Text Mining based Qualitative Student Assessment of Interactive Simulation Learning using SIMIO Tool – A Work in Progress

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Abstract

Computer simulations complement and extend the real-world components of industries and manufacturing organizations. Teaching simulation-based tools helps students in modeling and analyzing the behavior of real time systems. With the increased demand observed in products and technology consumption, manufacturing industries are evolving to embrace new technologies and initiatives. To keep the emerging workforce technically competent in current tools to understand and interpret manufacturing processes, this paper portrays an effort by the authors in introducing SIMIO i.e. a tool on Simulation of intelligent objects to undergraduate students at University of Texas Rio Grande Valley and in understanding the influence of using a hands-on tool to stimulate student learning. With the help of SIMIO, students were introduced to the concepts of Basics of Simulations, Logics and Methodologies, Developing Simulation Models, Analysis of Simulation Data, applications to Industrial and service system designs. To understand student learning and the grasp of the concepts discoursed during the course, Natural Language Processing techniques have been used to qualitatively measure concept association by the students.

SIMIO Tool - Introduction and Background

Simulation of Intelligent Objects (SIMIO) is an object-oriented modelling tool that helps in building and executing dynamic models to analyze, understand and predict a systems performance. Object-oriented modeling has been around for 50 years, first introduced by the modeling tool known as Simula [1]. The method used in these kinds of tools involves the user selecting objects from a library and placing them into a modeling "canvas". Traditionally, rapid modeling of complex systems has been challenging because of the limited selection of objects and the highly technical programming skills needed to develop new ones, if and when that is available. SIMIO has overcome this barrier by using process-based objects rather than the use of code-based objects that require significant programming and the associated skill. The logic for a SIMIO object is defined by graphical process flows and is visible to the user. They are easier to understand and to modify, perhaps the easiest example of which is the SEIZE-DELAY-RELEASE logic model. Not only does the defined delay time determine release, but resource constraints are factored in as well [1].

Aside from the advantages of being easier to create, understand and modify, the object behavior in SIMIO is defined using high-level process modeling constructs that span time, again providing development advantages. The ability in SIMIO to modify existing objects is a key feature of object-oriented modeling tools. [1],[2]. Major educational benefits of SIMIO include enabling its users to directly see the impact of the change in a simulation model. Users can especially see how the proposed or modified system design provides value based on the required key performance measures along with understanding the impact by the system variation. This clearer view of the effect of randomness on

simulation models makes it easier for the users to comprehend and grasp the basics of statistical, mathematical and systems modeling [3].
In this paper we demonstrate the effect SIMIO as a tool for students to learn and apply project-based case studies to the concepts discoursed in their course via face to face, lab and applied hands-on session every week.

To keep upcoming students of Manufacturing and Industrial engineering updated with systems simulation and modeling tools authors believe it is of a high need to shift from traditional simulation tools such as ARENA in academia towards using SIMIO. Students as a part of Systems Simulation and Modelling course at The University of Texas Rio Grande Valley, were introduced to the concepts of Industrial Systems and Simulations, using SIMIO.
To assess the learning of students registered to the course, text mining methodology [4] was used to qualitatively measure concept association by the students.

Course Module and Learning Outcomes

The main focus of this course was to introduce students to the current simulation technologies pertaining to the manufacturing domain, in providing a rapid modeling capability for assessing and understanding manufacturing systems. Students were able to design manufacturing systems by developing process-oriented models and interpret simulation-based data to identify and solve problems in design of manufacturing systems. Simulation models were developed using SIMIO modeling and simulation software. Aimed at the learning outcomes for the students to be able to (a) Design and conduct experiments, as well as to analyze and interpret data; (b) Use the techniques, skills and modern engineering tools necessary for engineering practice; (c) Identify, formulate and solve engineering problems; the following course objectives were identified.

