

## The Quest for Knowledge: How MOOCs Provide Insights for Innovation in Modeling and Simulation

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### ABSTRACT

Massive open online courses (MOOCs) could solve old problems in new ways. More than ever, people need access to knowledge. Since the earliest of days, this has been a never-ending quest. This paper looks at the knowledge process from the domain of education in order to stimulate innovation and advancement in another source of knowledge – modeling and simulation. This paper explores knowledge, starting with the innovations that propelled MOOCs to their current position in the marketplace. It then offers a framework based on current studies and draws parallels to modeling and simulation, probing the questions as to how modeling and simulation can learn from MOOCs so decision makers have greater access to knowledge more directly and easily through modeling and simulation tools as well as the discipline formed by that community. Today's modeling and simulation leaders need awareness of the MOOC business model and the potentially high returns on investment when integrating models and tools to solve new problems.

### ABOUT THE AUTHORS

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## INTRODUCTION

New conceptualizations provide better structures to capture the knowledge in coherent frameworks.

—Tolk, Diallo, Padilla, & Gore, *Epistemology of modeling and simulation*

Certain characteristics of the human endeavor are seemingly timeless. The search for knowledge is one such characteristic. This paper seeks to look at the innovations and advancements in one domain (education) in order to stimulate innovation and advancement in another (modeling and simulation). Both can be powerful modes of spreading knowledge. More specifically, the modeling and simulation community can learn much by gleaning insights from the revolution in education called Massive Open Online Courses (MOOCs) and how they spread knowledge throughout the globe. Modeling and simulation is at once a discipline and a tool (Tolk, Diallo, Padilla, & Gore, 2013a). Considerable progress is evident in modeling and simulation over the last decade. However, it needs a catalyst to herald in a new decade of progress. Many recognize this plateau and efforts exist to advance the utility of modeling and simulation to spread knowledge it can provide to a broader community. This plateau has existed for a number of years, and ideas have begun to emerge to surmount the challenges. However, the rate of innovation is shallow as compared to a decade ago. Meanwhile, a very old domain – education – has made tremendous inroads to advancing various dimensions of that field.

Modeling (specifically) and simulation (to an extent), can be found in history nearly as far back as education itself. There are many parallels between them. Within modeling and simulation, the late 1990s and the early 2000s resulted in technical advancements to interconnect disparate models and simulations. Much of that work stemmed from the use of emerging programming languages and architectures. Fortunately, the numerous advancements of that era have become commonplace; however, the “next big thing” in modeling simulation seems to elude the enterprises. Conferences and working groups have wrestled with new techniques and approaches for the last few years. For instance, at MODSIM 2014 there will be a workshop bringing together a group of people to investigate some of the new ideas not typically heard of in the modeling simulation community. This is noteworthy and of great interest. This paper looks at education, its innovation, and what it can teach the modeling and simulation community. The authors hope this paper plays a role not only in MODSIM 2014 discussions, but also as a thought piece for future workshops and conferences. The propositions made in this paper make use of observations within the environment surrounding the magnificent innovations of a very old and important enterprise – education.

## MOOCs – A BACKGROUND

It is very difficult to pinpoint the historical beginnings of education. It very likely emerged with the first human beings who wanted to learn new things – to survive. For purposes of this paper, we will begin at the time of the Renaissance. During that era, education was not accessible to everyone. Rather, it was reserved for people of means such as noblemen and royalty. The methods then were not markedly different from those used in the 1980s – brick and mortar institutions, educators, curriculum, and students. The size of the classroom was very small – in some cases one-on-one interaction between a sage and the king’s son perhaps. Topics included the ancient classics, the sciences, history, and perhaps a bit of fencing. Fast-forward to the 18th century. Many advances in education emerge in the United States as universities form. Once again, this era reserved education for people of means and primarily men. Some of the great institutions such as Harvard, William and Mary, University of Pennsylvania, and Yale were founded in this timeframe. The advancement was in bringing education to our shores from Europe. Much of the rest of the educational model remained the same. The 19th century sees the advent of public education. Education

became more open to both sexes and to a broader class of the population. Again, the locations, methods, and subject matter remain much the same.

