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TEACHING AT THE INTERSECTION OF SIMULATION AND THE HUMANITIES

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ABSTRACT

Human simulation (applying Modeling and Simulation (M&S) to topics in the humanities, the interpretative social sciences, and the arts) is a potent extension of social simulation. This paper offers reflections on teaching at this intersection, presenting best practices in pedagogy for undergraduate and graduate students engaged in formal studies, and for established researchers having no structured curriculum. The fact that human simulation is possible drives home the presence of formal patterns in a host of phenomena that for a long time were thought to be inimical to mathematical analysis. That implies a double pedagogical challenge: teaching humanities students to recognize formal structures in the phenomena they study (counter-intuitive for them), and teaching M&S students to collaborate with humanities people who think very differently (equally counter-intuitive). The three perspectives presented here underline the usefulness of human simulation, as well as the difficulties and benefits associated with teaching and learning human simulation.

1 INTRODUCTION

Human simulation is defined here as the application of computer modeling and simulation (M&S) techniques in the humanities disciplines, the interpretative social sciences, and the arts (for the sake of convenience, these will be collectively referred to throughout as the humanities disciplines). Human simulation can be regarded as an extension of social simulation, further expanding the range of theories and data that fall within the reach of the computational sciences. As with social simulation so with human simulation: it is impossible to capture everything important about a phenomenon of interest in a computer model of it. Yet M&S can still generate useful insights, enhance theoretical consistency, relate theories to data more effectively, and thereby deepen understanding of the varied phenomena studied within the humanities. These benefits have been clearly recognized within STEM education (e.g. Fishwick et al. 2014), within the field of social simulation (Gilbert and Troitzsch 2005), and also within the encompassing area of digital humanities (e.g. Burdick et al. 2014), but the pedagogical challenges associated specifically with human simulation need more explicit attention. That is the purpose of this panel paper.

Each of the authors of this paper is engaged in human simulation research and education. Wildman and Shults are philosophers leading projects in which M&S techniques are being applied to issues within humanities disciplines. They are deeply involved in teaching humanities to M&S folk, and computer simulation to humanities folk, at the graduate, postdoctoral, and researcher levels. Fishwick is a modeler embedded with scholars in humanities and the arts. He is intensively involved in teaching undergraduates at the intersection of humanities and M&S. In what follows, we address the main theme from different perspectives, drawing on our varied experiences in teaching human simulation.

One of the challenges associated with teaching human simulation is that humanities students and researchers sometimes do not think in terms well suited to expression in computer models, and computer engineers sometimes do not communicate effectively with such people. A related challenge concerns establishing mutual relevance so that computer engineering and humanities students and researchers grasp the point of working together on computer simulations of humanities topics. These twin challenges define a pedagogical puzzle of significant complexity.

We will discuss best practices in teaching both computer engineers and students of the humanities to do human simulation—and we will argue that this critically involves making the case for mutual relevance in ways appropriate to the level and type of education involved, with target audiences from undergraduates to seasoned researchers. We also argue that the intersection of simulation and the humanities offers advantages to both, and that grasping this mutual relevance is one of the keys to learning how to do human simulation well, regardless of the level of education.

Shults presents the first perspective, focusing on educating experienced researchers. He argues that it is vital to engage humanities scholars through explaining what social simulation and human simulation can achieve, and it is equally vital to convey to modelers what is important about the issues that humanities scholars engage. Communicating this information is not straightforward so Shults' reflections on best practices in this area are a valuable piece of the pedagogical puzzle.

Fishwick presents the second perspective, focusing on undergraduate education. He argues that computer modeling and simulation benefits from engagement with the humanities because applying M&S techniques to humanities concerns and human artifacts can deepen understanding of the formal concepts of M&S. It is important for computer engineers to grasp this point because they are frequently quite satisfied with the distinction between modeler and subject-matter expert, and perhaps not as ready as they might be to learn about how to improve teaching in their own field from engagement with the humanities.

Wildman presents the third perspective, focusing on the education of graduate students, post-doctoral fellows, and veteran researchers interested in human simulation. He draws on his experience to identify practical arrangements, settings, teams, and techniques that make teaching human simulation most effective. This information impacts both humanities scholars and computer engineers as they set up teams and devise procedures and protocols to optimize the effectiveness of learning within those teams.

With all three perspectives in place, we respond to one another's suggestions in an effort to deepen them and make them more precise, and in hopes that doing so will engage readers in a fruitful conversation.

