successful educational reforms (Datnow, et al., 2002; Hubbard, et al., 2006; Datnow, 2008). In these "co-construction" reforms, there is rich interaction among the participants of the educational reform efforts, with contributions being made by all, and with the reform that evolves in any given setting being shaped jointly by the people who created the reform and those who implement it. Often these implementations emerge in ways that diverge from the original reform, but often the differences are critical for the reform to flourish in the particular educational setting.

In trying to understand these co-constructed reform efforts, we found that conventional modeling media were unable to capture the non-linear, interactive, and mediated aspects of co-construction. For these reasons,

we examined multi-agent frameworks for expressing models of these reforms. These are computer applications that allowed us to capture the multiplicity of reforms, in which many different important activities were happening at any one time. They also allowed us to capture interaction between pairs of elements, and beyond that, the mediation served by some elements in supporting indirect interaction among other elements. We found that these models in some cases had emergent properties that we did not expect, and in particular modeled the non-linear persistent change that is characteristic of learning at many different scales of analysis.

What do our multi-mediator models look like?

We have constructed our multi-mediator models using a multi-agent computer application called NetLogo (Wilensky, 1999). NetLogo is a free simulation building program that runs on the most widely-used computer systems (Macintosh, Windows, Linux). It has been developed by Uri Wilensky and his team in the Center for Connected Learning and Computer-Based Modeling at Northwestern University, and has been used for building a wide range of simulation models. There is a large library of NetLogo simulation models and an active NetLogo user community. But most of the models are used as tools for teaching and learning in a variety of content area. Only recently has NetLogo been used to build models of learning and educational reform (Abrahamson & Wilensky, 2005; Abrahamson, Wilensky, & Levin, 2007; Blikstein, Abrahamson, & Wilensky, 2008, Maroulis et al., 2010).

We built a set of multi-mediator models of a specific educational reform, data driven decision making (Levin & Datnow, 2012). Broadly speaking, data-driven decision making (DDDM) is the process by which administrators and teachers collect and analyze data to guide educational decisions (Ikemoto & Marsh, 2007). In our models, there is a set of basic elements, the most important actions that principals, teachers, students, and district office personnel take related to the implementation of DDDM. Each action is represented by a circle, and has associated with it an activity level, represented by the size and intensity of color of the circle. Each action also has an external context (those factors outside the model), which taken together have a specific impact on the activity level of the action.

There are connections from an element to another. One element can have a positive connection, represented by a green line with an arrowhead at the end:

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An element can have a negative connection, represented by a red line with a bar at the end:

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Or an element can have no direct connection at all to another element.

How are multi-mediator models built from qualitative data?

How do we build such multi-mediator models, using the qualitative data that we typically gather in our research? We need two things:
1. data
2. a coding protocol for the data

Our data

The data that informed our models were gathered as part of a previous case study of 12 urban schools across the U.S. that have implemented the educational reform of data driven decision making (see Datnow, Park, & Wohlstetter, 2007; Datnow, Park, & Kennedy, 2008). Sites were chosen on the basis of their status as leaders in DDDM and for their record of improving student achievement over time. The schools serve student populations that were diverse in terms of race/ethnicity and socio-economic status. Selected sites were chosen from a list of over seventy five sites that had been recommended as fitting the criteria. The research team narrowed down the list of possible sites after reviewing school system Web sites, speaking with experts in the field, and conducting phone interviews with district leaders.

The research team's site visits to the school systems and schools took place from 2006-2008. In each site, the team interviewed two to three administrators from the central office, two to three administrators at each school site, and a minimum of five teachers across grade levels and academic disciplines. The team conducted over 120 individual interviews, all of which were transcribed verbatim. In addition, the team observed in classrooms, conducted focus groups, and attended key teacher development workshops in order to collect data to triangulate findings. Thus, a corpus of qualitative data formed the basis of the analysis for this study.

Our coding protocol

Given the qualitative nature of our data, there was no automatic way to generate a model. However, as is typical of qualitative data, we applied a coding process to the data. We developed the following coding protocol as a systematic way to generate multi-mediator models from qualitative data:

Multi-mediator model coding protocol

1. What are the most important elements?
2. For each element, what are the most important direct impacts (positive, negative, or none) that it has on other elements?
3. For each element, how strong is its support from its external context?