In this long history, one finds advances in the academic disciplines and hence the curriculum. However, what occurred in the 21st century with MOOCs marks a significant advancement and innovation that propels the idea of education and poises it for a very different future. MOOCs are “a course of study made available over the Internet without charge to a very large number of people” (MOOC, 2014, para. 1). MOOCs are revolutionizing the traditional forms of education and how they spread knowledge. They are an evolution in a series going back to the earlier Khan Academy with the mission of using technology to change education and training – not just deliver the old content over a new medium. Brick and mortar classrooms have made way for online learning. According to Attis, Koproske, and Miller (2012), MOOCs are initially expensive to setup but in the end are nearly limitless in their scalability and ability to reach vast numbers of knowledge seekers. MOOCs allow the development, creation, and sharing of knowledge with worldwide connectivity to practitioners and other students as opposed to a duplication of knowledge often found in the confinements of a standard classroom. Meanwhile, mobile devices have joined forces with the MOOCs to deliver that content on the millions of smartphones around the globe.

Meanwhile, MOOCs have become a big business. Attis et al. (2012) pose the question, “Will MOOCs generate a positive return on investment for their providers?” They would indicate “yes” and that MOOCs are a truly disruptive technology. Two to the three big MOOC providers are for-profit entities started with venture capital. Udacity began purely as a business with venture capital backing (Efrati, 2012), whereas Coursera (also for profit) had a strong partnership with Stanford University. It has received substantial venture capital in excess of \$60M (Kolowich, 2013). Predictions also point to a future of game-based learning through the MOOC architecture (Attis et al., 2012). Harvard University and MIT formed edX and is another MOOC provider. They have no venture capital and they are a not-for-profit entity. Figure 1 provides a screen shot of a Coursera (2014) MOOC offered on gamification from the Wharton School of Business at the University of Pennsylvania – without cost to the student.

**Penn**  
University of Pennsylvania

## Gamification

Gamification is the application of game elements and digital game design techniques to non-game problems, such as business and social impact challenges. This course will teach you the mechanisms of gamification, why it has such tremendous potential, and how to use it effectively.

[Preview Lectures](#)

[Watch Intro Video](#)

### About the Course

Gamification is the application of digital game design techniques to non-game problems, such as business and social impact challenges. Video games are the dominant entertainment form of our time because they are powerful tools for motivating behavior. Effective games leverage both psychology and technology, in ways that can be applied outside the immersive environments of games themselves. Gamification as a business practice has exploded over the past two years. Organizations are applying it in areas such as marketing, human resources, productivity enhancement, sustainability, training, health and wellness, innovation, and customer engagement. Game thinking means more than just dropping in badges and leaderboards; it requires a thoughtful understanding of motivation and design techniques. This course examines the mechanisms of gamification and provides an understanding of its effective use.

Subtitles for all video lectures available in: English, Russian (provided by Digital October), Turkish (Koc University), and Ukrainian (provided by Bionic University)

### Sessions

Jan 27th 2014

[Go to class](#)

### Course at a Glance

- 10 weeks
- 4-8 hours of work / week
- English
- English, Russian, Turkish, Ukrainian subtitles

[Earn official recognition for your work](#)

