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Spotlight Article: Perspectives on Enterprise Modeling

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To gather perspectives on the challenges and future direction of enterprise modeling, the Journal of Enterprise Transformation (JET) posed questions on the topic to thought leaders William B. Rouse and Hazhir Rahmandad.

William B. Rouse is the executive director of the Tennenbaum Institute at the Georgia Institute of Technology and a professor in the College of Computing and School of Industrial and Systems Engineering also at the Georgia Institute of Technology.

Hazhir Rahmandad is an assistant professor of Industrial and Systems Engineering at Virginia Polytechnic Institute and State University.

JET: Please describe one of your recent modeling efforts and how it is applicable to the problem of enterprise transformation.

Rouse: We have recently developed a multilevel model of the employee wellness program at Emory University. The model was motivated by a need to consider possible radical reorganization of the program due to a change of revenue model from capitation to pay for outcomes, in this case, reduction of risk of diabetes, cardiovascular disease, etc. The four-level model includes an agent-based model of Emory employees, a discrete event model of care flow, two microeconomic models—one for the provider and one for the payer—and a rule-based model of Emory human resources/benefits policies. This web-based model has enabled Emory to explore the impact of policy changes on the organization of care, the impact on participants in terms of future incidence of disease and healthcare costs, and the costs of lost productivity.

Rahmandad: In a research project conducted in a large telecommunication firm, we built and calibrated a detailed system dynamics model that captured the core product development processes observed in the organization and identified a few pathologies that had afflicted multiple projects.
Specifically, the project uncovered adaptation trap, a failure mode that can reduce the capacity of product development groups across different industries. Many products, once released to the field, may continue to create demand for the original product development organization through the need for bug fixes. However, this demand comes with a significant delay from the development work. As a result, when project leaders incrementally increase workload on their development organization to find the maximum level of demand that is not counterproductive, they are prone to overlooking future demands for bug fixes. That underestimation can be very costly because it overloads the organization and pushes it into a dysfunctional firefighting mode of taking bigger risks and shortcuts under pressure, facing more rework, and thus encountering further increase in work pressure.

The modeling work was based on 70 interviews, analysis of archival data over five years coming from two product lines, observations of product development team activities in three months of site visits, and extensive quantitative data on different aspects of product development processes. In addition to exploring the generic insights, we used the resulting model to build a microworld. Microworlds are simulation-based learning environments in which individuals and groups can interact, through a user-friendly and realistic interface, with a simulation model of a problem they could encounter in the real world. By providing rapid and unambiguous feedback on the impact of different actions the users take, microworlds can facilitate learning in and about complex dynamic systems. The microworld we developed can be used for training product development team members on different dynamic tradeoffs in common project settings. While enterprise transformation was not the main goal of the project, the extended involvement of the organizational members increased the buy-in and the potential impact of the microworld. The modeling process also increased the sensitivity of the research team to the organizational and political issues that are key to successful implementation of any change initiative.

**JET:** How do you think modeling and simulation can better support decision makers and enterprise transformation efforts?

**Rouse:** Modeling lets you “drive the future before you write the check.” A wide range of alternatives can be explored in the computational world before deploying and evaluating the best alternatives in the real world. You still need to empirically “flight test” the selected alternatives, but you will have weeded out the bad and mediocre alternatives using models and have tuned the best alternatives for deployment and empirical evaluation.

**Rahmandad:** Modeling projects can support decision making through three distinct channels. First, they can focus on insight generation and communication. Such projects leverage the model-building process as an intervention to change participants’ mental models. In this process, different stakeholders
in an organization can see their points of view integrated with those of others and the logical consequences of those views traced to performance measures of interest. Simple models and elaborate facilitation and client-interaction processes, including group model-building techniques, are commonly used when insight generation and communication are the goals of modeling. In these projects, the modeling process helps build more enriched mental models of important processes in an organizational setting, facilitates rational discussion of mechanisms, and brings hidden assumptions to the surface. Here, models are more important as boundary objects that facilitate communication among stakeholders than as decision support tools. These projects can help build consensus and commitment for decisions with multiple stakeholders and can be very helpful in laying the ground for enterprise transformation initiatives.

Second, modeling projects focus on developing models to facilitate learning. Learning in complex systems is hard because feedback in real settings is delayed, noisy, and costly. Robust simulation models can underlie microworlds that facilitate learning by providing fast, clear, and cheap performance feedback when learners manage simulated organizations. Design of microworlds relies on high-fidelity models that are robust to a wide range of inputs and provide realistic results. Experiential learning should be linked with cognitive feedback (e.g., discussion and instruction of causal mechanisms) to maximize the impact of modeling interventions. This use of modeling is best suited for training and for creating an appreciation of dynamics relevant to implementation of change in an organizational setting.

Finally, models can be used as decision support tools. The numerical results from such models inform organizational decisions. To be useful in that role, models should be validated against different sources of qualitative and quantitative data, capture the policy levers under consideration in the real world, and be trusted by the decision makers. The costs of building these models should not be underestimated because data collection and confidence building in models are lengthy and resource-intensive processes. Close interaction with clients during the modeling process is still required to instill confidence in the final model. Such models can inform recurring or one-time decisions in an organization and be used to decide among different options for a transformation initiative.

**JET:** What opportunities do you see for more cross-disciplinary integration in models of enterprises? Which disciplines would you seek to apply, and how can this be accomplished?

**Rouse:** Our modeling efforts involve engineering, computing, medicine, management, finance, and economic, as well as the behavioral, social, and policy sciences. We also work with interactive computing and digital media
colleagues to create compelling renderings of and experiences with the models.