2 PERSPECTIVE: THE IMPORTANCE OF UNDERSTANDING HUMAN SIMULATION (SHULTS)

Some scholars study nature. Other scholars study human beings. And never the twain shall meet. This classical division between the natural ("hard," quantitative, explanatory) and the human ("soft," qualitative, interpretive) sciences still prevails in many contexts. Despite the bridge-building successes of cross-disciplinary modes of research in the last few decades, the chasm between the so-called "two cultures" in academia remains a painful one – especially for humanities scholars and social scientists who feel that their contributions are inadequately appreciated (and underfunded). When the educational context for human simulation is seasoned researchers, encouraging humanities scholars to embrace, or at least to engage, new quantitative methodologies involving computer programming algorithms and complex causal architectures can be a hard sell. I think M&S scientists are often more willing to collaborate with humanities specialists, or at least they are more open to learning how this might be done and attempting to understand the unique challenges in simulating *human* systems.

My comments in this section are primarily aimed at M&S researchers who are interested in learning how to engage veteran humanities researchers as subject-matter experts. Based on my experience with the Simulating Religion Project (through the Center for Mind and Culture in Boston, USA; see http://www.ibcsr.org/index.php/institute-research-portals/simulating-religion-project) and the Modeling Religion in Norway project (see https://www.facebook.com/modrnproject/), I outline some of the strategies that I have found most helpful when trying to facilitate a deeper understanding of the opportunities and challenges involved in interdisciplinary efforts at developing computer models of human cognition and culture. First, I discuss four of the main virtues of M&S that can make learning human simulation attractive to humanities scholars. Then I discuss two of the main anxieties or suspicions that these scholars often have when they first encounter the idea of computer simulation. In each case, I argue that tackling these issues head on can help modeling methodologies feel less threatening, and more promising, thereby removing some of the barriers to learning. If M&S scholars can better understand these possible trigger points, they might find it easier to learn and teach human simulation.

One of the main virtues of M&S methods is the way they encourage, or even force, conceptual clarity. Of course, most scholars find it important to be as clear as possible when defining concepts, but this process is not identical in all fields. Significant concepts in the humanities are often highly contested, in part because they seem to be inherently fuzzy. Careers have been made (and unmade) in debating the meaning and use of terms such as culture, criticism, humanity, ritual, language, capital, ideology, and religion. While there may be no single "correct" meaning of these terms, having some concrete answer – some way of operationalizing the variables or mechanisms of interest – is necessary in the construction of computer models. Hermeneutical debates have their place, but convincing humanities experts of the potential fruitfulness of temporarily postponing those debates in order to explore some specific aspect of the phenomenon in a simulation is an important first step in the educational process.

For example, our interdisciplinary team was able to do this in a recent computational model of the relationship between the mechanisms of terror management and "religiosity." Acknowledging how contentious this latter term is among scholars of religion, we focused on the specific beliefs and behaviors that were most relevant for our proposed simulation (Shults et al. 2017). We delimited our use of this term in order to identify a set of statistically measurable traits that consistently engender recurrent sorts of beliefs and behaviors that mutate culturally in relatively predictable ways. Our interest was in modeling the relationship between mortality salience (death awareness, responsiveness to threats) and two reciprocally reinforcing evolved dispositions: the tendency to infer human-like supernatural causes and the tendency to prefer coalition-favoring moral prescriptions when confronted with ambiguous or frightening phenomena. For that reason, we clarified that we were using the concept *religion* to designate "socially shared cognitive and ritual engagement with axiologically relevant supernatural agents postulated within one's in-group." This sort of imaginative engagement, which promotes cooperation, commitment, and cohesion in the face of out-group threats and environmental challenges, is fostered by the intensification and integration of a hyper-active propensity toward detecting gods as hidden agents and a hyper-active propensity toward protecting in-group norms. Our model explored the ways in which these variables interacted with the mortality salience of simulated agents. Recognizing and accepting these specifications and limitations was key to helping humanities scholars learn about the usefulness of M&S techniques.

A second virtue of M&S that is particularly relevant for scholars in the humanities is the way in which it can shift the burden of proof in longstanding scholarly debates. Especially when it comes to historical arguments, it is not always easy to find adequate empirical evidence for deciding among competing hypotheses. Computer simulations may not be able to end a debate definitively, but they can lend plausibility to one hypothesis over another. For example, one member of our panel (Wildman) was part of a team that developed a model that shed light on a debate among historians about the transmission of violent ideologies in Anabaptist churches in the 17th century. Was violence diffused horizontally from group to group across networks, e.g., by traveling charismatic preachers? Or was violence inherited along denominational lineages, e.g., violent parental groups giving rise to violent offspring groups? Historians of the "radical Reformation" have long been at loggerheads over this question for centuries. Using a type of social network model, and a newly constructed data set, this team provided an analysis that lent more credence to the hypothesis that advocacy of violence was best predicted by a phylogenetic tree of congregational schisms (Matthews et al. 2013). While it may take some time to explain this sort of methodology to historians not familiar with computer models and phylogenetic analysis, the prospect of resolving such debates – or at least moving them along – can be a powerful lure for learning about these new methodologies. Establishing mutual relevance opens up educational opportunities.