- Develop process-oriented models
- Analyze and Interpret simulation-based data
- Input data analysis using statistical methods
- Apply commercially available simulation tools to real time problems
- Design of manufacturing and logistics systems via visual simulation
- Identify and solve systems problems
- Communicate results of models and simulations
- Use modern industrial engineering simulation and modeling tools

To attain the course outcomes and objectives, the course was structured as a 1-hour face- to- face lecture and a 3-hour hands-on applied lab every week. Each week students were introduced to concepts from SIMIO on how to use different SIMIO objects in meeting the model requirements and the 3-hours lab helped in implementing the concepts learned that week. In addition, students had to undertake a final project that consisted of understanding a real-world system and simulating it in SIMIO to suggest system improvement based on key performance indicators. Identified in Table 1 are lab modules and reading students were required to complete over the semester.

Table 1. Course Modules Covered

Week	Subject
1	Course Overview and Introduction to Simulations
2	Simulations by Hand & Queueing Theory
3	Single Server Single Queue/ Multiple Server Multiple Queue Problems
4	Introduction to SIMIO & SIMIO Modeling Framework
6	SIMIO Interface & Fixed Objects
7	Stationary & Non-Stationary Arrival Processes
8	SIMIO Dynamic Object Movement & Interpreting Simulation Results
9	Modeling Serial Manufacturing Systems
10	Entity Routing & SIMIO Animation
12	Routing with Sequences, SIMIO Processes & Add-on Processes
13	User Defined Statistics, Simulation Based Optimization
14	Vehicle & Conveyers
15	Project Discussion & Submission

In week 1 students were introduced to the concepts of what simulations are, common applications of simulations, advantages and disadvantages of simulations, different types of simulations and the steps involved in doing a simulation study. Week 2 and Week 3 extended the aforementioned concepts along with major concepts queueing systems, elements of a queueing process, queueing configurations, disciplines in queues, and performance measures of queues. Week 4 constituted of students downloading SIMIO software along with being introduced to the SIMIO standard library (different objects available for the users to develop simulation models), Weeks 6 to 12 consisted of students working on each and object from the standard library in building simulation models reflecting to serial manufacturing lines, buffers, buffer capacities, dynamic routing and routing of entities along with modeling basic operation based on inputs in SIMIO. Weeks 13 and 14 constituted of introducing students to various optimization techniques for performance measures such as number of entities in the system, time at queues, time of entities processing, scheduled utilizations, based on the simulation models developed from weeks 4 to 12. An integral part of the course was for the students to undertake a real-world project.

Students were tasked to analyze and appropriately size an urgent care center that will be open 7 days a week 13 hrs. a day. The facility comprised of a registration area, waiting room, triage area, and rooms that can be used for exams and procedures, staffed by a Receptionist, Nurses, General Physicians, Imaging Technicians, Orthopedic Physicians, Orthopedic Technicians, and Physician's Assistants. The primary objective of this project was to evaluate the urgent care center for the impact of flexible work patterns, simulate system response with varied patients' arrival, and optimize system performance measures of scheduled utilization, number of patients entering and exiting the system, waiting time in system and the throughput.

Student Learning Assessment

Text mining is an application of Natural language processing by applying mathematical models to text information for extracting patterns and hidden information

from a given collection of text. These methodologies have been used extensively in the fields of business, health sciences and manufacturing [4].

For measuring the student learning, at the beginning of the semester, students were first asked to take a survey based on 10 different open-ended questions to assess their understanding on the concepts of Simulation and Modeling. Over the semester, students were introduced to various concepts of modeling systems in SIMIO in meeting the given requirements using face-to-face lectures, hands-on labs and several reading sessions. At the end of the semester, students were given extra credit to retake the same assessment of 10 open ended questions to compare their answers and to qualitatively identify the concepts gained. Table 2 identifies the questions asked in the survey.

Table 2. Open Ended student concept evaluation questions

Assessment Question
Q1. What is a Model?
Q2. What is a System? Define Kinds of System.
Q3. What is the difference between a Static and Dynamic Model?
Q4. What is the difference between continuous and discrete models?
Q5. What is Simulation?
Q6. Identify the Classification of different Kinds of Models.
Q7. Give 2 advantages of Simulation.
Q8. Give 2 dis-advantages of Simulation.
Q9. Identify in the order of importance the different steps for molding a given system.
Q10. What do you understand by the term "verification & validation of a model"?