**Figure 1. Example MOOC. A screen shot with some information about the characteristics of the course.**

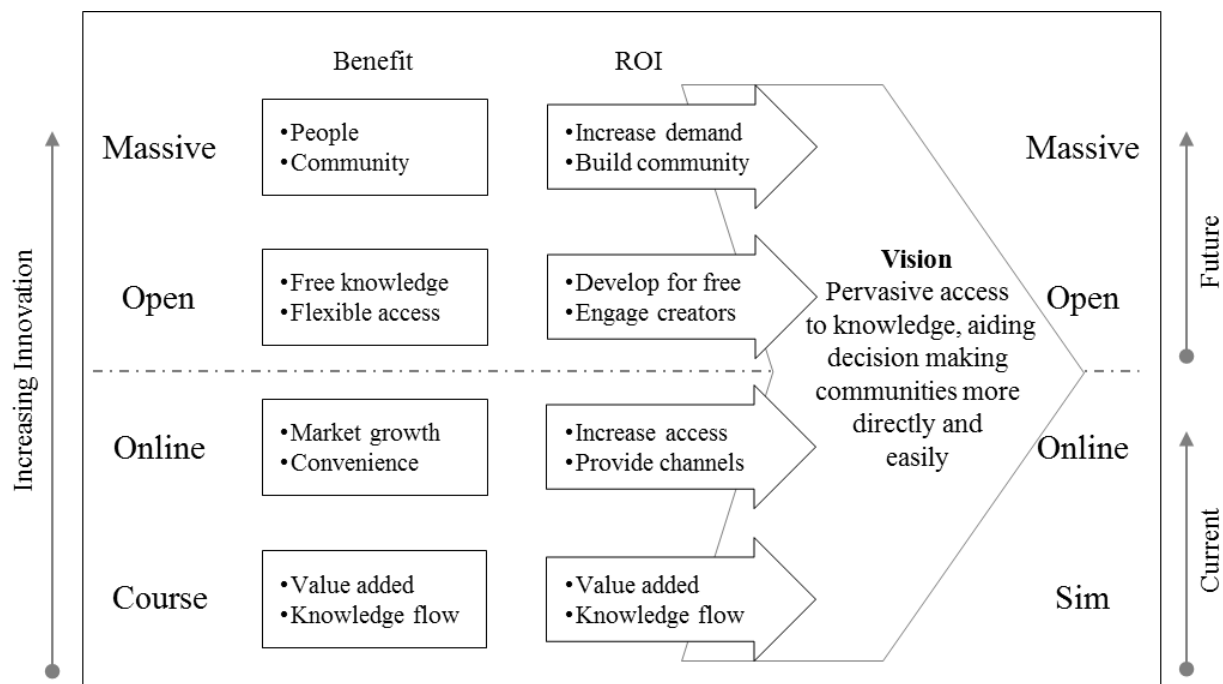
This giant innovation began from a small seed but has grown at an amazing pace and reached an even more amazingly large user group. MOOCs offer more than just a fascinating twist on an age-old domain. They offer other domains with an insight as to how they may innovate and advance themselves. Modeling and simulation is one such domain that can take advantage of observations from MOOCs.

## A FRAMEWORK FOR INNOVATION

Before providing the pivotal framework for the remainder this paper, it would be worth briefly looking at each of the four critical words of this new approach.

- Massive – the ability to bring hundreds of thousands of people together in real time to educate and share knowledge
- Open – characterized not only by its free cost to pupils, but also the great leap in accessibility of courses and knowledge to people in a much more flexible manner
- Online – both web based and mobile device centric, these offerings propagate via the World Wide Web to customer bases at the farthest reaches of the global community
- Course – the basic element of the exchange; the means of sharing knowledge and providing a value proposition to the customer segments

Having this basic understanding of MOOCs, the authors developed a layered framework to identify characteristics of this innovation within education and to consider how MOOCs can offer an approach to leverage in the modeling and simulation domain. Figure 2 provides a graphical framework that is the cornerstone of the remainder of this paper.



**Figure 2. Education Innovation. Observations of MOOCs projected on modeling and simulation.**

On the far left one sees the four characteristics of a MOOC as described above. To their immediate right is the benefit each of the characteristics provides to the educational domain in summary form. The white space to the right of the benefits symbolizes a porous interface through which observations gathered from MOOC innovation permeate over to modeling and simulation. The arrow blocks list returns on investment (ROIs) the modeling simulation community may realize by leveraging MOOC approaches. In this age of tight budgets, the authors chose to shape the modeling and simulation side of the equation in terms of not just benefits but the returns that one may achieve by investing in innovations trail blazed by MOOCs. At the far right is a large arrow with a vision statement

underlying the characteristics potential for Massive Open Online Simulations (MOOS). Admittedly, the acronym may not be the best branding available, and perhaps MOOSE (Massive Open Online Simulation Environments) better describes the concept. Nonetheless, the authors will allow the enterprise to judge the effectiveness of such a moniker. There are two other features in Figure 2. The arrows along the left and right are indicative of innovation within MOOCs and a movement from current to future activities within MOOS. Meanwhile the light horizontal line represents a critical transition point in both the innovation of MOOCs and the potential innovations of MOOS. This framework allows for the observation of benefits witnessed in MOOCs and then potential returns on investment available to MOOS by this awareness.