Third, M&S has the virtue of facilitating interdisciplinary theoretical integration. Not all humanities scholars will be tempted by this characteristic of M&S methodologies, but some will. Once scholars are over the hurdle of deciding whether they are interested in learning about such conversations and collaborations across disciplines, M&S can be a very attractive approach. In a sense, the causal architectures within computer models are themselves theories, complex hypotheses about the interactions among variables. However, they can also enable the integration of several different specific theories, even when the latter have focused on different aspects of the phenomenon. One can even incorporate micro-, meso-, and macro-level theories. For example, our team has recently completed a model of mutually escalating religious violence, or MERV (Shults et al. under review). In that context, we integrate theories of social identity, terror management, and identity fusion within the architecture of an ABM that is able to "grow" artificial societies in which religiously inspired conflict between groups begins to spiral. When it comes to modeling human systems, these methodologies enable theoretical integration in a way that I believe is currently unrivaled. Once humanities scholars see this for themselves, they often become deeply invested in learning about human simulation.

A fourth virtue that many humanities experts will appreciate about M&S methodologies is the way in which they can render research more policy-relevant. Once again, not every scholar in these fields will feel the urge toward practical application, but some will. This growing sense of the need to be relevant can be motivated not only by psychological predisposition or social concern, but also by the constraints of university budgets and the increasing demand by governments or the general public for the "application" of research. In dialogue with subject-matter experts in relevant fields, one team within the afore-mentioned Simulating Religion Project is developing a user interface called CLASP (Complex Learner Agent Social Platform, in development), which is designed to be more easily accessible to scholars with no experience programming and little knowledge of M&S methodologies. Another team within the same project, in close collaboration with the Modeling Religion in Norway project, is engaging public-policy makers, and other relevant stakeholders on issues related to the refugee crisis, immigration, secularization and social conflict. If successful, this will result in a policy-version of CLASP, which would further facilitate the use of M&S to study and explore human systems. These kinds of tools make more hands-on learning about human simulation practical for humanities researchers.

It is also important to acknowledge the serious concerns that humanities scholars have about M&S techniques and that function as barriers to the educational process. The two worries I hear most often are that these methodologies are deterministic or reductionistic. Many humanities scholars are interested in these sorts of "philosophy of science" issues, and this can be one of the easiest places to start the conversation. Do scientists who use M&S methodologies presuppose a deterministic ontology? Some might, but this is certainly not always, or even usually, the case (at least no more than in other fields within the "hard" sciences). In my experience, discussions about stochasticity and emergent complexity are most helpful here. Computer simulations are focused on identifying and understanding the "mechanisms" at work in human (and other) systems, but this does not make them mechanistic in the classical sense (Youngman and Hadzikadic 2014; DeLanda 2011).

When it comes right down to it, however, perhaps the most common worry I hear expressed by humanities scholars is that M&S is reductionistic. This concern has at least two dimensions. First, there is the epistemological worry that computer scientists think every aspect of the phenomena can be "explained" (away) by accounting for its lower levels. Here too a good dose of emergent complexity theory is usually an adequate cure. The second dimension of this concern, however, is related to the general worry (noted above) among many humanities scholars that the rise of M&S is one more example of the quantitative, "hard" sciences creeping into their territory. I argue, on the contrary, that this is actually an opportunity for the human sciences to creep into (and share) new multi-disciplinary territory with computer modelers. M&S has the capacity to breathe new life into the humanities. For those of us (on either side of this divide) who are interested in understanding and explaining human systems, these methodologies provide new tools for theoretical and practical collaboration.

Once these barriers are removed, and the relevance of M&S techniques to human concerns has been established, humanities researchers often become strongly committed to making their way up the steep curve associated with learning human simulation.

3 PERSPECTIVE: MODELING OF HISTORY (FISHWICK)

When we think of how the humanities and modeling communities interrelate, we must first emphasize the importance and relevance of the humanities to scholarship and learning. The humanities are primarily about culture—defining and characterizing culture throughout the past. In terms of culture, history and language play prominent roles. Herodotus, who lived in the fifth century BCE, is often referred to as the "father of history." Herodotus earned this title by adhering to roles that we still identify with today: using specific sources of authority (e.g. eye witnesses where available) and the use of explanation to establish cause and effect.