Step 1 in this coding protocol identified the following four most important actions by principals in the data use process:

- Formulating goals that are specific to the needs of the school and community
- Providing structures to support DDDM
- Building human and social capital
- Creating a climate of trust and collaboration and a culture of data use

How we developed the codes and determined these actions is described in detail in Levin and Datnow (2012). Step 1 of this coding identified the four principal actions above and also five teacher actions. Step 2 identified a set of positive and negative connections, and Step 3 identified the impact that outside context had on each action.

Figure 1 below shows one of our models. The box at the top contains four important actions that principals take in relation to the educational reform. The box at the bottom contains five important actions that teachers take in relation to the reform. There are connections from these actions to other actions, with some connections within a level (between actions of the principal, for example) and some are between levels (a connection from an action of the principal to an action of the teachers, or vice versa). The model operates over time, and the multiple actions, interactions, and mediations lead to a particular pattern of activity of the set of elements. The external context can be changed to represent additional resources allocated to the action by an increase or decrease in the activity of the action. If you are reading this paper in electronic format on an Internet-connected computer, you can click on the figure caption to start up the NetLogo applet for this model. It may take a minute or so to load the model so that you can interact with it.
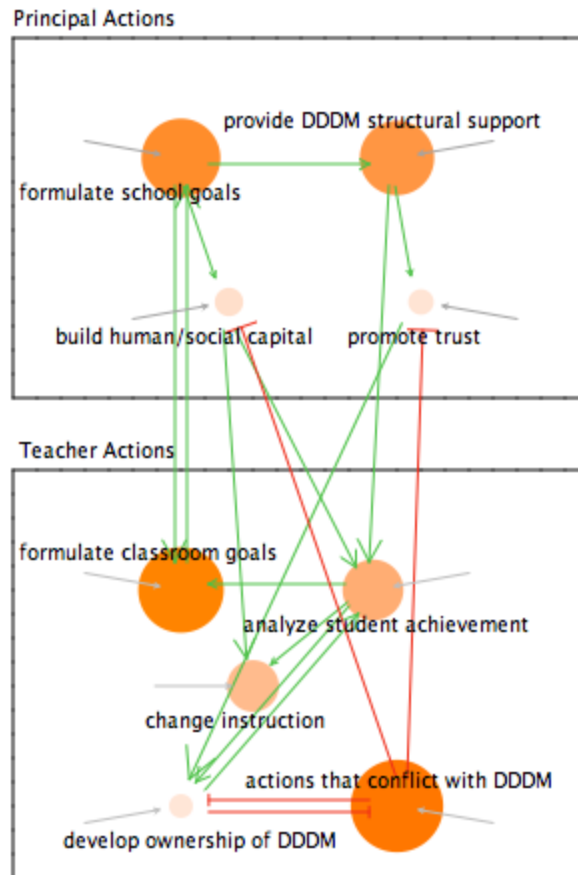
Figure 1: Interaction of principal actions with teacher actions related to site leadership in DDDM educational reform.
http://mmm.ucsd.edu/principal-actions-teacher-actions-repair.nlogo

This particular model has the property of "self-repair". That is, if the principal puts more effort into supporting the reform, then there is a change in teacher actions, but if the principal stops making that effort, then the state of activity of the teacher actions return to the previous state. Contrast the model shown in Figure 1 with a similar model, shown in Figure 2 (also linked to an applet). The two models are identical except the model in Figure 2 has an additional positive connection between the teacher action of "develop ownership" and the principal action of "promote trust".
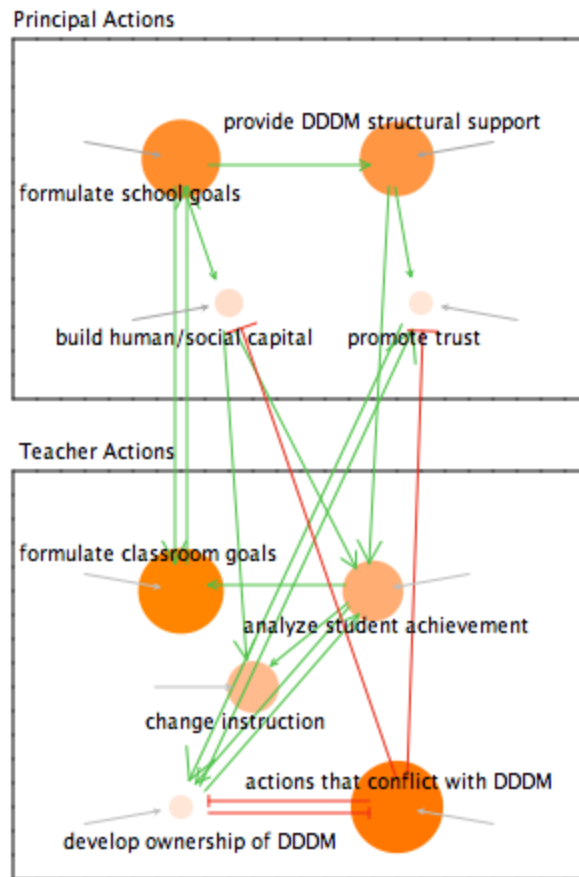
Figure 2: Interaction that leads to persistent reform.
http://mmm.ucsd.edu/principal-actions-teacher-actions.nlogo

