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AN EDUCATION OF SIMULATION DISCUSSION

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ABSTRACT

This paper takes three different viewpoints on the problems faced in the development of Modeling and Simulation (M&S) educational material. Two educational environments – academic and commercial – are discussed. The paper starts with a discussion on the establishment of the undergraduate M&S engineering program at Old Dominion University. The paper then explores the education in a commercial environment, discussing the challenges and possible connections between the two environments. The associated issues which have arisen in the M&S community, especially the accessibility problem, are discussed through the outcomes of a workshop. There is a strong relationship between M&S education and the ease of determining M&S usefulness (i.e., the evidence of success in M&S applications). This paper advocates for detailed case studies to be developed and used within the M&S classrooms. The more case studies (both successful and non-successful), the better the chance to understand different types of complex problems.

1 INTRODUCTION

While we often tend to think of "education" in terms of formal education offered by colleges and universities (Academic), education outside of these bounds (Commercial) is also significant. Both academic and commercial have their unique demands. One of the most important objectives of an academic setting is to produce graduates to be ready to work in an industry, while education in commercial setting gravitates toward solving specific problems. Education of M&S is no exception. There is a need to make sure that the participants (i.e., students) will equip with general knowledge to understand the concept of M&S in academia. On the other hand, in commercial, the need is to make sure the participants (i.e., staff) gain the abilities to solve specific problems. This paper discusses some of the challenges faced by educational content developers in these two environments and concludes by pointing out some of their similarities.

The rest of this paper is split into three sections, each written by a different author. The first section looks at the problems of developing an undergraduate program in M&S. This is followed by a discussion on challenges faced within the commercial simulation education environment. The last section discusses accessibility and the need for good M&S case studies. Finally, conclusions are given.

2 ACADEMIC M&S ENGINEERING EDUCATION – JAMES LEATHRUM

This section's discussion comes from the perspective of the creation of both the first undergraduate modeling and simulation engineering program at Old Dominion University (ODU) and its impact on the associated graduate program. The graduate program is relatively mature having graduated its first student in 1999 while the undergraduate program is relatively new, graduating its first students in 2013. The program strives to be an engineering program where graduates are capable of supporting other science/engineering/economic fields to understand and predict the behavior of systems of interest.

2.1 Curriculum

The undergraduate program was developed as a result of various trends in government (NSF 2006; NRC 2006; Scott 2007) and the prevailing literature (Rogers 1997; Petty 2006; Mielke 2009). In (Leathrum and Mielke 2012; Mielke et al. 2011; McKenzie et al. 2015), the various factors influencing the design of the curriculum were presented. The factors include the M&S Body of Knowledge (Oren 2005), an industrial advisory board (includes members from industry and government), Accreditation Board for Engineering and Technology (ABET) (McKenzie 2015; ABET 2012), internal research needs, and university general education requirements. These are often opposing influences, for instance, the university general education requirements take away credit hours that could have been employed to give better/any coverage to topics such as linear algebra and agent-based modeling.

Our goal for curricular development was to produce a well-balanced graduate. A balance was sought between:

- Core M&S concepts – modeling and simulation paradigms: discrete-event, continuous, and Monte Carlo (though Monte Carlo gets minimal treatment – due to contact hour constraints),
- Analysis –input data modeling, probability and statistics, random number generation, output analysis, and verification and validation, and
- Simulation software design – simulation application, simulation executive, and simulation tool design and development.

The curriculum developed is illustrated in Figure 1. In addition, it was deemed important to expose students to application fields since M&S is really a support discipline. Therefore, students are required through elective courses to take upper-level classes in a field of their choice that is related to M&S. The electives must be approved by an advisor to ensure they provide an appropriate experience. Applications areas frequently chosen include physics, biology, biomedical engineering, and autonomous systems. To assist in this process, the student can use these courses to satisfy a concentration, examples including digital manufacturing, cybersecurity, transportation, and serious gaming. They also tend to choose to strengthen their core skills in math and computer science. These courses strengthen their ability to communicate with subject matter experts.