What does history have to do with M&S? And how can this linkage impact undergraduate education at the junction of M&S and the humanities? These are questions that have intrigued this panel author for the past several years while situated in the colleges of Arts & Humanities (A&H), as well as the newly formed school of Arts, Technology, and Emerging Communication (ATEC) within The University of Texas at Dallas. The connection with the technical aspects of modeling arises through a joint appointment with Computer Science within the School of Engineering & Computer Science. M&S, of the sort discussed within the Winter Simulation Conference (WSC), and history are coincident along many paths. Some of these paths are identified in last year's conference proceedings (Fishwick 2016a) as well as in a paper under review (Fishwick 2017).

We first present a small subset of work (Fishwick 2016a, Fishwick 2016b) that relates to the subject of this panel. During Fall 2015, in an undergraduate class called Modeling and Simulation, we studied methods of modeling through an artifact at the Dallas Museum of Art: an Inca tunic shown in Figure 1, which was highlighted within a recent exhibit (DMAInca, 2016). The tunic dates from 1400-1500, with finely woven threads from vicuna and camelid fibers. The fibers are dyed using plant or animal products (e.g., indigo and cochineal). Tunics of this quality were reserved for Inca nobles.

In the 2015 class, students sought out examples of art from the museum, and then went through the process of defining formal model structures such as concept maps, state machines, and flowcharts (e.g., control flow diagrams).

Figure 1: Tunic with checkerboard pattern and stepped yoke. Courtesy of the Dallas Museum of Art, Public digital media collection. Additional Information: Inca Tunic (DMA-Tunic 2016).

It is interesting to explore how many ways M&S can be used to describe the tunic. Here are sample questions. All of these questions have answers that can be represented in the formal languages of modeling. Depending on the student's background and interest, different questions have more weight and significance.

- How was the tunic originally woven?
- How would the tunic be woven today?
- Can a computer program reproduce the tunic pattern?
- How was the red fabric dyed?
- What are the population dynamics of the alpaca or llama?
- Can the colored, square motifs be used to encode information?
- What were the behaviors or rituals of the tunic wearer?
- How was the tunic exhibit installed within the museum?
- What workflow process can be used to obtain a list of all tunics?
- What is the global timeline for Inca tunics across all museums?

For a subsequent undergraduate class called Creative Automata, the goal was similar: to take a historical process or object and then represent these within a modeling and simulation framework. Figure 2 captures a conceptual model (Fishwick 1994) for the eighteenth-century making of chocolate ice cream, including the necessary kitchen instruments and authentic ingredients. The conceptual model is defined by a directed graph of concepts and relations. For example, in the figure, Chocolate Ice Cream is a type of Dessert, and Milk, Vanilla, and Eggs are ingredients for a Recipe.

