AC 2012-3831: INTEGRATING BUSINESS PROCESS SIMULATION SOFTWARE INTO A FACILITIES LAYOUT COURSE

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Integrating Business Process Simulation Software into a Facilities Layout Course

Abstract

Many companies face productivity challenges brought about by today's economic impact. At the same time, computers and their software have become easier and easier to use. Computerized simulation of business processes enhances productivity by allowing project teams to test their solutions prior to actual implementation. Recently, at the University of Dayton, many industry sponsors of engineering technology senior projects are requesting that student teams develop simulation models of their facility layout designs. At the time of this request, no course in the engineering technology curricula taught even the basics of simulation. Discussion with members of the Industrial Advisory Committee (IAC) suggested two alternatives to meet the needs presented by business. The first choice, adding a business process simulation course to the Industrial Engineering Technology (IET) curriculum, proved unfeasible due to the difficulty of adding a new course to the curriculum. Falling back on the second choice, the Industrial Engineering Technology program initially inserted a few simulation modeling exercises into the Facilities Layout course. This tactic proved to be unsatisfactory because these exercises only gave students an introduction to the software and did not provide the skill level needed to model the industry projects. Another problem was that the projects being used for the class exercises and senior design projects were often too large to model with the student or examination versions of the simulation software. As a result of this program inadequacy, a project was initiated to select the appropriate business process simulation software to integrate into the Facilities Layout course. This paper will describe the process used to select the chosen software. Included in the paper will be discussions of the results of a survey to determine what process simulation software was being used at other engineering technology institutions, what software was ultimately chosen and why it was preferred, and how the Facilities Layout course was redeveloped to incorporate the use of the software. The newly designed course is currently being taught, so the paper will also discuss the students' evaluations of the new software and the redeveloped course.

Introduction

In the mid-nineties, the Engineering Technology Department at the University of Dayton decided to eliminate certain laboratory courses and integrate the laboratory exercises into the associated lecture course. The Facilities Layout Design lecture/laboratory courses were the first courses to implement this initiative. One of the reasons for implementing this initiative was the low enrollment in the combination lecture/laboratory courses since the courses had to be taken as co-requisites. These courses were required courses for IET majors and were technical electives for other majors. Faculty thought the reason for low enrollment in these lecture/lab courses was that

most non-IET majors would not take the courses as technical electives because of the extra laboratory credit hour. The other reason for implementing the initiative is the problem of synchronizing laboratory exercises with the corresponding lecture topics. Generally, the lab exercises did not line up with the time when the corresponding lecture content was being taught. This is especially a problem when the lecture and lab were taught by two different instructors. Experience since implementing this initiative has shown that integrating the lectures and laboratory exercises is more effective in terms of course scheduling for students and also for synchronizing the timing of lectures and labs.

Integrating Business Process Simulation Software

In April 2006, the IET Industrial Advisory Committee discussed the need for the IET program to teach Business Process Simulation (BPS). Integrating this software into the Industrial Engineering Technology curriculum has many benefits including updating and further developing the skills of the IET faculty in the area of Simulation modeling software technology, providing students with leading edge technology that they will use in industry, and possibly attracting more students from industry to take IET courses to update their simulation skills. Discussion of how to implement simulation in the curriculum led to the decision to integrate simulation modeling into an existing course because there was not room in the curriculum for a new course. The decision was made to integrate a module for an introduction to BPS software into the Facilities Layout Design course. Initially, student versions of business process simulation software were used for this module. This proved to be satisfactory for several years for teaching students the basics of simulation modeling. However, recently, Senior Project sponsors have asked student teams to provide process simulation for those senior projects that involve facility layout designs. Attempts by student teams to use the student versions of the software for these projects proved to be unsatisfactory because of the limitations on the number of steps, objects, or other limitations. The need for professional versions of the software became apparent.

