THE USE OF CONSTRUCTIVE SIMULATION TO TEACH PORT MANAGEMENT

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ABSTRACT
Current use of constructive simulations to teach port managers skill sets is in large missing. The fast pace of change in the maritime industry requires similar adaptation on teaching institutions. Old Dominion University (ODU) began development of a unique curriculum for a port management undergraduate course that integrates a GIS-based simulation environment with the traditional course curriculum. This paper explores requirements and options for teaching port management aided by constructive simulation. A sample case study based on a real world problem is presented. Additionally, a survey was developed and administered to determine whether utilizing a simulation tool gave students a better understanding of the course material and if they gained additional understanding through such a format as compared to classes where constructive simulation was not used. The results indicate that the use of constructive simulation can aid port management students to develop domain relevant problem solving skills, stimulate creativity, and critical thinking.

Keywords: simulation-based teaching, port management, logistics, and manager skill set

1. INTRODUCTION

Multiple terms, such as simulation, simulation game, or educational game, are used to convey the idea of using simulations as an aid in teaching (Ezz, Loureiro-Koechlin, & Stergioulas, 2012). The main goal of this paper is to investigate the importance and effectiveness of a constructive simulation tool in teaching undergraduate-level port management curricula to students at ODU. Current approaches to using constructive simulations in education can intersect three main groups: 1) domain learning; 2) problem solving, and 3) computer simulation concepts related to computer sciences. The first group pertains to the use of the simulation to teach domain specific phenomena and knowledge without getting into simulation knowledge. This focuses on using simulation to drive an educational game, allowing students to view the behavior of simulated systems and analyze output to reinforce concepts learned in the classroom (Ezz et al., 2012). The second group is a middle ground approach and pertains to teaching using computer simulations with a focus on solving problems in different domains. For instance, Saltzman and Roeder (2013) explored the challenges and opportunities to teaching computer simulation to less technical business students as compared to engineering students. Finally, the third group consists of simulation-oriented education programs, which dive deeply into modeling and simulation (M&S) concepts, including simulation theory and formalisms, modeling methods, and software development. This paper discusses an approach at the intersection of the first and second groups. It explores using a GIS based constructive simulation tool to teach domain specific knowledge, in particular, port management skills. The challenges of using a constructive simulation tool to teach non-simulation savvy students port management skills includes hiding unnecessary simulation development details, while taking advantage of a high fidelity modeling environment for developing complex system representation of ports, one that captures both their structure and behavior.

The authors' literature search did not identify any published reports or papers that discuss teaching port management with the aid of constructive simulations. Therefore, our review of literature focused on related maritime areas, such as supply chain management, operations management, business, and transportation. The primary goal of our literature review was to capture the state of the art in applying constructive simulation tools to teaching. Siddiqui, Khan, and Akhtar (2008) developed simulation-based training for supply chain concepts using Macromedia Flash. They noted that visualization features are an important factor for faster learning when using simulation. Additionally, if the engaging character of simulations is supported with competitive game-based learning concepts, students develop a desire to perform better, which can contribute to improved teaching effectiveness. According to Ezz et al. (2012), critical thinking and decision-making were mentioned as specifically applicable to using simulation for learning as they stimulate student's diverse cognitive skills, providing active learning by generating insight into systems that are captured in constructive scenarios together with various decision strategies. Moreover, the feedback from an exercise can be generated quickly and without harm to the actual system. Ezz et al. (2012) reported that in the last decade many types of simulation games were developed for different areas of management. For instance, Shapiro and McGougan (2003) developed web-based marketing simulation games of differing length and complexity. Uhles (2008) described a live simulation version of financial management training, and Chua (2005) proposed a template for designing constructive knowledge management simulation games using MS Excel as a platform. He considered three dimensions: content, gaming, and learning during development of a knowledge management simulation game. Grabis and Chandra (2010) developed a process simulation environment that supports teaching operations and supply chain management. They used case studies that included scenarios allowing students to encounter different problems related to management decision (e.g. increasing demand, process redesign, and system variability). The authors noted the difficulty in taking advantage of modeling features of simulation tools to experiment with model configurations and the consequences of changes as seen in simulation results. This problem pertains to the time required versus time allowed to introduce M&S basic concepts to trainees having traditionally less quantitative backgrounds. The use of constructive simulations to teach a specific domain skill set is limited, and primarily relates to simple simulation games.

The remainder of this paper is organized as follows. Section 2 discusses port management teaching challenges and simulation environment requirements necessary to improve teaching of undergraduate level port management curricula. Section 3 introduces important features of simulation software used, proposes lesson development process, and presents a sample case study scenario for teaching using a constructive simulation environment. Section 4 presents research method. Section 5 discusses survey results and instructor's insights. Finally, Section 6 concludes the paper.