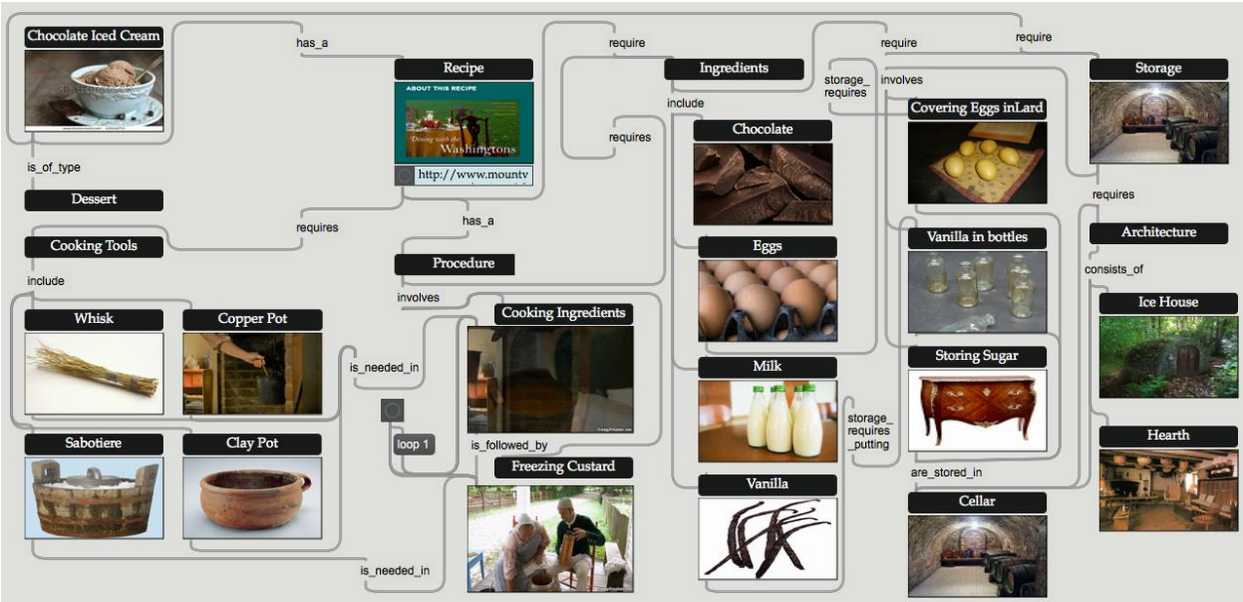

Figure 2: Concept Map of Chocolate Ice Cream (credit: Lakshmi Sharma)

One of my students created Figure 2 in a visual programming package called Max/Msp (referred to as "Max"). A Max patch (such as Figure 2) contains a collection of objects with cords. The cords connect objects together. Along the cords, data flows either in discrete chunks known as messages, or in a continuous signal. The continuous mode of operation is naturally associated with audio signals with frequencies such as 44.1Khz. Using these frequencies can be adapted to solving ordinary and partial differential equations, where required. The map in Figure 2 is different than those normally portrayed in the literature: the concepts are captured not only in a text caption but also in an image, which can be an artist's sketch, a photograph, or a looped video segment. Sound can also be captured, and the concepts can be hyperlinked to launch external web pages.

The concept map closely maps to other types of structures, such as mind maps and semantic networks, the latter being developed in the 1960s to visually represent knowledge in the form of logic. The student creating Figure 2 learned about 18th century cooking, directed graphs, and concept maps. In this fashion, modeling formalism was meshed with history from the humanities, and students were invested in the learning process.

One of the issues present when teaching undergraduate computer science students is framing the learned concepts within a strongly vocational framework. The students are there to learn concepts, but also marketable skills. It is not obvious that learning about Inca tunics, or eighteenth-century ice cream, develops skills that employers seek. However, our focus has been on using the historical contexts to teach undergraduates the formal concepts. It is the concepts that are important, and focusing on the topics that humanities specialists study can accelerate the absorption of the relevant concepts. It is tempting to think that a concept map of an ATM machine or a manufacturing scenario is more relevant, but this can lead to rapidly out-of-date vocationally targeted skill sets. It is vital that students grasp the abstract concepts, for which purpose humanities applications can be extremely useful.

4 PERSPECTIVE: PRACTICAL ARRANGEMENTS IMPROVE EDUCATIONAL EFFICIENCY (WILDMAN)

It is said that pandas in captivity are exceptionally difficult to mate. You may want to warn me not to go there, but I'm going there: humanities scholars and computer engineers have a mutual attraction problem, a communication problem, and a cooperation problem, which makes them, too, difficult to mate. Being a humanities scholar (a philosopher of religion), with some fluency in computer science generally and in programming languages in a particular, I have sympathy for both sides of this particular divide. Think of me as the neutral panda in whom both sides of the panda couple having difficulty will reluctantly confide. Though I hesitate to claim that my insights rise to the level of actually useful advice, I believe I have learned something during the last few years of intensive involvement in human simulation activities. Here's the number-one lesson: practical arrangements matter in facilitating learning human simulation. Other things matter, too, including the purpose and value of applying M&S techniques to questions in the humanities disciplines, as discussed in the other perspectives, above. But when the focus is on learning how to do human simulation in research teams consisting of graduate students, postdocs, and established researchers, practical considerations pertaining to places, peoples, and procedures have a huge impact on how well the modeler and the humanities specialist will get along and how effectively they can learn. I'll divide my reflections into those three aspects before returning to some more general observations.

First, *places matter*. And places matter in more than one way when trying to set up an effective educational environment for human simulation.

It is important to dislocate the humanities student or researcher from his or her home turf to reinforce that a new kind of learning is occurring, and an unfamiliar location sends that message loud and clear. Novel spaces effectively disrupt the powerful habits of association we build between place and practiced ways of thinking.

It is crucial that the workspace be calm, quiet, attractive, and neither too large nor too small. Humanities people are used to solitary work in quiet venues such as studies or libraries. They are typically not used to doing serious research in a busy, chaotic environment such as a lab or a set of office cubicles. While it helps to break habits of place we still need the humanities specialist to function in high gear within the learning process. So choose a conference room with comfortable seats that one might sit in for hours at a time, a place that looks clean and sharp. This means avoid using a small office or a vast conference space, stay away from crowds of people and incessant interruptions, and don't do ugly. Picture the humanities scholar's quiet library-like study setting and aim for that degree of welcoming warmth, though I admit it's hard to come by in the computer engineer's world.