**Rahmandad:** Modeling is interdisciplinary in nature. In building models of organizational phenomena, we are capturing mechanisms that fall into different disciplinary boundaries such as physical sciences (e.g., technological processes), psychology (e.g., managerial decision making), sociology (e.g., diffusion of ideas in an organization), and economics (e.g., resource allocation and competition). In fact, most counterintuitive insights of modeling come from feedback mechanisms that cross disciplinary boundaries. Good models start with what is known in these and other relevant disciplines to ensure a scientifically grounded representation of key mechanisms. In practice, I think many modeling efforts are weak on this aspect, and therefore they may put a lot of energy into rediscovering insights already known to disciplinary scientists.

Modelers will benefit from having a general familiarity with most relevant insights from each of the fields that inform modeling organizational dynamics. I would recommend a couple of graduate-level courses in economics, social psychology, organizational theory, and sociology, each, as a useful starting point for building that disciplinary appreciation. However, in practice, it is challenging for a single individual to master all the disciplinary knowledge related to a new modeling project. Collaboration with domain experts should help modelers stay true to the science while they integrate models that cross disciplinary boundaries. Such collaborations will also challenge our mental models as modelers and allow us to assess the true value added by a modeling project.

**JET:** What in your mind are the significant barriers to more widespread use of models and simulations to support enterprise transformation?

**Rouse:** Available tools are inadequate for rapid development and evaluation of models (i.e., having a prototype available within a few weeks). The situation is improving, but very slowly. There is also significant difficulty crossing representational boundaries for multilevel/multiscale models. Now this is approached heuristically, but I expect more principled ways will emerge that will enable dovetailing the various mathematical/computational representations across levels and scales.

**Rahmandad:** I can see general barriers related to both costs and perceived benefits of modeling as well as issues particular to enterprise transformation modeling. On the cost side, modeling could be expensive because of the limited supply of good modelers and the one-off nature of modeling projects. We still don’t know how to train modelers quickly; thus, many years of coursework and experiential learning are required. Even then there is significant variability in the quality and efficiency of active modelers, which sends mixed signals to the market. The supply is further constrained by...
the limited presence of modeling programs in academia. Moreover, each modeling engagement will only serve a single client, so the modeler’s efforts cannot be easily leveraged to serve multiple customers. A side effect of limited supply is that many good modelers prefer better paid consulting jobs to uncertain prospects in academia, which further limits the universities’ capacity to train modelers.

On the other side of the equation, the benefits of modeling projects are often hard to quantify. Sometimes models are so tightly connected with the proposed solutions that the value of a superior solution (if measurable) can be directly attributed to the modeling work. More often, however, modeling helps build client’s intuition over time. By the end of the modeling engagement, the client is prone to seeing those insights as trivial or detached from the modeling process. This tendency may be explained by hindsight, self-serving biases, and fundamental attribution error. Therefore, clients often undervalue the modeling process and may attribute the perceived benefits to the abilities of the consultant rather than the modeling work. Underevaluation of modeling benefits may also happen if modelers promise too much at the beginning and raise expectations to unrealistic levels that cannot be later satisfied. This risk is high, given that complex fancy-looking models can be shown to potential clients at the outset, leading the client to believe that it is cheap or easy to build a fully validated version of the model for their organization.

Enterprise transformation modeling may face disadvantages on both these fronts. Soft issues such as organizational power dynamics are central to understanding the success and failure of transformations, and capturing them requires experienced modelers who are in short supply. Transformation projects often use models as insight generation and communication mediums rather than decision support tools. Those projects are more subject to the perception biases discussed earlier because they lack the numerical precision and assurance that decision support models provide. Enterprise transformation is inherently a complex domain in which to apply modeling because it requires imagining, and quantifying, hypothetical organizational configurations for which we have limited data.

**JET:** What do you consider to be the current frontier for models and simulations that support enterprise transformation? What grand challenges lie ahead?

**Rouse:** We need to be able to create model-based environments where all key stakeholders can experience the transformed organization. This requires compelling rendering and experiences, not just plots and bar graphs. All of the stakeholders need to be able to move the sliders and knobs to see the impacts of their variations of assumptions. Such environments should include representations of agents that have their own interests and preferences,
adapt to changes of incentives and inhibitions, and self-organize to optimize the ways in which their interests and preferences are served.

**Rahmandad**: I think there is much work to be done in modeling how the flow of incentives across organizational levels influences the success and failure of transformation efforts. Economists use stylized principal-agent models and game theory for mechanism design. Simulation modelers should develop a modeling framework that captures the core insights about the relevance of interdependent incentives of organizational members but goes beyond stylized analytical exercises to capture the dynamics of transformation in realistic settings. Models such as these could be important tools for designing transformation efforts more successfully.

Developing a more modular modeling process could be another major area for future work. To the extent that modeling projects can be broken down into replicable modules, previous efforts can be leveraged in new modeling projects, reducing the costs and increasing the accumulation of modeling knowledge. This is a tough challenge because modeling projects often call for different levels of aggregation, feedback mechanisms, and core concepts depending on the problem definition.

Finally, I think more flexible estimation methods that allow modelers to use a wide range of data types to calibrate their models to quantitative data will constitute another frontier. These methods can enhance our confidence in the results of modeling projects and help build bridges to other disciplines that can then appreciate, within the statistical frameworks they are familiar with, the relevance of mechanisms uniquely captured in a simulation model. There has been much work in econometrics and engineering within the last two decades—from filtering methods to simulated method of moments—that can provide the steppingstone for developing these tools.