Students in the undergraduate program are highly sought by employers. Prior to graduation, students are getting multiple internship opportunities, frequently we have more requests for interns than students. We are also seeing a high percentage of students going on to graduate school. Those that choose to enter the workforce are finding employment in various industries (shipbuilding, transportation, simulation, government contractors, etc.) as well as the government, especially the Navy (ODU is in Norfolk, VA, which is a Navy town). The 2017 graduating class (the most recent for which complete data is available) had 100 percent having a job or continuing to graduate school upon graduation. Sixty percent of the class of 2020 have had internship opportunities within the M&S field.

2.2 Educational Issues Encountered

Unfortunately, not all is rosy. A series of issues are encountered with teaching an M&S undergraduate program. Several particularly difficult issues are discussed here.

2.2.1 Practice vs. Classical Education

Anytime creating a new curriculum, the problem of finding appropriate educational material to support the courses is common. At first, this did not appear to be a major problem as graduate M&S programs have existed for decades. An exception is that graduate programs do not generally address software development, resulting in a lack of textbooks. An example textbook (Nutaro 2011) does walk the student through the development of software for a discrete-event simulation, however it does not address creating a reusable simulation executive, requiring knowledge of programming concepts not often taught even in a computer science undergraduate program – an example concept is command patterns for encapsulating method calls for future execution.

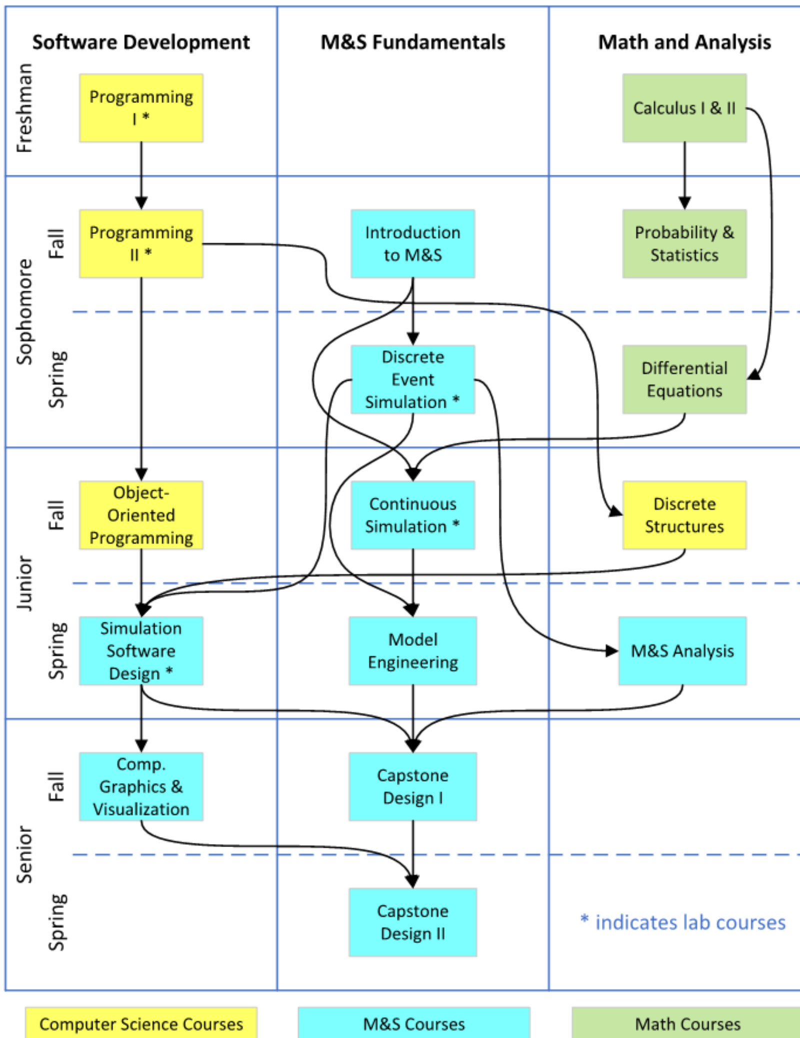

Figure 1: Curriculum core for Old Dominion University's undergraduate program in M&S Engineering (McKenzie et al 2015).