It is also vital that the location for model building be suitably equipped. Instead of crowding behind a computer screen, make sure the space offers a large high-resolution projection screen or wall display for showing a model as it is built, a large whiteboard for specifying the model and brainstorming, and a big table on which the team can sprawl books, computers, and notepaper.

Second, *people matter*. Here again, there are several senses in which this rather obvious-looking statement is thought-provokingly true when it comes to efficiency of learning.

You might assume that it is wonderfully useful when the modeler actually knows something about the humanities students' or researcher's subject matter but most of the time that's neither necessary nor desirable. Instead, the modeler needs to master the priceless skill of evincing from the humanities team member a level of precision and clarity that they may not be accustomed to supplying. This type of seductive empathy is not easy to come by so, if you have a budding modeler who is no good at that, and you can't fire them, team them with a humanities subject-matter expert seasoned at building models, and save your interpersonally gifted modelers for the newbie humanities specialists who have the steepest learning curve.

Likewise, it is just not a good idea to assume that all humanities students and scholars are interested in learning M&S, or can be seduced into becoming interested. That will only lead to disappointment. Choose the adventuresome humanities person who enjoys new learning challenges, the person who is unafraid of discovering that they don't know their own pet theory as well as they thought they did – because that's definitely going to happen.

Also, make sure that the group doesn't get too large. One modeler with one or two subject-matter experts is enough. Four is too many, unless one of them is secondary to the main proceedings, more of an observer than an active participant in the learning process.

Third, *procedures matter*. Certain features of the simulation-learning process are inevitable. But, particularly when striving to learn human simulation, several quite specific procedural matters are crucial.

Right at the beginning, humanities students and researchers need to learn the difference between a system-dynamics approach and an agent-based approach to simulation. These are the two modalities of simulation most important for capturing what humanities people tend to think about and the first point of business has to be deciding which type of model to learn to build. While this decision is obvious to many kinds of subject-matter experts, the very distinction is very likely to be anything but obvious to a student of the humanities.

Theories in the humanities tend to be rather vague because they are not oriented to yielding predictions that might be used to test and improve those theories. So-called hard scientists tend to lament this state of affairs, or mock the people engaged in such imprecise forms of theorizing, but that completely fails to register the sophisticated interpretative moves that this very vagueness permits. It follows that computer engineering students and researchers must learn both to appreciate vagueness in the humanities for its hermeneutical subtlety, and to acknowledge that some of this subtlety is inevitably lost in a model. The computer engineering student or researcher who can take those educational steps is more likely to inspire the humanities student to engage M&S. If the humanities person is immovably resistant to increasing precision and clarity, or if the computer engineering person is intractably resistant to seeing the interpretative virtues of humanities disciplines, then you are dealing with the wrong people and learning will be thwarted. By contrast, when these learning obstacles are successfully hurdled, the deepening of precise clarity (for the humanities student) and hermeneutical subtlety (for the modeling student) are routinely named as the single most rewarding aspect of the entire learning process.

Lastly, the vital process of verifying and validating a model can look a bit different in human simulation. This is especially because data is sometimes hard to come by, or takes more qualitative forms, in the humanities. Consequently, face validation in the form of the humanities student or researcher recognizing model dynamics is relatively more important and validation against crisp data sets is relatively less important. You must work with the data you have.

In conclusion, I have built enough models, sometimes as subject-matter expert and sometimes in the modeler role, to know that it can be an unpredictable process, surfacing hidden assumptions that may never have been properly addressed in the extant literature, or confronting unanticipated obstacles that are genuinely difficult to remove. But I have set up enough modeling teams with humanities students or scholars, and computer engineering students and researchers, to know that the right place, the right people, and the right procedures can optimize the process of learning and transform what can be a tedious, frustrating process into an efficient and rollicking good time for all. Veteran modelers often report that they have more fun working with novice humanities people than any other type of subject-matter expert. Maybe that's just because it is a different kind of experience than simulating data networks or solving traffic-light-timing problems or designing factories. But I think it's mainly because it is extremely satisfying to work on a team with such different people learning how to address an issue of human concern. And it's pretty cool to see humanities scholars get so excited by the learning process, too.