Increases in any of the principal actions initially lead to no impact on the teacher actions. But enough of an increase leads to a tipping point, beyond which the activity of the teacher actions to develop ownership of the reform suddenly increases substantially and the activity of the actions that conflict with the change decreases. This is shown in Figure 3.
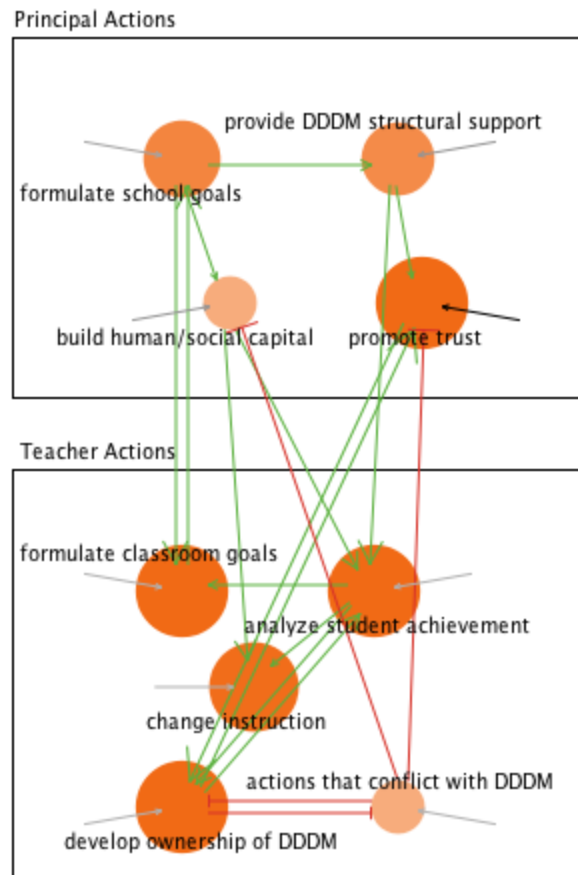
Figure 3: The model just beyond the tipping point.

An important feature of this model is that if the principal reduces the activity of the actions back to where they were in figure 2, the state of activity of the teacher actions will not return to the state shown in Figure 1, but instead to the state shown in Figure 4.
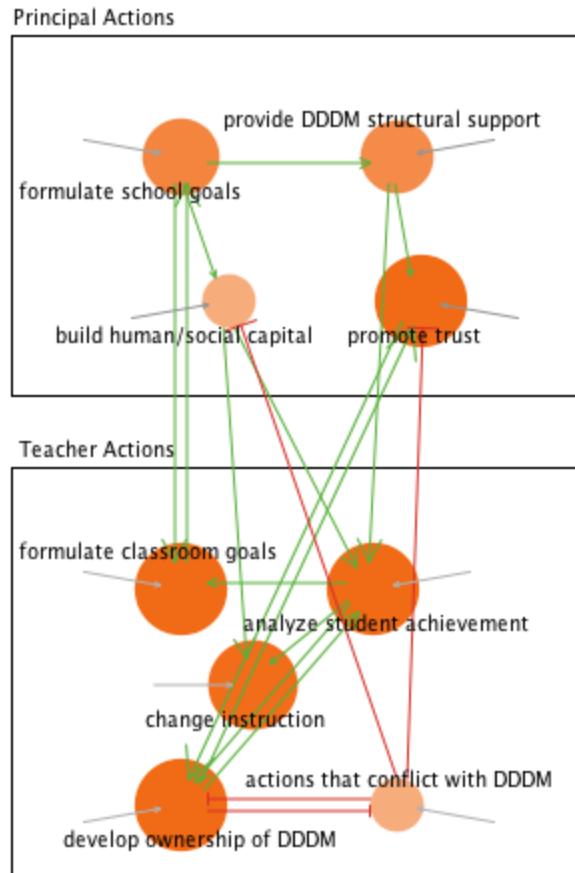
Figure 4: The model after the external context supports for principal actions have returned to their previous levels.