Text based analysis of the identified questions and their responses are given below. Several word clouds are generated based on the responses before and after the course completion for each question. Figure 1 illustrated the word clouds generated before and after the course for the question on “What is a Model?”.

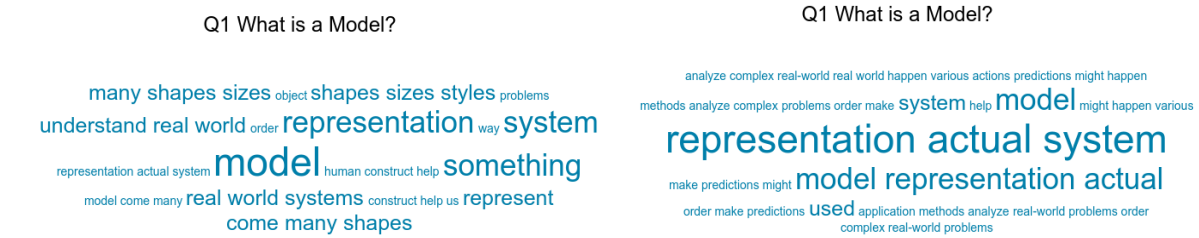

Figure 1. Word clouds generated for responses of Q1 before (extreme left) and after (extreme right) completing the course

As observed, before undergoing the course module, the students perceived a model to be something that comprises of shapes and sizes that help humans to represent and understand real world. After completing the course, the concept of a model drifted towards a model being something that enables to analyze a system, predict and represent complex real-world problems.

In understanding what a concept of a System means to the students, illustrated in figure 2 are the word clouds generated based on student responses. It is identified that students have had the basic understanding of what a system is, seeing that they used the concepts such as components, objective, goal, and functionality, both in prior and post assessments. This is due to the fact that, all the students taking the course are seniors and are required to take Systems Engineering Fundamentals as a prerequisite where the concepts of systems design and development are covered.

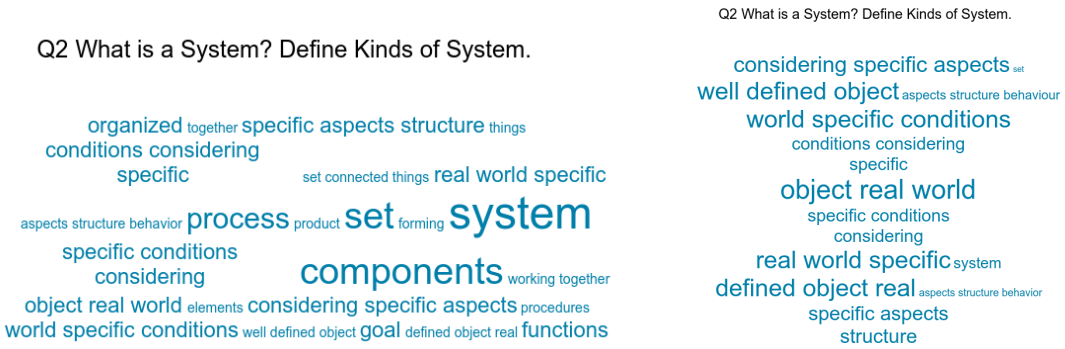

Figure 2. Word clouds generated for responses of Q2 before (extreme left) and after (extreme right) completing the course