A bigger issue arose when it became obvious that the existing educational material does not necessarily address the current state of M&S. An example is in discrete-event simulation where we originally followed classical material generated from the field of industrial engineering. But several issues quickly arose. First, the queuing models utilized do not translate well to all fields such as digital circuit simulation. Second, the material primarily relies on teaching the event scheduling worldview which focuses on the execution of events which modify the system state and schedule new events at a moment in time. However, Rashidi

(2017) has shown that the majority of industry utilizes the process interaction worldview with event scheduling being the second most prevalent. Process interaction focuses on processes or the logical flow of entities through the system. This has required reconsidering the material taught, hopefully without creating a larger amount of content. We have sought to find the commonality between the worldviews for teaching purposes rather than treat them as distinctly different concepts (Leathrum et al. 2017). However, there is little educational literature to support this effort.

2.2.2 Impact on Graduate Curriculum

As our undergraduates complete their degree, it is desirable to give them options to pursue further education. Several have pursued degrees in other disciplines, including autonomous systems, transportation, and even medical school. For those wishing to continue in the core M&S field, adapting our graduate program to support those students was desirable. The undergraduates unfortunately (or fortunately based on your point of view) were overqualified for our own Masters program. This resulted in upgrading the graduate program. This was becoming more necessary even without the undergraduate program as the average student entering the program was unable to support much of the ongoing research efforts, especially those involving software development. Accelerated leveling courses were created to bring incoming students from other disciplines up to an acceptable level prior to beginning the core, allowing our own undergraduates to get a benefit from the graduate program, bypassing the leveling courses.

2.2.3 Recruiting

Recruiting has been the most challenging problem encountered in developing the undergraduate program. The graduate program has always populated itself by the needs of industry/government/research as seen by potential students' experiences, whether as undergraduates or returning to school for a degree based on needs in the workplace. However, potential undergraduate students do not know/understand M&S. Any preconceptions tend to be influenced by gaming and they do not appreciate the engineering involved.

Recruiting difficulties include educating the public and institutional roadblocks/expectations. When talking to potential students, the primary effort is educating them on what M&S engineering is, a problem not encountered by other engineering programs (although potential students do not truly understand the other disciplines, they just believe they do and thus are interested). However, once given access to the students, it is not hard to get them excited about the possibilities.

But access to students is the second hurdle that is best addressed with institutional resources. If the university is not willing to provide resources to get access to students, either in person or through media, it becomes difficult for a program to self-fund those efforts. ODU has a unique academic program that should sell well nationwide, but that requires access to databases of qualified students for direct communication or access to media for broadcast communications. In addition, engineering academics are not well qualified in the field of advertising, especially with the rapidly changing field on teen communication through social media.

Lastly, we have been observing the impact of internal student perceptions of the program. Originally students saw the program as difficult, resulting in low numbers but high-quality students. Then there was a shift where students seemed to see the program as the easiest program resulting in higher enrollment, but greater attrition due to poor student preparation. Now perception has swung back to being difficult but resulting in very high-quality students, but a larger number of them. It is believed that this fluctuation is from faulty external advising (freshman division) and peer interactions. Advising has been addressed, but peer interactions are more difficult to deal with. The draw for high-quality students is highlighted by the fact that in its short time of existence, the program has graduated two students awarded as the top engineering students in the college, despite the student having a fraction of the size of the other programs.

2.2.4 Interest in Computation

Another problem encountered at ODU is getting engineers interested in computation. Unfortunately, the freshman level computer science course has no math prerequisites, thus the material in the course is of little interest to engineering students and many students come out losing interest in the computational side of engineering, a problem that computer engineering has suffered. An attempt to solve this problem has begun with engineering teaching its own freshman programming course. This involves students' programming assignments focusing on solving engineering problems, including robotic control, data encryption, state machine programming, and data analysis. The result is while more difficult, the students see the connection to engineering. This idea was well received by other engineering programs as it offered them the chance to influence the content to include an introduction to MATLAB.