### **OBSERVABLE BENEFITS OF MOOCs**

Using the framework describe, discussion will begin at the bottom – the atomic level – and rise through the levels to the more innovative and advanced aspects for consideration.

#### **Course**

This level almost needs no explanation, yet it is important to begin at the atomic level. In the case of education, one considers the atomic level the course itself. The course is the “good” in the market exchange system of education. It is also the transfer vehicle for something shared amongst many domains, that being knowledge flow. Simply stated, the course is the value proposition. This atomic component marries the providers and the customers and is the source of both cost and revenue. Three statements may be made of courses.

#### **Courses are Valued**

A student’s accumulation of courses shows their progress and advancement in knowledge within the educational system. The value is manifest by providers who can reap revenues; customers who desire and indeed advance in knowledge; and the global community, as knowledge propels new ideas that better communities and the world.

#### **Courses are Diverse**

A customer is likely to find anything they need in the MOOC marketplace to provide knowledge and advancement. The educational domains have used models to better understand, and in some cases simulate, the effects of natural phenomenon, mathematical ideas, and social interactions.

#### **Courses are a Means to an End**

Educators know that despite the labor and love in creating and perfecting a course, the course is but a means to a greater end – which is knowledge.

#### **Online**

Education in the 1990s saw something completely different – online university education and the large growth of students in graduate courses. This represented the beginnings of an innovation that has expanded into what MOOCs are today. One must recall that the Internet had existed since the days of the ARPANet in the 1970s. Yet, the World Wide Web phenomenon of the 1990s that sparked interest among universities to offer the first online, for-credit courses. Online education opened up brick-and-mortar schools – MOOCs may turn them inside out. Going online was a significant milestone in the overall innovation of MOOC education. The benefit they provide is a great expansion of the marketplace. Unlike the Renaissance in the 18th century leading into the 19th century, the expansion of the market allowed more people to become educated regardless of their socioeconomic status. The expansion was due to the ability for students to take advantage of education at a time and place more convenient to them – be that after work or in their living rooms.

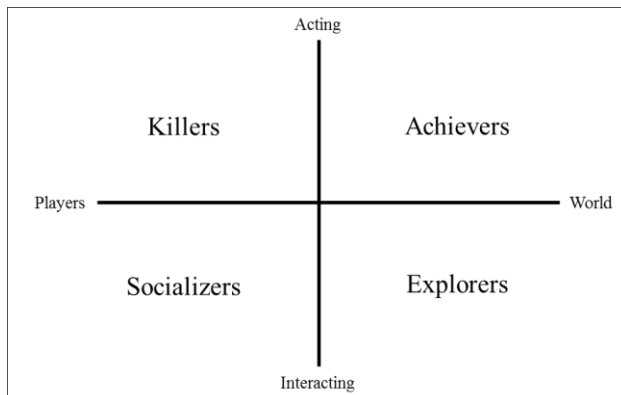
#### **Open**

The term “open” has multiple variants of meaning in the domains of MOOCs. One common theme, however, is that of “free”. Among MOOCs, open represents free knowledge and flexible access (i.e., freedom). The openness provides a freedom wherein people magically become students with nothing more than a click of a button and personal desire. The sense of openness between MOOCs and MOOS differs from one another. MOOCs have built

upon proprietary systems based on venture capital investment. Knowledge spreads freely using a “freemium” business model to attract a different type of return on investment.

## Massive

This level lies at the top of the framework. It has been one of the largest implications of MOOCs for spreading knowledge. Simply stated, the term “massive” implies a characteristic beyond mere technology – it is about people and community. One of the most interesting implications of MOOCs is the scalability they provide. With very little marginal cost, a MOOC can reach audiences in the tens to hundreds of thousands of students. Students are taking a course in a near real-time situation working in a very familiar educational structure composed of weekly quizzes, assignments, and even final exams. Discussion forums aid them by enabling communication with one another and knowledge providers. The instructor does not moderate those MOOC discussion forums. How can he or she interact with 90,000 to 300,000 students? Using gamification techniques of points and badges and status, staff and “community teaching assistants” help run the vast number of threads on discussion forums. A quick visit to any forum will yield a rich dialogue. The authors have personally witnessed dialogues in business-oriented MOOC offerings where chief financial officers of large corporations are students who are interacting with other students. That is community building. That is knowledge sharing. The massive in MOOS would rely on the concept of open source. To explain the returns on investments for the modeling simulation community, a model from massively multiplayer online games (MMOGs) is presented in Figure 3.