2. PORT MANAGEMENT TEACHING CHALLENGES

Instructors should challenge students to acquire cognitive skills that support proactive thinking habits. The inherent limitations of traditional forms of learning can limit an instructors' ability to properly prepare students for changing port management practices. This section focuses on describing challenges relevant to teaching port management. The complex interactions between terminals, ports, ships and intermodal service providers must be clearly understood by students in order to facilitate their mastery of decision-making skills. The learning of the concepts related to a complex system can be difficult using standard techniques. On the other hand, when a student is tasked to create a port facility and to design its operational policies and procedures, then execute them within a simulated environment, they experience a "learning by doing approach". This in turn will help students to better understand structure, behavior, and the scope of their roles as a decision-maker or analyst responsible for a port or its subcomponents. Simulation tools enable dynamic what-if analysis of different scenarios which can be integrated within a course curriculum.

Alderton (2008) pointed out that modern port managers and transportation professionals must be able to adapt and manage change using forecasting. Depending on the type, simulation tools can facilitate different levels of knowledge learning according to Bloom's taxonomy. Usually the three lower levels such as knowledge, comprehension and application are easier to capture and support by simple game simulation. The upper levels such as analysis, evaluation and especially creation are limited within simple simulation games. These levels require more flexibility, allowing hands-on practice in developing accurate system structure and behavior, and providing valid feedback from scenarios. This can be especially true for undergraduate and graduate courses, like port management, where more fidelity in modeling domain specific representations and creativity in solving problems is required.

Port managers are required to know the system and its behavior in order to be able to evaluate them and critique possible benefits and problems with proposed solutions by examining them in what-if scenarios. This examination must include system structure, scheduled and emergency operations, and resources planning. Lastly, enabling creativity and proactivity in students is facilitated in the process of developing a virtual port model, one that involves determination of its location, designing terminals and operational areas, like berths, staging areas, inspection stations, adding needed resources, and designing schedules.

Light weight simulation games may not be flexible enough to support student creativity and proactivity in the management of a complex system, like a seaport. The requirements for teaching future port managers call for using conceptualization aids in the form of computer simulation environments. Next generation port managers should be able to envision operating as port managers or in a similar relevant authority role. Simulations will support this in a more tangible manner than afforded to them by academic exposure to theoretical concepts.

Development of virtual seaports that model their main components, like terminals, operational areas and resources ensures that students understand structure and exercise. Testing and evaluation of proposed new designs or changes to a port using simulation experiments enables proactive thinking. This must be supported by a highly usable simulation tool that present to students relevant information and hide unnecessary details. Moreover, if rigid scenarios are scripted within simulation games, teachers have no options to improve curriculum based on their teaching experience. Using a flexible and reconfigurable simulation environment that allows a change of elements that will support new exercises related to advancements within the area of study. Simulation tools should be flexible so the teacher can easily improve their curriculum, adding new scenarios and teaching concepts. For instance, if new ship designs with different characteristics are developed in the real world, it should be possible to model them using an existing simulation environment.

The time required to learn simulation skills and how to apply them to build simulation models can be prohibitive for non-programmers and non-simulation oriented audiences, especially in cases of general purpose, commercial off-the-shelf (COTS) simulation products. Development of a multi-level simulation model that includes ports with multiple terminals, and many interconnected operational areas within the terminals requires significant modeling skills and time when generic simulation tools are used. This is a problem when the simulation itself is not the subject of the instruction, but rather an aid in teaching domain specific knowledge.

Using simulation environments to learn domain related knowledge, in our case port management, should require minimal knowledge about simulation and teach only required concepts as students are gaining proficiency about the subject matter. The university undergraduate port management course is traditionally several months long and includes a significant amount of domain specific information, which makes it prohibitive to also teach simulation technology in detail. Simulation tools must be simple to use and appropriate for the students' background, with a focus on accessibility to domain knowledge relevant to the system of interest. This places more stringent requirements on the user interface than those in a generic simulation tool. In summary, non-technical students should be able to develop, visualize, and simulate complex port facilities, providing them a unique learning environment which enables the application of creativity and proactivity superior to traditional instructional methods.

3. A SAMPLE CASE STUDY LESSON

The purpose of the case study is to demonstrate the potential of a high fidelity simulation environment when applied to a higher education port management curriculum. First, we provide a brief introduction to Scalable End-to-End Logistics Simulation (SEELS) environment. Next, a proposed framework showing how M&S based lessons can be developed is concisely described. Finally, a simple case study in the lesson format is described.