2.2.5 Distance learning

The timing of the creation of the undergraduate program coincided with a university initiative to create distance learning programs. As a new program, the university saw it as a perfect candidate for a distance learning program. This had both pros and cons. The pros relate back to institutional support for recruiting as distance learning has provided the only advertising support. The cons relate to the difficulties in working through the difficulties of going online while still developing the program. We believe that we have succeeded through online, but synchronous content, though only within what we control. We have lost some distance learning support since we cannot provide the complete program online as we rely on other programs to provide the math and sciences, and if they are not willing to provide online content, we cannot advertise the whole program to be online.

2.2.6 ABET Accreditation

There are challenges with being the first program of a new engineering discipline associated with accreditation. Accreditation is important to establish as a legitimate engineering program. The reader is referred to (McKenzie et al. 2015; McKenzie 2015) for details in this process. But in summary, a new program in a new discipline must be accredited as a general engineering program in the absence of an established ABET category. This creates extra hurdles in the process. We were extremely surprised and satisfied to receive full accreditation (6 years) with no concerns as a result of the first visit. But it is crucial to plan for ABET in the development of the curriculum to ensure all content areas are sufficiently covered and assessed.

2.3 Curricular Results

Several key results have come from the curricular development and the resulting student population. First, the program became the first ABET accredited M&S engineering program, receiving full accreditation much to the delight of the faculty involved. Continuing improvement through input from faculty, our industrial advisory board (a highly involved group), and graduated students has resulted in an even better experience than the original curriculum.

But most important is the student body themselves. The program has attracted high quality students. The first seven undergraduate classes have twice produced the top engineering student in the college, quite a feat for a program that is still by far the smallest by an order of magnitude. Students also go on to a wide variety of postgraduate opportunities, including highly prestigious graduate schools, medical school, and high-quality jobs in industry and government. While the issues highlighted here are real and warrant further attention to improve the educational experience, the resulting quality of graduates easily justifies the effort.

3 SIMULATION IN COMMERCIAL EDUCATION - DAVID STURROCK

When organizations initially deploy simulation to solve pressing problems, they usually look to internal knowledge first, but this knowledge is often lacking. Sometimes enough time has passed that the knowledge is largely forgotten or has become outdated as technology continues to advance. Sometimes the product learned in school is not the product selected for use, or perhaps no simulation knowledge exists among the current staff.

In many cases organizations simply identify simulation as such a critical technology that they want to provide their staff with timely and expert training in the chosen product to maximize their likelihood of success and minimize their time to success. This training is often provided by the private sector – e.g., the vendors of the simulation products, partners of those vendors, or instructors that are independent of any product.

But this commercial training has many different issues and challenges that are not usually encountered in traditional academic training. We will explore some of those issues in the following sections.

3.1 Student Background and Homogeneity

Academic courses are generally offered at specific levels (3rd year, graduate, …) but commercial courses are usually attended by a wide variety of participants. It is not unusual to have a class consist of a few "experts" who have used simulation widely for years, several novices with minimal simulation (and often minimal technical) background, and others with varying degrees of experience. This type of course is sometimes referred to as a "bathtub class" based on the frequency chart of participants' background. Keeping the experts challenged and interested while not leaving the novices behind can be a huge challenge.

In commercial courses offered on the customer site, customers often want to take advantage of having managers and stakeholders attend at least parts of the course. This allows these users to better understand the projects and the activities of the modelers. But this also puts more pressure on having materials or course modules that can be taught to students with a variety of backgrounds, objectives, and expectations.

3.2 Grading and Student Preparation

While academic students expect to be graded, commercial students rarely expect that degree of rigor, but do expect a certificate to recognize their accomplishments. "If you grade it, they will do it." is an adage often cited in academia. But this usually doesn't apply to commercial courses. Commercial participants have "day jobs" which often prevent doing prework and preparation they might want to do. So, while we can suggest and even "mandate" prework and prerequisites to help overcome the "bathtub" discussed above, in a commercial environment we generally must teach the people who show up, regardless of their background or degree of preparation.