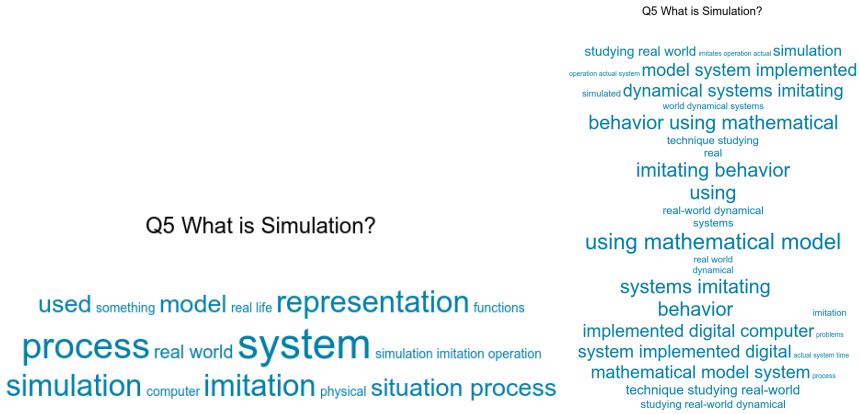

Figure 3. Word clouds generated for responses of Q5 before (extreme left) and after (extreme right) completing the course

Analyzing question 5 of the survey i.e. to understand what a simulation meant to students before and after completing the course, an increased use of concepts such as mathematical modeling, dynamical behavior, system imitating real world behavior is seen implying to a gain of knowledge in the concepts related to understanding and implementing simulation models. Please see figure 3.

Assessing the student understating on the advantages and disadvantages of simulation tools use, a gain in concepts and knowledge on how simulations are useful in executing models such as verifying system changes, leading system improvements, facilitating what-if analysis is observed. Please see figure 4 and figure 5.

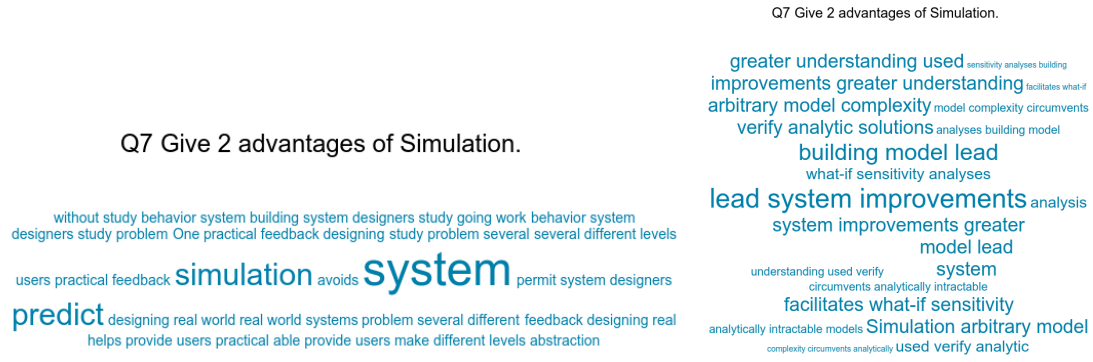

Figure 4. Word clouds generated for responses of Q7 before (extreme left) and after (extreme right) completing the course