3.1. Brief Introduction to Simulation Environment

The SEELS interface allows for a design of highly configurable models that are defined using the provided GIS graphical interface based on ArcGIS map and polygons representing infrastructure. The GUI is designed to match the scalability of the SEELS simulation core (Mathew, Mastaglio, & Lewis, 2012). SEELS enables representation of a logistical network that can be composed of multiple ports. Through a network, entire seaports can be represented within a hierarchal structure of multiple terminal areas, which in turn consist of operational areas as shown in Figure 1. Moreover, cargo and transport profiles can be defined as needed to represent appropriate metrics.

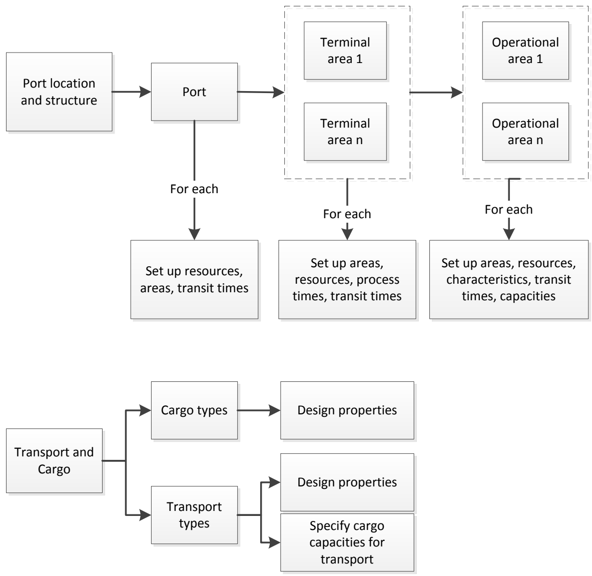

Fig 1. Port design in SEELS

After the development of model components it is necessary to design simulation scenarios that describe a desirable experimental frame. This involves developing a schedule of transport arrival events, the arrival times, transport quantity, and destination of each cargo load for each individual transport item (see Figure 2).

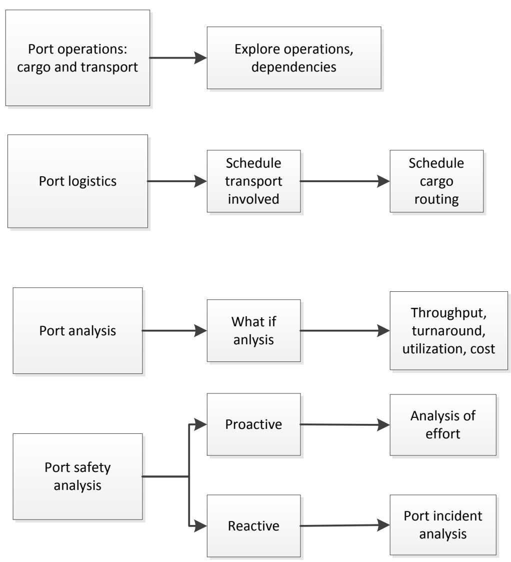

Figure 2. Port and safety scenarios in SEELS

The interface provides an instructor with flexibility to develop learning objectives that enable students to explore ports structure, and requires critical thinking by having multiple paths and options to explore the same problem. Proactive security analysis can be conducted by inserting proposed inspection stations anywhere within the port facilities to assess the impact that they will have on cargo flow. Reactive analysis consists of developing response strategies to disruptive incidents when they occur. Transports can arrive empty or loaded with a mix of cargo headed for different destinations (Mathew et al., 2012). A simulation run consists of a single scenario that can consist of multiple profiles, which can be mixed and configured to work (toggled) with one of multiple network configurations (structure, resources) providing experimental flexibility for end users (see Figure 3).

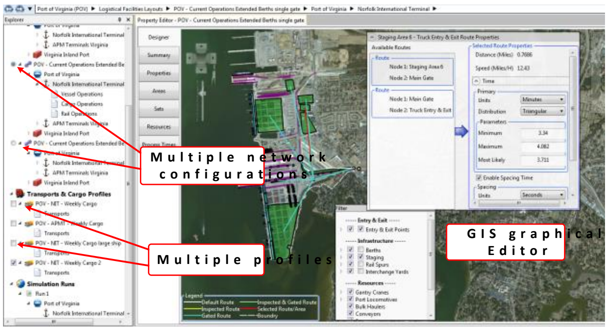

Figure 3. View of SEELS GUI

3.2. Lesson Development

Figure 4 provides a proposed technical approach to developing M&S-based lessons.