5 CONVERSATION: RESPONDING TO ONE ANOTHER

5.1 Shults' response to Fishwick and Wildman

I very much appreciated Fishwick's perspective, which I saw as complementary to mine in at least a couple of ways. First, while I focused primarily on how to transgress the boundaries of the "two cultures" at the level of interdisciplinary learning among established scholars, Fishwick focused on ways in which to make the link at the classroom level with undergraduate students. Second, my emphasis was on the way in which individuals on the "human sciences" side would perceive the learning challenges and opportunities, while Fishwick pointed out some of the learning challenges faced by computer science folks, including the need for their engagement with the humanities to reinforce understanding of general principles and thereby provide skill sets that improve their job prospects. At the University of Agder, we are just beginning a new research project (in collaboration with the mathematics education department) that involves exploring new ways of teaching computer simulation methodologies to humanities students (in our case, students of religion). It was very encouraging to hear about the success Fishwick has had at The University of Texas at Dallas. It seems to me that the emphasis on helping students learn how to deal with concepts and their interrelation could be a good place to start when trying to facilitate the integration of M&S methodologies within humanities and social science classrooms.

Wildman and I have worked together in educational collaborations of the sort he describes in his perspective, and my experience confirms his conclusion that places, people, and procedures really do matter. As I read through his assessment, concrete examples floated into my mind – examples of specific cases in which these three desiderata were fulfilled, and the learning process went swimmingly, and specific cases in which one or more were not in place, and we had had to paddle hard to stay afloat. Learning how to facilitate an educational process involving people from such different fields is an ongoing process. People usually raise their eyebrows (whether in disbelief or fascination, it is not always easy to tell) when I tell them that we are trying to get scholars of religion and other humanities specialists to learn how to work with computer engineers and modelers. When I tell them how we hope such collaboration will help lead to new scientific insights and new ways of evaluating policies for solving practical problems related to issues like the refugee and immigration crises, then almost everyone lowers their eyebrows and starts to ask questions; their interest in learning about human simulation is sparked. We believe that it is worth the effort to bring scholars from different disciplines (and policy-makers) together to go through the human-simulation learning process. It's all about getting open-minded pandas into a comfortable space, giving them a comfortable amount of time, and setting up a set of procedures that helps put them in the right mood to learn how to get the job done.

5.2 Fishwick's Response to Shults and Wildman

Shults' perspective is an essay on understanding the phrase "human simulation." Shults' audience in this perspective is M&S scholars. His attempt is to explain this phrase and to help M&S experts learn how to reduce the anxiety felt by the humanist scholars when working with M&S researchers. He identifies four "virtues of M&S." The first virtue is: "One of the main virtues of M&S methods is the way they encourage, or even force, conceptual clarity." This clarity stems mainly from science and engineering having roots in mathematics. In mathematical thinking, there is a focus on levels of formalism or abstraction, and it is vital that these formalisms comply with a set of rules. As Devlin (1994) points out, mathematics is the "science of patterns." Given that, it is natural for M&S researchers to adopt this framework in all of their work. The patterns may be textual (e.g., natural language), symbolic (e.g., modern mathematical notation), pictorial, or even sonic in some capacity. But the goal of formalism is still there. The second virtue relates to empirical evidence and the lack thereof in some humanities areas. Models are also an instrument of communication and education, and not only of prediction and statistical analysis. Two remaining virtues are examined, but we will skip these for reasons of economy. Toward the end of Shults' perspective, he makes this observation "When it comes right down to it, however, I think the most common worry is that M&S is reductionistic." This point is certainly worth considerable time and effort for both M&S and humanities researchers. Shults is correct that this concern is widely felt among humanities scholars. Without reductionism, however, there would be no method, no formalism, and therefore no deep knowledge. The methods of abstraction and analogy-making, as well as language, seem inherently reductionistic. Our main question with this term is why it has a negative connotation for some, whereas for others, it expresses business as usual? Most scientists and engineers think that reductionism is fundamental to science and engineering disciplines. How could these areas have come to be without reductionism? That the humanities have a strong sense of formalism, rules, and method is argued by Bod (2016). One reading of Bod's account is that the humanities invented reductionism.