3.3 Participation/Focus

Another commercial aspect is that the "day jobs" of participants often don't even allow full focus while in the course itself. It is not unusual for a person to be called away for an hour or a half day to attend to urgent business. This is especially prevalent in courses offered on the customer site. In an academic class, taught in a long series of short-duration intervals (such as 30, 1.25-hour classes) there is plenty of time between classes to catch up on any missed materials. In a commercial class, if someone misses a half day of a multi-day intensive course, there is very little opportunity to catch up.

3.4 Expectations of Immediate Use

Academic students often pursue simulation because it's required, for general information, or perhaps to use in a subsequent course or project. Commercial students, however, are often expected to *complete an important and time-critical project* within weeks of taking the course. While basic competence is a reasonable expectation in a short class, developing project-level mastery is a challenge. For this reason, it is popular to extend the formal course with an informal "jump start" session where the instructors help determine the correct approach and provide a good start on their first project.

3.5 General Learning vs Product-Specific Learning

In a college course, it is often felt important to prepare students to use simulation with *any* product, in *any* domain. So, instructors often focus on generic topics such as how an event calendar works or how to approach verification and validation. But in commercial classes given their need for immediate use, students want to focus only on topics of immediate use and only on the product they will use. So, they are more interested in topics such as "How does the event calendar in product X affect my modeling?" or "How can I use the debugging features in Product X to verify and validate my model?" As much as an instructor might desire to impart more "background" and general information, time pressures and customer demands often limit the opportunity to do so in a commercial course.

This same concept also applies to statistical concerns. Given the wide variety of student backgrounds in a commercial course, it is not unusual to have students with little or no statistical background. It is a challenge to impart adequate statistical knowledge within the scope of a relatively short course. A partial solution is to focus on the statistical analysis built-in to the product being taught.

3.6 Application Domain

Similar to academic classes, public commercial classes often include students from many application domains, but unlike academic classes, commercial students are more likely to have a strong interest and knowledge in a single domain, and little interest or awareness of other domains. They expect the class materials and examples to be customized for their own maximum understanding. This is even more true when commercial courses are taught privately (e.g., on-site for a single customer). For example, an aerospace customer does not want to see the training illustrated with healthcare examples, but rather with aerospace examples. In an academic environment, you can often reuse the same materials for every class, but there is a much greater need for customization in the commercial environment.

3.7 Summary of Challenges in Commercial Education

While on the surface it may seem that academic and commercial simulation courses are similar; in fact, there are many differences. The variety of student backgrounds, level of preparation, and focus/intensity combined with their expectations for immediate use solving problems in their own application domain make commercial courses quite challenging to teach. By raising these issues in this panel discussion, it is hoped that we can exchange ideas, approaches, and potential solutions to make teaching commercially easier and more effective.

4 THE NEED FOR CASE STUDIES – ANDREW COLLINS AND YING THAVIPHOKE

The previous two sections have provided some insight into the education of M&S from both an academic and commercial perspective. These sections highlighted the some of the technical difficulties of creating educational content in those domains. The underlying premise of these section is that those that are being educated what to learn about M&S. What about the education of those that do not know about M&S or have little or no interest in it? If M&S is to expand, new individuals need to become aware of its capability. To understand how we might make more people aware of M&S, we conducted a workshop of M&S professionals to understand what can be done to help educate the wider community.

Simulation is extensively used for education and training in certain domains (i.e., military and healthcare). The US military simulation and training market alone is estimated at USD 10.31 Billion in 2016 (Marketsandmarkets 2016) and there is an expanding healthcare simulation market, which may be worth more (Severinghaus 2012). Given this phenomenal success in these subject areas, it might be surprising that M&S is not used everywhere. The lack of propagation of simulation, beyond its traditional arenas, may lay with some of the challenges that new simulation modelers face. There are a number of practical challenges that simulation faces from having the financial resources to develop simulation platforms in an increasingly open technology environment (Joshi and Murphy 2007) to the use of a simulation's visualization as a rhetoric device (Collins et al. 2015). Understanding some of these boundaries will help us understand what education requirements we need to provide new potential M&S users and make M&S more accessible to the wider community.