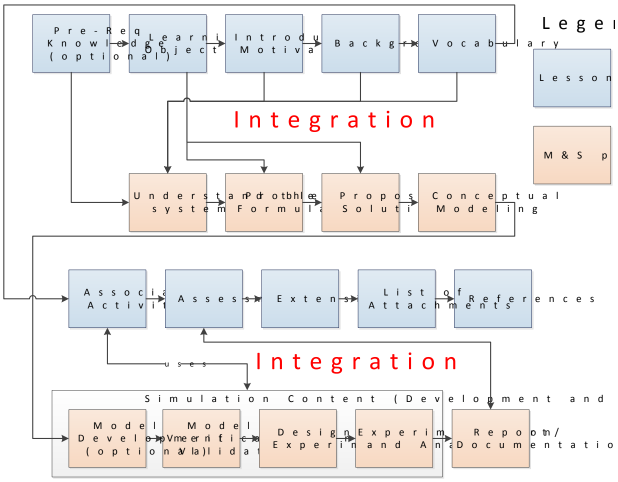

Figure 4. Technical approach to develop an M&S-based lesson

M&S processes adapted from Kelton, Sadowski, and Sturrock (2007) and Law (2007) were overlaid onto STEM-like lesson development sections. Instructors design objectives for the lesson based on real world problems. Depending on lesson objectives, basic theoretical understanding of port operations may be necessary up front. Some problems may require development of port, terminals, and their networks, while other lessons can focus on experimentations using already created models. If development of a model is a part of the lesson, students can use SEELS to visualize possible layouts of terminal areas. This way, conceptualized structure can be developed into simulations by adding resources, specifying processing times, and profiles within the modeled environment. Instructors should introduce implications of model validity and provide necessary relevant data (e.g. processing times to ensure output relevancy) with the lesson objectives. One of the advantages of SEELS for teaching is its embedded domain specification, which allows student to focus on the lesson activities and not time consuming aspects of model coding and related V&V. For instance, statistical output analysis may not be a crucial element of the lesson but a secondary aspect, which is different in comparison to the M&S curriculum. Finally, a student prepares a final report and/or presentation about an insight or a solution to a problem including necessary concepts, models, simulation results, and recommended decisions.

3.3. Background and Objectives of a Sample Lesson

The concentration of container volumes when mega-ships are used is more profitable to the container shipping industry as compared to using smaller vessels, but cargo surges can strain vessel, yard and gate operations at marine terminals Mongelluzzo (2013). This situation can be investigated by students using a simulation model. A model of a terminal for this lesson would be provided to a student. Figure 5 shows a sample model representing Norfolk International Terminal including; berths (blue), staging areas (green), rail spurs (violet), and gates (blue circle) based on Mathew et al. (2012).

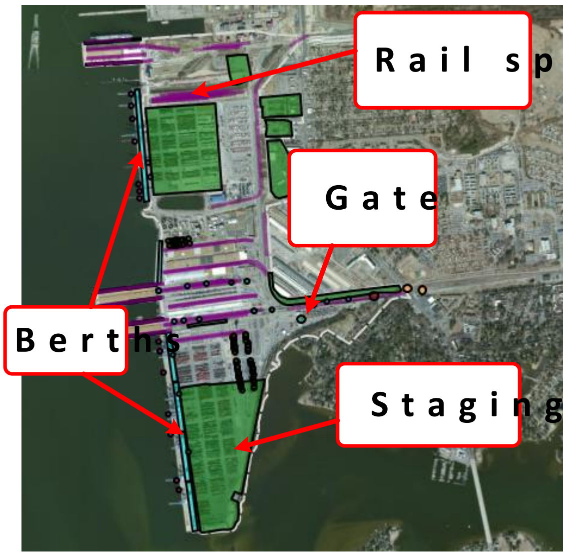

Figure 5. A layout model of Norfolk International Terminal (NIT) developed in SEELS

Students would utilize the provided model to process 10,000 40 ft. containers: 5,000 for import and 5,000 for export. Two types of vessels should be considered:

Panamax vessels capable of carrying up to 5000 40 ft. containers and Feedermax vessels with capacities up to 1,000 40 ft. containers. Import cargo should be processed out of the terminal by 3,500 trucks and the rest of containers should be handled by trains. All exported cargo will be delivered by trucks and shipped out in empty vessels. The objective of the lesson is to expose students to the effect of ship size and schedule options on performance. Students would be tasked to design and conduct simulation experiments to analyze tradeoffs depending on ship type and schedule as a potential for a better outcome in terms of resource cost per container processed and total processing time of cargo. The instructor provides the following types of data: modeled areas included in analysis, number of resources available, operational times, and cost of main resources per hour. Detailed description of all parameters is out of the scope of this paper because it could easily encompass the entire paper. The most important parameters as determined by the authors are provided in Table 1.