**Figure 3. Player Interest Graph. Four types of players in gaming environments and their motivations.**

It depicts the Player Interest Graph developed by Bartle (2004) and is presented as a means to articulate what motivates and engages gamers. The Bartle model is broken up into four quadrants. On the left is the players, representing individuals and on the right is the world, representing the game space. At the top is the verb “acting” and at the bottom is the verb “interacting”. These verbs refer to the actions on either the players or the world. Bartle provided a single word descriptor summarizing the characteristics of each of the quadrants.

Beginning in the top right we find those who are acting on the world. These people are achievers. Their motivation in a game environment is to reach a level of achievement and to overcome obstacles. Meanwhile, those interacting with the world are explorers. Their motivation is to see what is possible within the game space by pushing the limits and finding new things and new capabilities within an existing game. On the left, those interacting with people are socializers. Their interest is to become part of a team – to become part of a community through the social interactions that the game space allows. The last time quadrant is the most controversial. Bartle points to a rare (approximately 1%) number of people who are motivated to act on players. These people he refers to as killers. Their goal is control. Sometimes in damaging other players but other times in controlling the situation by helping other players with healing powers, for example. The important point that Bartle makes is that killers are a small but very important group of players. Why? Because they really care to an extreme level about the game world. A lot of this gamification theory forms the benefit of the MOOCs because they increase in value as a very enlightened community made up of providers, leaders, moderators, customers, students, and volunteers offer to improve the community.

## PERMEATING KNOWLEDGE THROUGH MOOS

Simulation will continue to be a key source of knowledge discovery in the future.

—Andreas Tolk et al., (2013b)

### Simulation

Simulations lie at the atomic level of the MOOS business model and are fundamentally similar to courses as a means to enhancing knowledge flow. Simulations are both a good and a market in the knowledge economy – transferring information shared amongst many domains. Tolk et al. (2013b) notes, “We actually do not get knowledge of the natural system itself, but of the representing formal system that we used to describe the system” (p. 1). Robert Rosen made this statement in 1998 and it holds even more viable today in this world of data generating applications, smartphones, and social media – where massive quantities of data are applied in big data modeling to gain knowledge of customer preference and appropriate business decisions. Models and simulations provide a value proposition. This atomic component marries the providers and the customers and is the source of both cost and revenue.

### Modeling and Simulation is Valued

Models and simulations aid in the growth of knowledge domains as seen in economics, biosciences, and education to name but a few. Combinations of simulations create further advances in knowledge in these domains. Like education, value is manifest by providers who can reap revenues; customers who desire and indeed advance in knowledge; and the global community, as knowledge propels new ideas that better communities and the world.

### Modeling and Simulation is Diverse

With a little searching, one is likely to find a model or simulation for nearly anything. This is a potential return on investment (ROI) for modeling and simulation. Providers of modeling and simulation capabilities may ask themselves, “How accessible are those models to the greater marketplace? Could they become as abundant and accessible as courses are in the MOOC framework?”

### Models are a Means to an End

George Box stated, “All models are wrong, but some are useful!” Tolk et al pose the question whether we can “gain knowledge from something that is essentially wrong? What are we doing when we build models, derive simulations, and then execute the simulations?” (2013b, p. 2). They retort that humankind can create more than they understand – they can use virtual means to understand the unknown better...and create knowledge. Simulations exist not to behold but to “be-used” to increase knowledge of a system or a system of systems for a customer – an interested “student”.