4.1 Workshop on Making M&S Accessible

To understand how to make M&S more accessible, we ran a workshop of M&S experts to help understand this problem (Thaviphoke and Collins 2019b). The workshop was held at the MODSIM World Conference & Expo 2018 in Norfolk, Virginia, USA. The workshop was entitled "Simulation for the Common Man: How do We Make M&S Accessible?" The MODSIM conference is a practitioner-focused conference which we hoped would give a practical focus on workshop question. The workshop was run over a short half-day session with approximately 20 individuals attending. The attendees came from a variety of M&S discipline backgrounds and included those from both the public and private sectors. The approach to the workshop was to use a shortened version of Strategic Options Development and Analysis (SODA) (Eden and Ackermann 2001).

SODA is a Problem Structuring Methods (PSMs) (Rosenhead and Mingers 2001). SODA is designed to help individuals explore the problematic situation before making an important decision (Ackermann and Eden 2001). Though no decision was needed for the question posed, we felt that SODA represented a structured and systematic way to explore the accessibility question. The primary purpose of SODA is not acting as a problem-solving tool but rather a reflective device of a problematic situation – reflective problem solving (Eden 1988). It is a "making-sense" tool (Thaviphoke and Collins 2019b). The output of the workshop was a cognitive map. The cognitive map had thirty-two nodes (concepts), which we grouped into six clusters and summarized in Figure 2 (Thaviphoke and Collins 2019a).

The six meta concepts of our cognitive map are accessibility, awareness, ease of determining the usefulness, education, multidisciplinary, and selling. Accessibility refers to how easy the techniques are to implement for a novice in terms of knowledge requirements and resource requirements. Awareness is how aware potential users of M&S and its capabilities are. Ease of determining usefulness is self- explanatory. Multidisciplinary refers to how much M&S is used over multiple academic fields. Selling refers to how easy it is to sell M&S, as a solution, to problem owners. Finally, education refers to the availability and quality of educational material both in written form and through courses.

All six clusters, shown in Figure 1, are linked through influence arrows. These influences could be both positive (green) and negative (red). It is noticeable that education is linked to five out of the six cluster, which highlights its importance in making M&S accessible. The multi-disciplinary concept had a negative influence. We will focus here on how simulation education can help the ease of determining simulation usefulness and how it helps accessibility.

So, what was the key underlaying concept of the educational meta concept? It was the need for case-studies. Case studies provide evidence of the usefulness of M&S. They also provide insight into the limitations of M&S; knowing the limitations of M&S is something a new potential user would most likely wish to know about. Unsurprisingly, the concept of the need for case studies was strongly linked to both helping accessibility and ease of determining usefulness of M&S. Hence, we have concluded that more caste studies are needed increase the accessibility of M&S. Why Case Studies are Important?

The ease of determining usefulness of simulation is difficult. Simulations tend to be large black boxes that require a large set of skills to develop (conception model, programming, testing, etc.). It is difficult to show how a simulation directly might benefit a stakeholder's problem because a simulation's output does not necessarily provide a simple answer to a given problem. A simulation might provide a conceptual understanding, especially of complex situations, and it is hard to quantify this conceptual understanding into some benefit. This lack of quantification of benefit makes it difficult to determine the Return on Investment (ROI) of simulation and there have been no universally acceptable ways to determine a simulation's ROI (Oswalt et al. 2012).