Table1. Sample model data

Sample areas	counts	measure
Berths	17	14634 ft
Staging areas	8	8422087 sq ft
Rail Spurs	60	79680 ft
Gates	1	2 inbound and 2 outbound lanes
Sample resources	**utilized**	**cost per hour $**
Straddle carriers	83	80
Container cranes	16	300
Gantry cranes	17	80
port locomotives	6	80
harbor pilot and tugs	5+5	80+80
Sample processing parameters	**minutes**	
berth time	20	
deberth time	20	
crane load and unload time in berth	2	
crane load time	2	
container load and unload time in staging	2	
gates processing time in/out	2/2	

It should be noticed that deterministic values for processing times are assumed in this exercise to simplify analysis and focus in this lesson more on port management learning objectives and less on M&S concepts related to statistical output analysis.

3.4. Design of experiments

Students should have enough freedom to design specific scenarios so the design of experiment (DOE) permits them to examine the problem space. For instance, four sample scenarios are shown in Table 2. Different transport arrival times are considered for the cases with five smaller ships and a single large ship. For instance, Scenario 1 can be read as follows; five ships arrive at time 0, carrying 1000 40ft containers each (import), which are processed out by 3500 trucks and 30 trains that each consist of 50 railcars arriving at time 0. Additionally, 5000 export trucks arrive, each carrying a single 40 ft. container that will be all loaded on five ships also arriving at time 0. Scenario 2 spreads the arrival of transports within five day period for ships, trucks and trains. Scenario 3 is similar to Scenario 1 but single large ship arrives, while Scenario 4 resembles Scenario 2, but only arrival of trucks and trains can be spread in time.

Table 2. Sample Scenarios

	Direction of cargo	Arrive	Contaners picked up by	Arrive
Scenarios 1	Import (five ships) 1000 containers each	at time 0	3500 trucks	at time 0
			30 trains x 50 railcars	at time 0
	Export (5000 Trucks) each with a container	at time 0	five ships	at time 0
Scenarios 2	Import (five ships) 1000 containers each	one a day	3500 trucks	700 a day
			30 trains x 50 railcars	6 a day
	Export (5000 Trucks) each with a container	1000 a day	five ships	1 a day
Scenarios 3	Import (single ship) 5000 containers	at time 0	3500 trucks	at time 0
			30 trains x 50 railcars	at time 0
	Export (5000 Trucks) each with a container	at time 0	single ship	at time 0
Scenarios 4	Import (single ship) 5000 containers	one a day	3500 trucks	700 a day
			30 trains x 50 railcars	6 a day
	Export (5000 Trucks) each with a container	1000 a day	single ship	1 a day

The main output of interest required consists of average throughput of the facility related to processing time of cargo in the terminal, and average cost per container based on resources utilized; however, students can use additional measures.

3.5. Case Study Results and Discussion

Table 3 provides a set of results from sample scenarios.

Table 3. Results from simulations

SCENARIO	1	2
days to process cargo	12	12
average daily throughput	833	833
straddle carrier cost	$1,243,360	$ 1,171,900
container crane cost	$ 292,900	$ 240,313
gantry crane cost	$ 21,173	$ 23,733
port locmotive cost	$ 2,920	$ 2,739
harbor pilot and tugs cost	$ 8,820	$ 8,840
Total considered cost	$1,569,173	$ 1,447,525
cost per container (40ft)	**$ 157**	**$ 145**
average daily cost	130764	120627
SCENARIO	**3**	**4**
days to process cargo	17	17
average daily throughput	588	588
straddle carrier cost	$ 979,372	$ 986,847
container crane cost	$ 191,945	$ 191,894
gantry crane cost	$ 25,550	$ 19,893
port locmotive cost	$ 2,752	$ 2,751
harbor pilot and tugs cost	$ 1,232	$ 1,242
Total considered cost	$1,200,851	$ 1,202,627
cost per container (40ft)	**$ 120**	**$ 120**
average daily cost	$ 70,638	$ 70,743

Processing time of Scenarios 1 and 2 is 5 days less than Scenarios 3 and 4. This difference is a result of the large amount of cargo that arrives at a single berth in Scenarios 3 and 4, which strained berth operations and subsequently increased total processing time. For instance, the worst cargo turnaround time at berth area for Scenario 1 did not exceed 35 hours, while for Scenario 3 it reached over 70 hours. The overall cost per container is higher for Scenario 1 and 2. This is due to more ships processed by harbor pilots and tugs in Scenarios 1 and 2, but also the high cost of processing cargo by various resources within a terminal. Lower cost per container in Scenario 2 as compared to Scenario 1 pertains to ability to divide ships arrival time, hence allowing avoidance of a lumpy demand within the terminal. Five smaller ships allow for more flexibility in scheduling, which can prevent lumpy demand in the terminal, resulting in savings without compromising the processing time. The division of truck and train arrivals did not make any significant changes in Scenarios 4 in comparison with Scenario 3. Scheduling of large ships is more constrained. On the other hand, the tradeoffs between cost and time should be also considered. Constrained to single berth operations in Scenario 3 and 4 was a bottleneck to the whole process within the terminal, which on the other hand decreased the resource operating cost.