### Online

This poses an interesting ROI proposition for modeling and simulation. Although the capability has long existed inside of universities, federal agencies, and Department of Defense training organizations, the authors suggest that modeling and simulation has entered an online stage similar to education in the 1990s. It has opened up by virtue of federated systems and aggregators combining the works of various institutions into a collective and unified environment. Without data, it is hard to gauge whether modeling and simulation has become as accessible on a relative basis as education was after online education became popular. However, whereas MOOCs may turn education and the brick-and-mortar system inside out, modeling simulation has not achieved this. The returns on investment in following a MOOC style strategy for modeling simulation is the number of new customers from defense, users within the government, and other nations in our alliances. Gendron, Barboza, and Tolk (2013) explore the idea of Modeling and Simulation as a Service (MSaaS) in a concept paper for the North Atlantic Treaty Organization. The basic idea of the concept – currently under review in the NATO Innovation Hub – is to provide modeling and simulation services more easily via online architectures. In fully envisioned form, these services will not require the intervention of modeling simulation specialists to instantiate and environment. MSaaS is not the only way for modeling and simulation to become more accessible online. This becomes evident when considering the next MOOC characteristic – “Open”

## Open

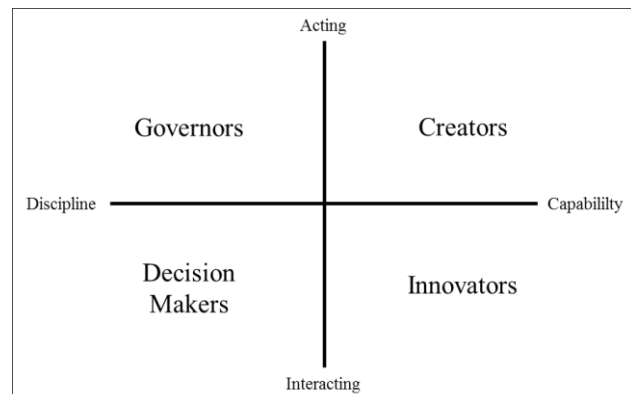
This level of accessibility is possible within modeling and simulation and to some degree does exist. One can point to the NetLogo modeling and simulation capability. NetLogo is a programmable, agent-based modeling environment used by tens of thousands of users including teachers, researchers, and students (Wilensky, 2014). NetLogo is a freely available online simulation tool that allows for the investigation of a multitude of problems in various domains such as social issues, transportation, health sciences, economics, forestry, and a variety of other interesting areas. NetLogo is interesting because it shows another dimension of “open” – that of open source.

The topic of open source modeling and simulations is a topic the modeling and simulation workshop will discuss during MODSIM 2014. Open source denotes “software whose source code is available free of charge to the public to use, copy, modify, sublicense, or distribute” (Dictionary.com, 2014). Open source provides numerous ROIs to the modeling and simulation community. Essentially, open-source products provides for free development activity of models. This is plainly evident in the NetLogo environment. Open source provides an engaging and challenging space for people of a certain motivation to enhance the body of knowledge by contributing to open source code. Additionally, these two characteristics combined to form a very interesting and inexpensive way of marketing modeling and simulation to a larger marketplace. Entire companies exist using the open source business model. Ned Lilly, CEO of xTuple, founded his business to create enterprise resource planning software, which itself is based on an open source database called PostgreSQL (N. Lilly, personal communication, January 30, 2014). This approach provides numerous ROIs that modeling and simulation can leverage to engage more market share (see the Appendix for the questions and answers of the interview with Ned Lilly).

This for-profit model would not work in a government space although it could operate in an industry modelling and simulation context. Open source could provide a launching point to propel modeling and simulation in a manner not unlike we saw GPS its early days. Consider that the military built GPS for national defense and it slowly became available to the public domain. Now, consider a day without GPS enabled devices. What might happen if certain government-built modeling and simulation products were slowly released into the public domain? What potential implications could there be in taking modeling and simulation from a somewhat exclusive domain to something that is pervasive within society?

## Massive

This level holds the biggest implications for spreading knowledge in MOOS architectures, just like in MOOCs. The authors adapted the Bartle framework to depict an emerging discussion about the modeling simulation domain. A paper by Gendron and Tolk (2013) point out that modeling and simulation has been seen in the past as a capability: a thing – a tool – created by science. The paper also makes the point that modeling and simulation is a discipline composed of providers within a community who can be both teachers and helpers and volunteers. Figure 4 provides a framework based on the Bartle approach but adapted for modeling and simulation. Once again, “acting” and “interacting” form the verbs; however, based on the work of Gendron and Tolk (2013), players have been replaced by the term “discipline” – the community. The world, or the game environment, has been replaced by the term “capability” based on the modeling and simulation tool.