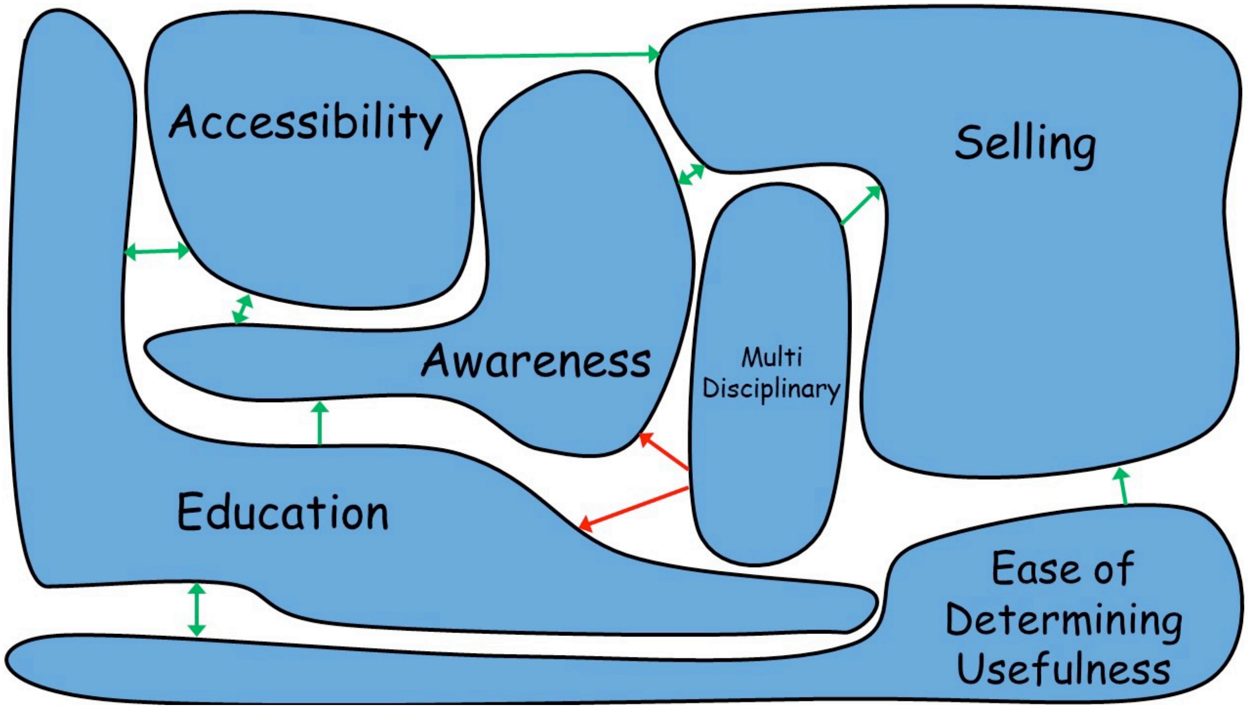

Figure 2: Workshop output on accessibility of simulation problem (Thaviphoke and Collins 2019a). Green arrows imply a positive influence whereas red indicates a negative one.

Someone new to simulation has a high investment to make, both in terms of time and equipment, before they are able to practically use a simulation to help them understand their problems. They must make this investment without ROI figures to rely upon and must accept the word of simulation modeler that it is a useful tool. Effectively, new simulation users need to take a "leap of faith" by investing their resources in the new technique of simulation. This is not an ideal situation for attracting new simulation modelers. It is not simply adequate to expect decision-makers to use simulation because the simulation community thinks it's great. There are a lot of communities out there that think their ideas are "great" and true (e.g., the recent flat-earther movement). There are also those that are touting alternative approaches to simulation, promising high returns on low investments, i.e., the 80% solution (Collins 2012). "Selling" simulation is happening in a crowded market of ideas. What we need to do is show decision-makers that simulation is great and, more importantly, useful using actual evidence. We argue that providing detailed case studies is the key to providing this evidence and we believe this is the reason that case-studies were such an important concept in our education meta concept in the cognitive map

4.2 What do we Mean by Case Studies

By case studies, we mean the details of the development of actual simulations that were actually used to help real decision-makers. Not the toy cases provided in our simulation textbooks. By creating a bank of detailed case studies, that highlight both the strengths and weakness of a simulation, we believe will provide the evidence to show M&S worth.