Overall, the results from simulations of complex systems should not be considered as generalizations of the system behavior but observations of its particular configuration. Different configurations create different cases related to characteristics of areas, number of resources available, and business rules. Changes made to a single point of system can drastically change the results.

3.6. Report/presentation and student evaluation

The assessment should measure whether the participants achieved the pedagogical/androgogical objective, which is a better understanding of port management concepts. The evaluation can assess whether students were able to make sound business decisions by using the SEELS environment. This can be measured objectively by taking into account the decisions leading to actual simulation output (e.g. financial or operational performance) of the ports or terminals. Moreover, the students should be able to explain the output performance they achieved during the simulation. The presentation given to the class and/or report students submit at the end of lesson could provide additional measures for evaluation. Performance during the simulation needs to be explained based on results. Students should provide an explanation about how the simulation-based decision improved performance.

4. RESEARCH METHOD

A survey was administered to evaluate the undergraduate port management course that integrates a GIS-based simulation environment into a traditional course curriculum. This gauges the current approach, allowing to analyze it and determine whether the possible application of SEELS to support different undergraduate and graduate level maritime courses is feasible. The research question examines whether the use of SEELS benefited students during acquiring port management knowledge and allowed them to experiment with a synthetic environment provided a value-added experience to a traditional curricula. The survey content is provided in the Appendix A. A total of 14 responses were obtained from the MSCM 472 class of 30 students, hence almost half of the class responded.

In addition to the survey, the MSCM 472 instructor will qualify the training strategy. This will include a comparison of the class where the simulation was used with the previous class without using simulation. This evaluation will also provide the instructor insight into what can be learned using this strategy in the context of port management and how competent learners can become. For instance, would they perform better in real life and attain superior results using the learning strategy that includes simulation?

5. ANALYSIS OF SURVEY RESULTS AND DISCUSSION

5.1. Survey Results

Table 4 displays results of the survey. The results are discussed in the context of enabling constructive simulation integration with port management domain knowledge tailored for students not acquainted with M&S. Question 1 and 2 aimed at identifying students' experience and formal training in the M&S. The results in large indicated that the audience was not advanced and have limited experience in M&S concepts. This is important as a baseline to determine possible benefits, limitations, and attitudes of using advanced M&S software such as SEELS for domain learning and problem solving activities by students inexperienced in M&S concepts. Question 3 clearly shows that students had to think critically when using SEELS (4.63, 4.93), which in turn indicates that SEELS assisted the instructor to develop the exercise allowing students to observe, conceptualize, apply, and reason. This is important because it immerses students in the complexity of port management decision making. For instance, question 6, 7, 8, 9, and 10 explored different aspects of SEELS such as development and analysis of simulated data, port capacity and planning, handling equipment allocation, terminal constraints, and terminal modifications respectively. The responses to these questions were highly rated; showing diversity of port management concepts that can be supported by SEELS, and showed enhanced domain learning capability in the case of port management. The challenging aspect of port design and modifications is indicated by results of question 10 (3.5, 4.65), where one student did not agree and three students neither agreed nor disagreed with the question. Question 11 shows that using SEELS benefited students in gaining understanding of the relationship between port operations and supply chain efficiency (4.12, 4.88). Question 4 indicated a high complementary value of using SEELS to the Port Management course, confirmed by question 12 that reflected general perceived benefits of using SEELS.

Table 4. Results from survey

Question Number	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Mean	95% CI - lower bound	95% CI - upper bound
1	4	4	0	4	1	2.5	1.7	3.4
2	9	2	0	3	0	1.8	1.1	2.5
3	0	0	0	5	9	4.6	4.4	4.9
4	0	0	0	1	13	4.9	4.8	5.1
5	0	0	0	7	7	4.5	4.2	4.8
6	0	0	0	4	10	4.7	4.4	5.0
7	0	0	0	5	9	4.6	4.4	4.9
8	0	0	0	6	8	4.6	4.3	4.9
9	0	0	0	6	8	4.6	4.3	4.9
10	0	1	3	4	6	4.1	3.5	4.6
11	0	0	1	5	8	4.5	4.1	4.9
12	0	0	0	3	11	4.8	4.5	5.0
13	0	0	1	10	3	4.1	3.8	4.5
14	0	0	0	5	9	4.6	4.4	4.9

Results of questions 13 (3.83, 4.45) and 14 (4.36, 4.93) indicated that user interface features allowed students critical thinking processes during creating port layouts. First, the SEELS user interface allows for easy visualization and manipulation of port and terminal components that overlay GIS. Second, separation of structure, behavior, data, and visualization allows for hiding unnecessary computer science details. Both characteristics could be beneficial by allowing for a student unexperienced in M&S concepts to jump right into domain learning and learn faster about a terminal and its layout dependencies despite its complex structure and behavior.