**Figure 4. Simulation Interest Graph. Adaptation of Bartle (2003) model for modeling and simulation.**

Those who act upon the capability are the creators. These practitioners are motivated to overcome obstacles in attaining achievement by creating great models and simulations. Meanwhile, those interacting with the capability are innovators. This is not to imply that the creators are not innovators, but it is say this group of people are motivated to take the capabilities provided by the creators and explore them for new uses and to see what is possible with the existing set of models

What emerges as one traverses this framework from a modeling and simulation standpoint? Those who act upon the capability are the creators. These practitioners are motivated to overcome obstacles in attaining achievement by creating great models and simulations. Meanwhile, those interacting with the capability are innovators. This is not to imply that the creators are not innovators, but it is say this group of people are motivated to take the capabilities provided by the creators and explore them for new uses and to see what is possible with the existing set of models



and simulations. Like the Bartle model, some people choose to interact with other people – the discipline. These are people in the modeling and simulation community available to discuss the domain. Mind you, these people may also be creators. Those who interact with the discipline of modeling and simulation are decision-makers. Their motivation is to engage the community in order to solve problems that they face. Very often, this involves becoming part of some type of a team. In a future view, decision-makers may have direct access to the simulations themselves. Lastly, those who are acting on the discipline are governors. In the paper by Gendron, Barboza, and Tolk (2013), one of the key elements for successful MSaaS is governance. Aligning the various model and simulations in a cohesive way is an essential function. This is manifest in MOOCs, which establish a standard and govern it such that various universities can provide courses on their architecture. Likewise, the governors in modeling simulation are those that can help set, enforce, and revise standards for the greater good – not for exclusivity but for inclusivity. Overall, the ROIs of a massive simulation discipline and capability is increased demand for modeling and simulation and the recognition of what modeling and simulation can do for communities and leaders in the global environment.

## CONCLUSIONS AND RECOMMENDATIONS

Build a better mousetrap and the world will beat a path to your door.

—Emerson

The eminent Ralph Waldo Emerson notes that man is always in search of a better mousetrap. The excitement inherent to innovation is a timeless characteristic of the human condition. Woe to the civilization that loses the desire for innovation. Woe to that domain and community that likewise loses the desire to innovate and advance. Innovation is amongst the most difficult endeavors and requires a concerted, synchronized effort while at the same time remaining loose and fluid enough to accept the changes and disruptions that innovation brings. Such a paradox may be very difficult to deal with. When times are difficult, role models can help encourage progress. MOOCs are a role model for MOOS. The authors offer four conclusions and recommendations as thought pieces for future discussions, workshops, and conferences. However, beyond those gatherings they serve as recommendations to the creators, innovators, decision-makers, and governors of the modeling and simulation community.

First, look at MOOCs from the perspective of a new business model. It is hard to forecast the status of MOOCs in the year 2024. Although the authors would say that MOOCs would radically revolutionize education in a manner unseen in previous centuries, others can effectively argue that MOOCs may become a failed experiment and at its core, education will retain much of the characteristics from its roots. While their future is debatable, it is hard to argue against the sheer power of change MOOCs have brought into the educational domain. While the iron is hot, other domains should take heed of the engines powering the MOOC business model. Look to the methods and approaches that have brought substantial interest through venture capital and volunteerism to touch an entire planet.

Secondly, recognize the similarities between MOOCs and MOOS. As the framework in Figure 2 depicts, MOOCs offer a way to provide benefits and spread knowledge to an extent never seen before. Knowledge is the value proposition of modeling and simulation as well. There is room in this stream to accommodate the discipline and capabilities of modeling and simulation and help to surmount the plateau that has existed over the last few years. MOOCs offer the catalyst to move modeling and simulation to the next level.

Thirdly, the broad community of the modeling and simulation discipline – the creators, the innovators, the decision-makers, or the governors – should discuss the ROIs enumerated in this thought piece into the many discussions that occur on a weekly basis throughout government, academia, and industry. These ROIs are merely a starting point and can be refined through discussion and careful examination in the context of a MOOC business model. The potential exists to attain some of the higher levels of ROI provided by the MOOC/MOOS Framework – specifically open source and massive communities.