Simulation Software Study

During the Spring semester of 2011, a study was implemented to determine which Business Process Software would be best for use in the Facilities Layout Design course. The study began with a search of the current literature on Business Process Simulation software. A number of recent articles on simulation were available, some of which are included in the references section at the end of this document. There are a number of technical and professional organizations and conferences devoted to the application and methodology of simulation. One such organization, the Institute for Operations Research and the Management Sciences (INFORMS) is an international society for practitioners in the fields of operations research and management science. The INFORMS publications *Management Science, Operations Research,* and *Interfaces* publish articles on simulation. Notable among these articles is the Simulation Software Survey by Swain[1] in which he contacted suppliers of discrete-event simulation

software. As noted by Hall and Harmon[3], most simulation modeling tools provide some form of discrete event simulation capabilities, either as part of the tool or as an available, separate add-on module. Discrete-event systems simulation involves developing models of systems in which the state of the system variable changes at discrete points in time. In most real-world situations, the amount of data to be analyzed and stored is so large, a computer must be used for this task. For discrete-event system computer simulation models, data is generated by the software based on the user's assumptions about the system and observations are collected and analyzed to estimate the true system performance characteristics.

Swain's survey of 26 vendors revealed that there were 48 different types of simulation software on the market at the time of the 2009 survey. He published an updated survey in the October 2011 issue of *OR/MS Today* in which 29 vendors responded to the survey and 55 different simulation products were identified. After the literature search, an online survey was developed and conducted of members of the Engineering Technology Division (ETD) of the American Society for Engineering Education through the ETD listserve. This survey served to narrow the search for suitable software. Twenty-nine members of ETD responded to the survey. Eighteen different simulation software products were identified by the respondents. The results of the survey are summarized in Table 1 below. Note that some organizations were using multiple software packages.

Name of Simulation Software	**Number of Users**
ProModel	4
Arena	3
Multisim	2
Automation Studio	2
Flexsim	2
Process Simulator	1
Simul8	1
CAD/CAM Pro/E	1
Simprocess	1
Robocell	1
Simio	1
Labview	1
Laerdal	1
Simulink	1
Witness	1
Delmia	1
Automod	1
Simtronics	1
Not currently using simulation	4

Table 1 Simulation Survey Results

As can be seen in Table 1, more organizations used ProModel and Arena than any other software package. Based on the survey, an evaluation was conducted by building several models using student versions of both ProModel and Arena. ProModel was found to be more difficult to learn than Arena. An advantage of Arena is that it is based on flowcharting and most of our students already have some exposure to flowcharting. Based on the evaluations of the two simulation software products, faculty initially decided that Arena would be the best fit for our program. Since there would not be a dedicated course for simulation, the software chosen would continue be implemented as a module in an existing course and therefore would have to be fairly user-friendly. Several weeks were spent gathering material and learning the ProModel and Arena software products by developing simulation system models. Then in May of 2011, a Rapid Modeling Workshop presented by Simio LLC at the University of Dayton. Simio is one of the newest Business Process Simulation software products. In this workshop it was learned that Simio is based on Arena, and was developed by people who also helped develop Arena. However, Simio has some advanced features that Arena does not have, such as converting a model from 2-dimension to 3-dimension with the press of a button.

Simio is ***Sim***ulation based on ***I***ntelligent ***O***bjects. In object oriented simulation software, the system is modeled by describing the objects that make up the system. The objects may be customers, machines, robots or other objects that pass through the system. A model is built by combining all the objects that make up the system. The model builder specifies the properties of each intelligent object such as speed, processing time, setup time, etc. Since the simulation software objects model real world objects, the complexity is reduced and the program structure is clearer. An evaluation version of the Simio Simulation software was obtained and some practice models were developed using this software. Simio was found to be a little more difficult to learn than Arena, but somewhat easier than ProModel.

In the Simio Rapid Modeling Workshop, it was learned that Universities could apply for a grant of the professional version of the Simio software that has unlimited capabilities. As mentioned above, one of the lingering problems that Engineering Technology students have faced in the Senior Project capstone course is that many companies recently want the student teams to provide a simulation model of their designs. However, most of the projects are too large to model with student or evaluation versions of the Simulation software. Thus, a large advantage of selecting Simio was that professional versions of the software for use by our students are available at no cost to the university. This professional version of the Simio software has full capability with no model size limits. An application was subsequently submitted to Simio LLC for a grant. The application was successful in obtaining a grant valued at $79,200 for 40 seat licenses.