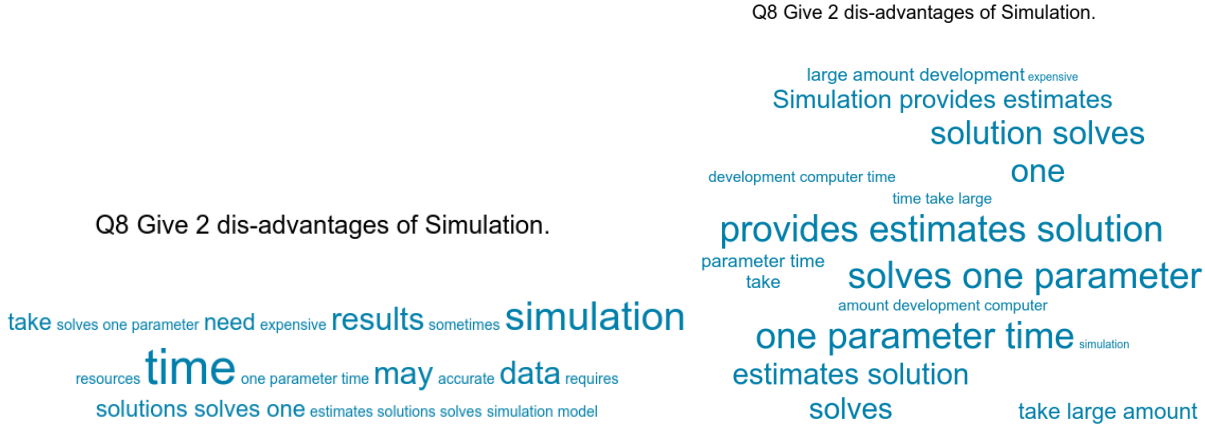

Figure 5. Word clouds generated for responses of Q7 before (extreme left) and after (extreme right) completing the course

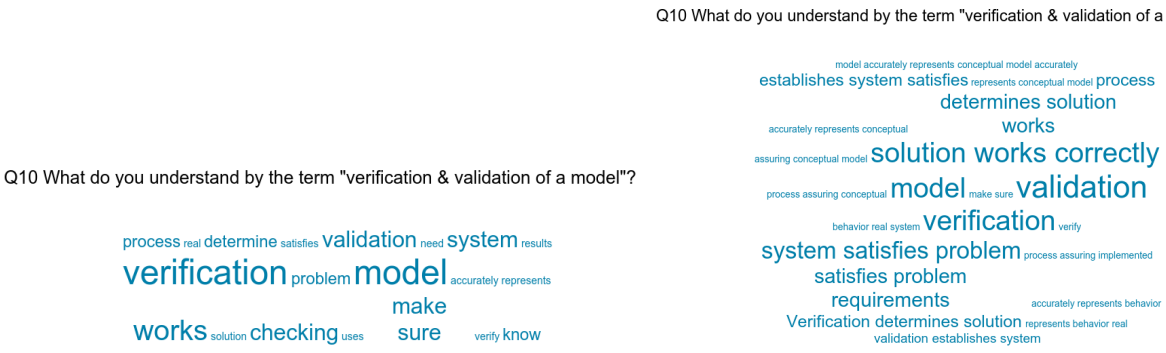

Figure 6. Word clouds generated for responses of Q10 before (extreme left) and after (extreme right) completing the course

Further, it is also observed that students gained a better understanding on the importance of verification and validation towards systems development. Specifically, while executing

their project at the design stage, on making sure their proposed project design adheres to the requirements given to accurately represent the intended system behavior. Please see figure 6.

The observations drawn from figures 4, 5 and 6 illustrate that students gained concepts within a simulation modeling project lifecycle framework that contains the following phases: Define objectives (and stakeholders), Define (understand) the system, create functional specifications (detail scope planning), Manage the project (to gain valuable insight), Collect input data, Build and verify the model (iterative), Validate the results, and Experiment, analyze, and present the results [1]. This insight is supported by the course content covered during weeks 4-12 (please see table 1 for a detailed view of course concepts covered during weeks 4-12)

Based on the use of words by the students in answering their assessments before and after the course completion, the use of text mining helped to identify specifically the concepts gained over the semester. For instance, 10% of the survey respondents associated the term model with keyword shape, 16.6% with keyword something and 16.6% with keyword representation. However, after the course completion 44.4 % of the students associated the concept of a model to the keyword system, 11.11% with Complex system, 11.11% with prediction. Similarly, the concepts such as mathematical modeling were used by 37.4%, object-oriented design were used by 29.4% of students in defining what simulations are.

Conclusion and Future Work

This paper portrays the effort on the use of text analysis in trying to identify the gain of knowledge and concepts related to simulation and modeling. The use of tailored lecture and related hand-on lab assignments along with weekly readings positively influenced students learning. This paper portrays an initial effort by the authors on the use of text analysis to understand student learning. To better realize the use of text mining for student learning assessment the authors, for future work, plan to use text mining by using advanced text analytics to find student sentiment towards the opinions expressed by the students to computationally identified and determine their attitude towards the concepts of simulations and the use of SIMIO simulation tool over the semester. In addition, the observed results will be compared with the traditional learning assessments metrics such as exam scores.

References:

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