Lastly, acknowledge the scalability that MOOCs have demonstrated. People talk about scale when it comes to new product development. Scales demonstrated at the levels attained by MOOCs are nearly unbelievable. The magic of MOOCs was not in the technology but in the building of the community surrounding the technology and innovating education and knowledge transfer. Open source and the adapted Bartle model for a massive community provide modeling and simulation a framework to build upon and establish their own massively open market space. Sometimes it is better to give than to receive. Yes, economic times are difficult. However, as evidenced by the success of just one of many open source developers, Ned Lilly made more by giving than by taking. His enterprise is

successful and growing. He has a robust community of developers who continually improve his product on a weekly basis. The product markets itself. The product is in 100 countries across the globe. This is all been attained because of a “massive”, “open” mindset. Modeling and simulation should strive to attain such heights.

In closure, Tolk (2012) lays out a strong case for the role of modeling and simulation as a means to capture multiple viewpoints in intelligent models. As noted by van Dam (as cited in Tolk, 2012), “If a picture is worth 1,000 words, a moving picture is worth a 1,000 static ones, and a truly interactive, user-controlled dynamic picture is worth 1,000 ones that you watch passively” (p. 360). The words of van Dam penned in 1999 ring so true of not only online learning (video), but also of MOOCs as well as MOOS. The modeling and simulation community can learn much from successes attained by MOOCs and be a strong force for spreading knowledge.

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## APPENDIX

### Interview with Ned Lilly of xTuple

On January 30, 2014, Mark Friedman interviewed Mr. Ned Lilly, CEO and Founder of xTuple. His business began based on a business model of using open source product development. His company has grown and continues to thrive using this open source model. The interview focused on his experience in developing open source products.

**MF: What motivated you to go for an open source solution for your application? What was the most enticing aspect of its value proposition for your enterprise?**

NL: We were already heavy users of open source, and appreciated the combination of flexibility, value, and quality that it provided us as users. Particularly the PostgreSQL database, which in many ways is a model open source project – broad distributed base of users, many companies (as well as individuals) working together to further the core platform. When we decided to make our own ERP application open source, we were in many ways hoping to replicate (albeit on a slightly smaller, narrower scale) the success that they enjoyed in building a large, devoted, base of professional users.

For xTuple as a company, the value proposition is threefold: (1) We get our software in the hands of as many users as possible, and realize substantial network effects from having more people using it - in terms of quality control, new features, online user help, documentation, etc.; (2) All that additional help in product development is driven by actual users, and costs us next to nothing; and (3) It's also very effective and inexpensive marketing!

**MF: What were the tradeoffs you had to consider between that and proprietary / COTS software to sell or license via traditional methods?**

NL: We didn't really consider a traditional/proprietary model. There are plenty of legacy ERP systems out there, and the world didn't need another ERP vendor unless we were prepared to do something different.

**MF: How important and how challenging was it to “manage” the user/development community? Was the blur between supplier and customer a difficulty or didn't it matter?**

NL: It's very important - nature abhors a vacuum, and leadership in open source communities is critical. But that leadership needs to walk a line between being transparency/accountability, and the nuts and bolts of running an operational software project. You get lots of points for honesty, transparency, and being willing to listen.

**MF: How would you describe the type of business relationship you have with open source customers? How would you describe the relationship with suppliers/developers?**

NL: Our commercial customers pay us for a commercial license to the software and often services and support as well (although we also have partners who provide those as well). There are also thousands of active community members with whom we don't have a commercial relationship, but who participated in the process of improving the software, online discussions, etc.

**MF: What is the best part of open source? What is the worst aspect of it?**

NL: The best part is the fantastic people you meet – all around the world, customers, partners...dedicated professionals who self-educate on our product, and get deeply involved in its ongoing development – often without ever meeting us face to face. Very cool.

I suppose as a vendor, the worst aspect is the people who just download the free version, go off and disappear, and never engage with us. But even in those cases, they're still using our software - and I'd rather have someone using xTuple software for free than using something else!

**MF: Do you think there are some applications that just don't fit the open source model? what types?**

NL: Something that is super-narrow-vertical-specialized, used only by a very small group of people, where there is no analog to the horizontal core/platform. But generally, I think the model can apply to many different types of software development, most definitely including what I know of MODSIM.

**MF: Would you do it all over again?**

NL: Absolutely.