Wildman's perspective observes correctly that there is a "two cultures" problem, an issue which can inhibit useful cross-fertilization between engineering and humanities students. Wildman notes that places matter, people matter, and procedures matter for effective collaboration. On the first (places matter), perhaps we need a combination of labs and informal spaces to optimize the learning process. At The University of Texas at Dallas, we have a weekly "watering hole" meeting that is fairly open-ended and philosophical in nature. It helps to have structures that support healthy collaboration practices and encourage all to speak, without letting some dominate the conversation. There are a fair number of scientists and engineers who also like solitary spaces – those who are not empirically grounded (in science) or lab/machine dependent (engineers). This creates a continuum in research spanning large, collaborative teams down to a one-person research. Wildman's comment on getting the right people to work together is logical. Wildman notes, "Theories in the humanities tend to be rather vague because they are not oriented to yielding predictions that might be used to test and improve those theories." This brings back the importance of modeling: the artifacts modeled and the process of modeling are equally about understanding a thing (via system dynamics, for instance) and not necessarily always to predict. Models, such as computer programs, are there to help the author understand the phenomenon. The understanding occurs by way of modeling.

5.3 Wildman's Response to Shults and Fishwick

On the basis of extensive experience, Shults describes what is involved both in encouraging humanities scholars to learn about M&S techniques, and in helping M&S specialists grasp what human simulation might be. I have found the very same in regard to convincing diverse specialists to think of collaboration as a potentially useful activity. We have been noting the reactions of humanities scholars and computer scientists to this kind of collaborative endeavor. Every humanities scholar who crosses the threshold and gets involved in M&S has come away from the process extremely energized, declaring that they understand their own subject matter more deeply than ever, and buzzing with new ideas. Most of the computer-engineer modelers also report high satisfaction with these encounters because the subject matter is so different than the technical topics they usually deal with and because it is rewarding to see a humanities scholar so engaged with and excited about learning M&S. The computer engineers also report frustration with the slow pace preferred by humanities scholars, which is probably driven partly by uncertainty and partly by a kind of perfectionism that might be out of place in modeling humanities topics. Natural and justified humanities concerns about invidious reductionism – note, not reduction as such, but reductionism that neglects the subtleties of the object of study and thereby damages understanding – decline as the humanities scholars see that every conceptual model, even their own native way of thinking about a topic, is inevitably perspectival and reductive to some degree, and thus that the challenge of managing reductionism in computer M&S contexts is actually not different in kind to the same challenge of oversimplification and perspectival bias they confront in their daily work as humanities scholars.

Fishwick's presentation of humanities topics as pedagogical means to an M&S end – namely, grasping the formal principles of modeling – is thought provoking. Evidently, he is using this way of thinking to draw humanities students into M&S ways of thinking and also to help M&S students develop a sharp distinction between formal principles and subject-matter applications. I think he is correct that creating this distinction in a sharp way is likely to be aided by modeling subject matters that are less commonly discussed in the world of M&S, such as Inca tunics and procedures for making chocolate ice-cream from earlier centuries. I suspect that many humanities topics could have this same function. Standing behind this is a problem that computer engineers engaged in teaching M&S may need to consider carefully. How much are they focused on formal principles, and how much on applications? Are they learning to draw a clear distinction between the two? My impression is that some M&S specialists complain about others who don't care much about logically crucial phases of model development. This complaint acknowledges that they might care about problem specification but they don't spend a lot of energy on verification and validation, including checking the formal consistency of the assumptions of a model. If Fishwick's pedagogical practices are to become more widely embraced among teachers of M&S methods, these teachers may need to commit themselves more clearly to maintaining a distinction between formal principles and subject matters, and to covering all of the important formal principles, not just those that seem most relevant to a particular subject-matter application. Finally, using humanities subject matter areas to teach modeling and simulation develops specific skills in modeling intelligent agents, which is a theoretically complex and computationally challenging area within social simulation generally and human simulation in particular. If more modelers could handle those difficulties with ease, human simulation would be greatly advanced.

6 CONCLUSION

Human simulation – in the specific sense of applying M&S techniques to topics that arise in the humanities disciplines, the interpretative social sciences, and the arts (which we have collectively referred to throughout as the humanities disciplines) – is a potent extension of social simulation. The sheer fact that human simulation is possible drives home the presence of formal patterns in a host of phenomena that for a long time were thought to be inimical to formal or mathematical analysis. All three of us have testified to the usefulness of human simulation activities, the difficulties associated with learning how to participate effectively in this kind of cross-disciplinary work, and the benefits that accrue to understanding once the threshold is crossed and intensive learning begins. We have presented what our experience suggests are best practices for teaching and learning how to do human simulation. We have responded to one another's perspectives, refining and extending the insights offered.

We conclude with a double challenge. To those already interested in human simulation, we encourage you to do your own thinking about best practices in M&S pedagogy in this domain, with its peculiar problems. Hopefully the reflections in this paper will help. To those who haven't thought about applying M&S techniques to topics from humanities disciplines, or using humanities topics to teach M&S principles, perhaps now's the time to start.

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