Full transcript of open ended questions 15 and 16 is provided in Appendix B. Question 15 provided insight into aspects of the SEELs software that contributed to learning. The responses pointed at importance of hands on experience that can complement books and lectures to gain better understanding of port layout, operations, scope of decisions, through easy to handle visual and analytical representation. Question 16 equivocally supported or even commended SEELS as allowing creativity, being fun, interesting, and educational; the only complaint was a wish to have more time to spend using it.

5.2. Instructor's evaluation

Throughout Port Management lectures students learn and discuss the various mechanisms that ports utilize to improve operating efficiency; however, with the SEELs technology, the students gain the ability to work hands-on with a selected port. By manipulating quay, yard and rail operations students can identify the optimal handling needs and resource requirements for specific terminals. In previous classes where SEELs was not incorporated into the curriculum, students merely heard about simulation technology and planning mechanisms or watched online demonstrations. More questions were raised in the classrooms without SEELs as to how ports administrators accurately forecast changes in vessel calls; adjust to changing vessel sizes and plan infrastructure needs or intermodal projects. The class that utilized SEELs also raised such hypothetical scenarios, but took the questions and used SEELs to simulate the environment and identify solutions.

Moreover, the hands-on application and the ability to actually create a model and simulate a facility showcased how terminal handling operations can be optimized. As an example, by personally adjusting the number of cranes located on the quay or the number of straddle carriers used within the yard, the students gained better insight into how cargo handling equipment influenced port productivity; i.e. how many additional containers were moved per hour with the addition of another crane. Moreover, the students could then analyze the financial side of the operations, as to whether additional equipment and additional labor improved port performance ratios and had a significant return on investment for the organization. Accompanying the analysis, students could further discuss how a change to yard operations could lead to a greater competitive advantage for the selected terminal as compared to a neighboring terminal.

With additional training, it is predictive that students could also utilize these scenarios and solve port planning problems related to supply chain disruptions. These could include simulated weather disturbances and cargo backlogs and cargo diversions or labor-related issues such as union lockouts or strikes. As students transition from the university setting to port-related careers, the students with the SEELs knowledge have the potential to perform better in port planning and terminal operation positions. Their familiarity with existing modeling and simulation tools will provide them with a competitive advantage over students who have not been exposed to hands-on applications. They also have the ability to influence terminal management buying behaviors as they relate to port planning technology since they have experienced the tools in the classroom and recognize the applicability to real-world port situations.

6. CONCLUSIONS

The use of a constructive simulation environment to enhance learning port management has not been previously investigated. The paper discussed challenges related to teaching port management. Brief guidelines to development of lessons that utilize simulation models were proposed, and a sample lesson/case study was described. The study used a survey that examined the effectiveness of initial phase of a port management curriculum development that included constructive simulation as a learning aid. The results provided a strong support for the learning strategy adopted.

In future work, a transformative learning environment that supports students' collaboration within lessons should be considered. This could further enhance motivation and stimulate learning, enabling the execution of exercises that require teamwork as one of port management skills. This can be achieved by developing problems scenarios divisible into roles or tasks that constitute a larger effort, enabling students to develop and examine concepts working in teams via modeling and simulation experiments.

APPENDIX A

1-Strongly Disagree
2-Disagree
3-Neither Agree nor Disagree
4-Agree
5- Strongly Agree
N/A- Not applicable

Student

1. I have previously used modeling and simulation software in other business courses.
2. I have had formal modeling and simulation training in the past.

Content

3. The SEELs module in MSCM 472 required me to think critically.

4. The SEELs module complimented the in-class course lectures and/or added value to the Port Management course.

5. The SEELs software allows for the analysis of real world data (i.e. cargo volumes, ship calls, truck deliveries and railroad operations).

6. I gained a better understanding of terminal design and layouts with the use of the SEELs software. For example, with the use of the software, I understand how a terminal's design influences the volume of cargo that can be handled on an hourly, daily and monthly schedule.

7. I gained a better understanding of port capacity (i.e. vessel scheduling and berth allocation) and planning with the use of SEELs software.

8. I gained a better understanding of cargo handling equipment and asset allocation with the use of the SEELs software.

9. The output report provided me with an understanding of terminal constraints.

10. I used the output report to modify the port design model and incorporated changing port services demand.

11. With the use of SEELs software, I have a better understanding of how port operations affect the supply chain and its efficiency.