A bank of case studies is required because a decision-maker will want to study a case that is relativity close to the problem they face so they can answer questions such as: will simulation be appropriate for my problem? What are its downsides?

Some might argue that modern simulation development platforms make it easy for a new user to create a simulation and a potential simulation user can explore their ideas though simply created simulations. We are not disputing that fact; however, there is a world of difference between a toy prototype simulation that you can create in an off-the-shelf software package and a simulation that provides useful insights to a problem that someone is facing. Simple models are useful when the decision-maker has to make the decision to invest time into learning how to *create* a useful simulation and there are plenty of simulation education tools out there (Padilla et al. 2016); they are not necessarily useful in determining whether the final simulation will actually be useful. Hence, we argue that better simulation case studies are needed within our community.

Some have already used a case study approach to show new users the benefit of simulation. Wilensky and Rand (2015) introductory book about agent-based modeling and simulation is effectively one case study after another, which is a different approach to the usual technical development presented in the ABMS textbooks (Macal and North 2013).

4.3 Issues with case studies

The use of case studies is not without its problems. There are a number of issues that deriving and implementing case studies face including how to incorporate case studies into a formal education curriculum and deriving case studies that are universally applicable to all potential users for simulation.

Studying a case study requires time and might require an experienced instructor. To fully go through a real-world case study in detail may take longer than the standard class time or workshop length. This might mean that case studies need to be included as a university class. Modeling and Simulation, as a subject, has many topics to cover in a formal curriculum (Leathrum et al. 2017) and including a case study course might not be possible especially considering the accreditation requirements that a university-level simulation course might require. Some would argue that there are more important things than case studies for simulation students to study such as the foundations of the subject (Padilla et al. 2011). Hence, if a case study requires too much time to truly explore its benefit we are, once again, asking a potential simulation modeler to invest a lot of their time to determine simulations benefit.

All users of simulation do not come from the same academic background. Simulation usage spans from engineering to healthcare to education. Each subject has its own quirks, expectation, and terminology. For example, engineers have advocated for Unified Modeling Language (UML) to be used as the standard way to represent agent-based models (Bersini 2012) whereas social scientist advocated for the ODD protocol for agent-based model representation (Grimm et al. 2010). UML is node-arc approach, which systems engineers are familiar with reading and interrupting. The ODD protocol is a prose-based which is more suited to humanity and social science scholars (Collins et al. 2015). Thus, different subjects have different requirements for their standards making it hard to create a universal attemptable approach that is valued by everyone (Collins et al. 2012; Turnitsa et al. 2012). We would argue that the same is true for M&S case studies and that it is difficult to find case studies that are universally useful to all potential practitioners of simulation. Hence a large pool of case studies might be required.

As a "believer" in the power of simulation, it can be difficult to imagine our worlds pre-simulation. Simulation has provided us immense benefit on the way we understand the complexities around us; however, expressing that benefit to a layperson can be difficult. Though not without problems, the development of detailed educational case studies might be one step in that direction to help others understand the benefit of simulation and make simulation more accessible.

5 CONCLUSION

This paper presents three viewpoints on the problems facing simulation education. It discusses the problem of developing an undergraduate course for M&S, the problem of teaching bespoke simulation skills in a non-university setting, and the problem of provide M&S education to non-users to help make M&S more accessible. Some themes came out of this discussion including the problems of attracting new people to simulation (both for recruiting to university programs and to getting new companies to consider using simulation); and the problem of developing teaching material when students are coming from vastly different backgrounds and experience levels.

The final discussion does advocate the use of in-depth case studies. Though studying case studies is a time-consuming activity, it has a high potential to benefit both academic and commercial education. In academic, having real case studies embedded in the curriculum can solve the problem where the traditional textbook cannot address the current real-world situation. The students will have an opportunity to explore what actually happens regarding problem-solving process using M&S knowledge. On the other hand, successful case studies can provide a better look at the expected outcomes of the M&S application for potential customers in commercial education. As mentioned, there is a high expectation of immediate use in a commercial setting. The results from the workshop mentioned in this paper confirmed that more case studies are needed in M&S community.

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