How are these multi-mediator models evaluated and used?

These are qualitative models of qualitative data, so the conventional approaches for evaluating quantitative models of quantitative data don't really apply. However, the models certainly exhibit characteristics during their operation that can be used to evaluate the models and to generate recommendations for effective practice.

When the models operate as expected given the analyst's knowledge of the situation that is being modeled, that serves as a relatively weak confirmation of the model. A strong basis for evaluation is when the models operate in some surprising way, especially when that surprising characteristic is then found in analyzing new data of the same or a similar setting. So when analyzing a model, the analyst can "code" the model's operation into "expected" and "unexpected" operation. Both the "expected" and "unexpected" features can then be more carefully

compared with existing or new data.

For example, with the models presented above, the tipping point behavior of the model shown in figures 2, 3, and 4 was unexpected, so a strong confirmation of the model would be to find that the interconnections that distinguish that model from the one shown in figure 1 is present in successful implementations of the DDDM reform.

Another way to evaluate and use these models is to indentify the minimal subparts of a complex model that lead to the unexpected behavior. In the case of the "reorganization" model, we were able to determine that the subnetwork shown in Figure 5 is responsible for the bi-stable nature of the larger model.
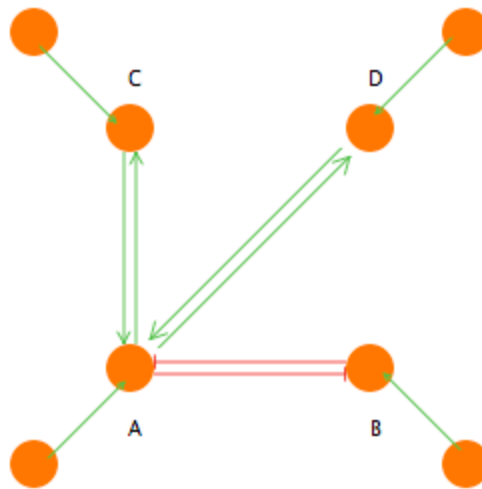

Figure 5: A minimal bi-stable multi-mediator model.
http://mmm.ucsd.edu/femu-2.nlogo

This model exhibits "hysteresis", where the state of a system depends not just on the inputs to a system, but also on the history of inputs. This hysteresis is not a permanent change - if the relevant activity is reduced further, there is a second tipping point.   But there is a "persistent change" region, over which changes in the activity of one element does not lead to the previous state. This is shown in Figure 6.
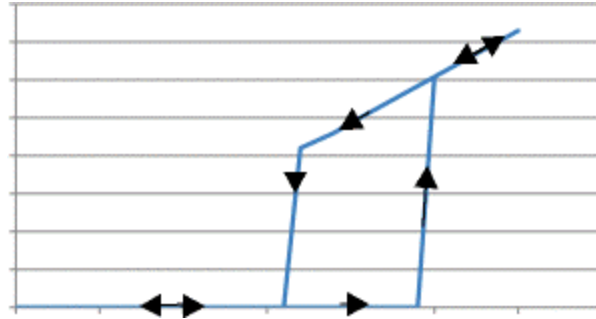
Figure 6: The activity of one element as a function of the activity of another element in a bi-stable multi-mediator model.