12. Overall, I learned or benefited from using the SEELs software.

Navigation

13. The SEELs software provided a user-friendly interface.

14. Creating a port layout required critical thinking

Open Ended

15. Which aspects of the SEELs software exercise contributed most to your learning?

16. Would you recommend using Modeling and Simulation software to learn about port operations and planning?

APPENDIX B

Question 15 responses (10):

- Learning about port development and how critical they are to operate efficiently.
- Felt like it was more of a hands on experience. Books and lectures can sometime miss this element.
- The output of the port productivity and throughput was key. With that I was able to make decisions on what needs to be changed. Therefore, I believe that was the most important part of the SEELs program.
- The SEELS exercise was very helpful in my understanding of ports and port operations.
- Being able to see how a layout of a port looks
- SEELs is a great learning tool that allows you to see what it takes to create a port and how to maximize its use.
- I learned how ports need to be set up in order to function properly, and also to prevent accidents and unauthorized entry into the facilities. I also realized that to have a successful port, location is everything. There are just so many things to consider if a person wants to design a new port. I

now see how unbelievably complex the whole operation is. But I also learned what many of those operation are and how they work, so overall, I'd say I learned a good amount of useful information.

- The layout of the ports and all the other things around it that are necessary. A port needs a lot more than just a berth basically.
- Visual representation of cargo capacity and constraints; could adjust size of port area and amount of equipment to see changes in throughput, congestion etc.
- allocation of equipment and resources, capacity and time constraints of various port operations.

Question 16 responses (13):

- Absolutely.
- Yes. I thought it was very interesting. Wish I would have had more time with SEELS. One session didn't give me enough inside to master the program.
- Yes, I would suggest it because a hands on approach and first person experience is key to understanding a ports operations.
- Yes, I believe that there should be more use of Modeling and Simulation software in MSCM and related classes.
- yes I would
- Yes
- Yes, absolutely. It adds a feel of "real world" application.
- Yes, I think having/ being able to use the SEELs program was very beneficial to the course. It provided a great tool that allowed us (the students) to be creative and design a port. Being both fun and educational I think the SEELs program is a must for the port management class!
- Yes, absolutely
- Yes
- Yes; an excellent tool
- Yes
- Yes, it is a great way to visualize a port and its operations that way. At least I think so.

REFERENCES

Alderton, Patrick. (2008). *Port management and operations*: Taylor & Francis.

Chua, Alton Y. K. (2005). The design and implementation of a simulation game for teaching knowledge management. *Journal of the American Society for Information Science & Technology, 56*(11), 1207-1216. doi: 10.1002/asi.20224

Ezz, Inas, Loureiro-Koechlin, Cecilia, & Stergioulas, Lampros. (2012). *An investigation of the use of simulation tools in management education.* Paper presented at the Simulation Conference (WSC), Proceedings of the 2012 Winter.

Grabis, Jānis, & Chandra, Charu. (2010). *Process Simulation Environment for Case Studies.* Paper presented at the Simulation Conference (WSC), Proceedings of the 2012 Winter.

Kelton, R.P., Sadowski, R.P., & Sturrock, D.T. (2007). *Simulation with Arena*: New York: McGraw Hill.

Law, A.M. (2007). *Simulation modeling and analysis* (4th ed.): New York: McGraw-Hill.

Mathew, Reejo, Mastaglio, T. W., & Lewis, Andrew. (2012). *A Simulation Tool for High-Fidelity Modeling of Complex Logistical Networks.* Paper presented at the European Modeling and Simulation Symposium.

Mongelluzzo, B. (2013). A Taxing Situation: Mega-Ships and Vessel-Sharing Agreements, Though Beneficial to Carriers, Strain Port Terminal Operations. *The Journal of Commerce*(03/3/2013), 52.

Saltzman, R., & Roeder, T. (2013). *Perspectives On Teaching Simulation In A College Of Business*. Paper presented at the Proceedings of the 2013 Winter Simulation Conference, Washington D.C.

Shapiro, Stanley J., & McGougan, Catherine. (2003). Software Review: The Marketplace Game Innovative Learning Solutions Inc. www.marketplace-simulation.com. *Journal of the Academy of Marketing Science, 31*(1), 92-95. doi: 10.1177/0092070302239221

Siddiqui, Atiq, Khan, Mehmood, & Akhtar, Sohail. (2008). Supply chain simulator: A scenario-based educational tool to enhance student learning. *Computers & Education, 51*(1), 252-261.

Uhles, NevilleWeimer-Elder BarbetteLee James G. (2008). Simulation Game Provides Financial Management Training. *Healthcare Financial Management, 62*(1), 82.

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