IET-332 Facilities Layout Design and Simulation

The Facilities Layout Design course was redeveloped to include Simio lab exercises and was renamed "Facilities Layout Design and Simulation" to indicate that simulation was a major part of the course. Some of the lecture material, of course, had to be eliminated to make room for the Simio exercises. The course remains three semester credit hours. The redeveloped course was taught in the fall semester of 2011. There were 16 students enrolled in the course. Eleven students were Industrial Engineering Technology majors, three were Mechanical Engineering Technology, one was Global Manufacturing Engineering Technology, and one was Electronic Engineering Technology. The simulation lab exercises constituted more than 40 percent of the course. In addition to simulation, the Facilities Layout Design topics covered in the course were the following:

1. Process and schedule design. This section of the course focuses on how to develop certain process tools such as bills of material, parts lists, route sheets, assembly charts, and how to determine the number of machines needed to produce a product.
2. Flow systems, activity relationships, and space requirements. This section addresses analysis of the flow through a facility, how to prepare relationship and from-to charts, and how to determine the space requirements for a facility.
3. Personnel requirements. Those parts of a facility used by employees such as parking, restrooms, cafeterias, etc., are discussed in this module.
4. Material handling. In this module, the different types of material handling equipment are discussed and student teams prepare reports on a particular type of material handling equipment.
5. Layout planning design. This module primarily focuses on how to prepare a facility layout using the Systematic Layout Planning Procedure developed by Muther[11].
6. Warehousing. Receiving and shipping, loading docks, order picking, and storage layout planning principles are discussed in this module.
7. Office layouts. Various types of office layouts and how planning for office layouts differ from manufacturing layouts are discussed.

Simulation lab exercises are woven throughout the course. Some of the lectures/exercises were as follows:

1. Introduction. Simulation defined. Examples of process simulation products. Simio defined. Classes of objects. Managing variation. Steps in a simulation study. The Simio user interface. Simio Standard library objects. Building your first Simio model. Queueing Theory. Building the second Simio model and comparing the simulation results to the characteristics using Queueing Theory formulas.
2. Simio modeling framework.

3. Additional Queueing Theory. Understanding steady-state requirements. Building an ice cream store model.
4. Types of links; connectors, timepaths, paths, conveyors. Developing an airport model.
5. Understanding replications, experiments, responses, and scenarios. Airport model extended.
6. Branched paths. Routing logic. Airport model revisited.
7. Modeling a manufacturing cell.

An example of a student's Simio project is shown below.