More multi-mediator models

Recently, we have been able to apply the same multi-mediator modeling techniques to capture some of the important aspects of learning at different scales of analysis than the models presented previously in this paper. In one case, we were able to develop a model of the "tipping point" of a single school reform effort investigated (and instigated) by David White (2011) in his doctoral dissertation research. That model is shown in figure 7.
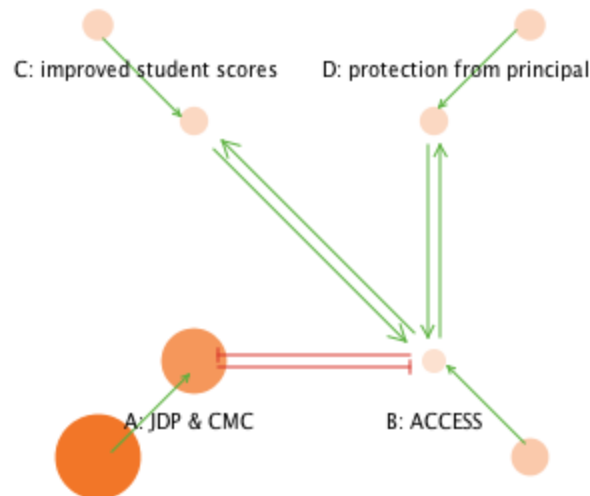

Figure 7: A model of the tipping point of a successful reform in a low-performing school.
http://mmm.ucsd.edu/access-tipping-point.zip

In another domain, we were able to construct a very similar model that captured aspects of individual conceptual change in acquiring the ability to think non-linearly, based on research by Michael Jacobson and his colleagues in the COCO Lab at the University of Sydney (2012). This is
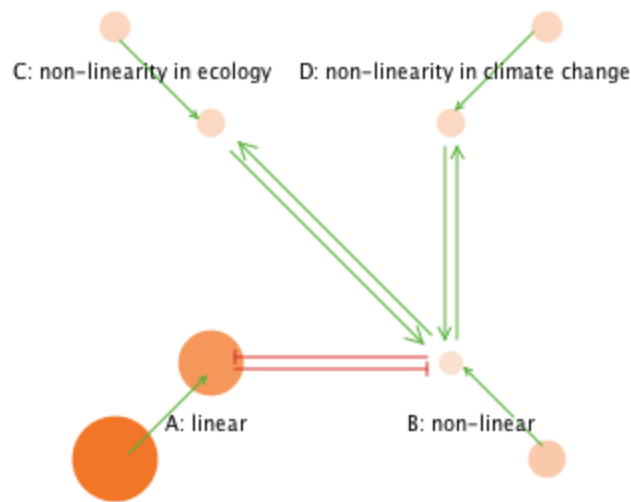
shown in Figure 8.

Figure 8: [A model of the relation of learning general concepts vs. specific instances.](http://mmm.ucsd.edu/learning-non-linear-analogy.nlogo)

http://mmm.ucsd.edu/learning-non-linear-analogy.nlogo

While these additional models are in very preliminary stages, they demonstrate that multi-mediator models can be applied to model learning at a number of different scales of analysis (district-wide organizational learning; organizational learning within a single school; individual learning).

Summary

In this paper, we have described multi-mediator models that characterize the multiple simultaneous mediation in educational reform. The models incorporate the actions and interactions of principals, teachers and students. Our hope is that these simulation models help in understanding the dynamics of the particular educational reform of data driven decision making, and also of educational reform more generally. Using models to show the fluid nature of the change process across a set of key individuals in reform helps to explicate the concept of co-construction. In doing so, our goal is to show how some configurations of interaction lead to more persistent reform while others are more likely to lead to the organization self-correcting and returning to business as usual.   One intriguing implication of our models is that initial resistance to reform efforts may in fact be a positive indicator that successful educational reform is possible in a specific situation, while lack of resistance may be an indicator of less lasting

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change.

The multiple mediator models of educational reform described here characterize more persistent educational reform as organizational learning, while less persistent reform is characterized as the self-repair that is a property of many complex dynamic systems.   Learning is seen as "persistent change", where bi-stable units move past one of their tipping points and change to states that persists even when the change factors decrease. Learning is an emergent non-linear property of the interactions among the elements of the model.

We describe systematic coding protocols for building these models from qualitative data. We also describe systematic model analysis techniques to derive qualitative properties of the model that can be used both to evaluate the models and to provide guidance to practitioners. The multi-mediator models can serve as mediators of productive interaction between practice and theory.

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