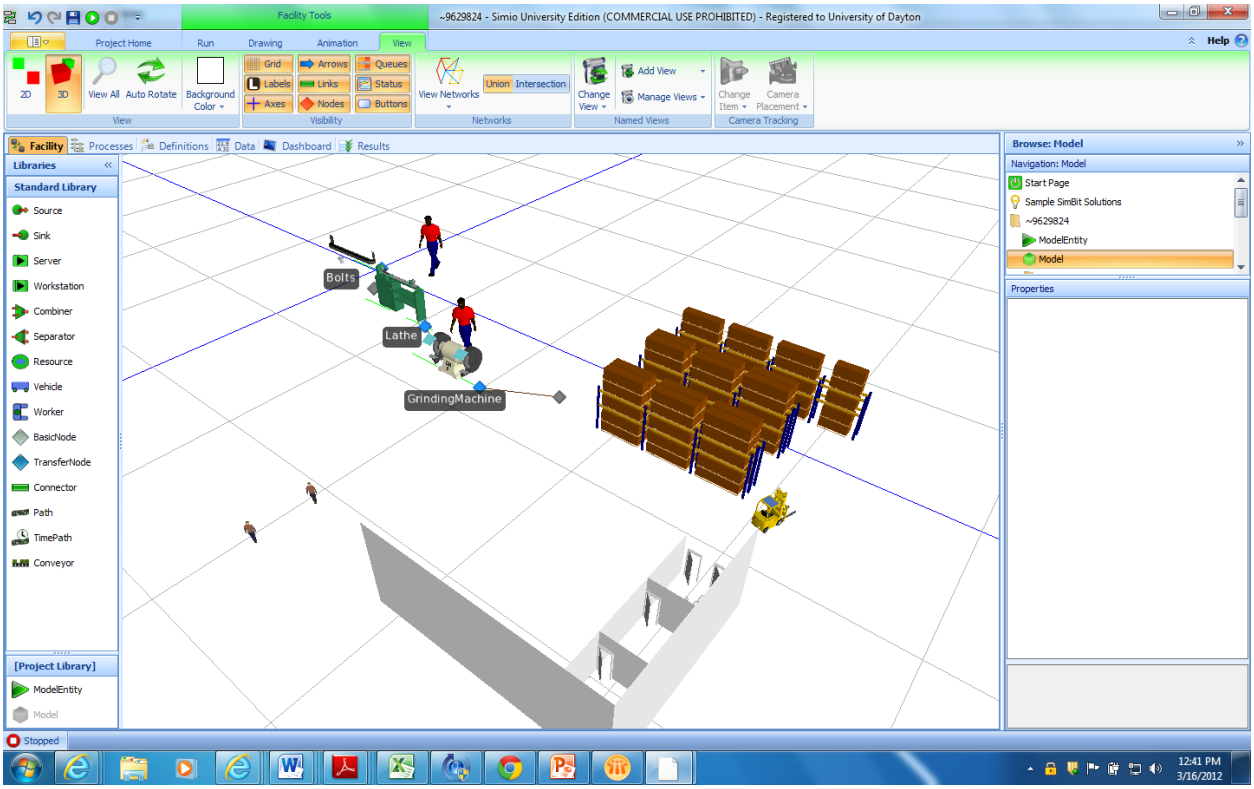

Figure 1 An Example Student Simio Project

Students' Evaluation of the Course

At the end of the course, students were asked to evaluate the course with the Simio software. Students' evaluations focused mainly on the software and were mostly positive, however, there were some valuable lessons learned.

When asked to list some things about the Simio software that they liked, some of the students' comments include:

"That you can set up multiple layouts and virtually implement them in minutes to see if they work. Also, the 3D options through Google warehouse."

"Easy to add items, easy to replace stock images with more relevant images, easy to change run cycle times."

"Ability to change objects quickly."

"How you can make it look like a real facility."

"3D, random time calculations, symbols to reflect objects."

"Easy to learn, quick to do, helps you visualize."

"I could see using the software to make an accurate plant layout."

"It was easier to see the Queueing Theory happening."

"The ability to show results in multiple forms."

"Watching the entities run through the model was cool."

When asked to list some things about the Simio software that they did not like, some of the students' comments include:

"Changing item parameters was far from intuitive."

"Not enough time to really learn it."

"Some things are hard to find in the program."

"Learning all the program functions."

"The reports are confusing."

"Very confusing to interpret data."

"Some functions are not as obvious as others."

The students rated the ease of learning the software 3.3 (slightly above average) out of 5.0 points. User friendliness of the software was rated 3.5 (between average and above average) out of 5.0 points.

One student in the Facility Layout course was also enrolled in the Senior Design Project course and was a member of a team whose project was to do a facility layout for an industry sponsor. The team decided to use the Simio software to simulate their project. The Facilities Layout Design course instructor mentored the team in the simulation portion of their project. It became quickly obvious that the level of simulation modeling that was being taught in the course was not adequate to model the senior project layout of the facility. It was necessary for both the instructor and the student who was primarily responsible for the simulation portion of the senior project to spend numerous extra hours learning additional Simio modeling content.

As a result of the student feedback from the evaluations and the experience with using Simio for the senior project, it became obvious that students would need a higher skill level to be able to use the software to do Senior Projects. The equivalent of a dedicated course was needed to achieve this level of skill. Again, because of the difficulty of adding a new course to the curriculum, a more creative approach was needed. After considering various options, it was decided to find a way to incorporate additional course time in the Facilities Layout Design and Simulation course for learning the simulation software. The approach that will be used when the Facilities Layout Design and Simulation course is taught the next time is to keep the course at three semester credit hours, but it will be taught in a two lecture hours and three lab hours format. This format will allow additional lecture hours but most importantly additional lab time to teach the simulation software.

Conclusions

Using simulation software to model the processes of an actual industrial facility requires a high level of simulation skills. Experience during this last semester has proven that students cannot achieve this level of skill by simply having a simulation module in a lecture course. This approach does not allow students the amount of time needed to fully explore the software. The equivalent of an entire course or lab is required to master the software.

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