

Designing a Learning Historian for Manufacturing Processes

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Table of Contents:

I.	Introduction	3
II.	The Arena Model	4
III.	The Learning Historian	4
IV.	Arena and The Learning Historian	5
V.	The Controls of the Learning Historian	5
VI.	Usability Studies	7
VII.	Learning Historian Usability Study	8
VIII.	The Pre-Questionnaire Form	8
IX.	The Exercises	8
X.	Post-Questionnaire Form	8
XI.	Changes to the Historian and the Usability Study	8
XII.	Results	
	Pre-questionnaire Form	9
	Exercises	9
	Post-questionnaire Form	10
XIII.	Observations and Conclusions	11
XIV.	Further Research	11
XV.	Appendix A	12
XVI.	Appendix B	22
XVII.	Bibliography	29

Designing a Learning Historian for Manufacturing Processes

1. Introduction

In all aspects of life, reviewing history has proven to have some influence on future decisions. Review of past events is not new to our society. Basketball coaches often review videotapes of games to see what worked well and what could be improved upon (Plaisant et. al page 1). Black boxes in airplanes also provide a record of the conversation held by the pilot and co-pilot prior to a plane crash (Plaisant et. al page 1.) Allowing users to have some record of their actions gives them the opportunity to review these actions and perhaps decide what to do next. Providing a way to review history may also prove beneficial in the manufacturing environment. Simulations provide a means of modeling a “system to reproduce the dynamic behavior of the system” (Herrmann page 11). While simulations are excellent tools for creating these models, they may lack in helping the user to understand the relationships that exist in manufacturing processes. For example, they may lack in facilitating learning that would help the user to understand the relationship that exist between such measures such as the capacity (the number of machines), rate (part/time), through-put (number of completed parts), net profit and cycle time (average time per part). Understanding the relationship held between these measures is the key to understanding the model itself.

The Institute for Systems Research at the University of Maryland in a joint effort with the Human Computer Interface Lab (HCIL) at the University of Maryland endeavored to provide a solution to helping the user understand these relationships. Their objective was to help students understand the relationship held between the following performance measures: capacity, throughput and cycle time. Once this relationship is understood, the student could use this knowledge to optimize system design. It is believed that providing a link between the student and the simulation that would facilitate learning and understanding would accomplish this objective. The Learning Historian had the capabilities of providing such a tool. The following course of action was followed in designing a Learning Historian for a manufacturing process:

- Develop a simple simulation of a manufacturing process using Arena
- Use a Learning Historian that is able to read the Arena file
- Select the input and output configuration files to be displayed in the Historian
- Develop a study that would test the usability of the Historian as a user interface
- Test the usability of the Historian on users by means of an informal study
- Observe and record users comments and suggestions
- Implement minor changes to Historian based on frequency of suggestion or comment
- After initial testing of historian is complete collate all studies and look for trends in suggestions, comments and problems encountered by users

2. The Arena Model

The first task was to design a model of a simple manufacturing process. A simple model of a cast iron part was created using Arena. Arena is a simulation software that enables the computer modeling of any existing or new system. Its graphical interface design tool allows for easy modeling. It is a modeling system that is built on the "Siman/Cinema" simulation language (Drevna, Kasales page 431). Siman is a generic-based simulation software. So Arena acts as a front end to this simulation language. Arena is based on the "concepts from object-oriented programming and hierarchical modeling" (Drevna, Kasales page 431).

The Arena model that was designed simulates the processing of three individual parts. Each part consists of a cast iron metal piece that is bought from an outside manufacturer. Parts arrive at a fixed rate. After arriving into the system, each part is sent to the drill press machine. A hole is drilled into the part. Once the part has been drilled, it proceeds to the deburring machine. The part is deburred (the removing of rough edges from a piece of machined metal). Upon completion it advances to the cleaning machine. There the part is cleaned so that it may be welded to a handle. The part goes to the welding station where the part and handle are welded together. The part is also inspected at the welding station. Parts that pass inspection are shipped. Parts that fail inspection are sent to the rework station, where they are disassembled, cleaned, repaired and re-inspected. Parts that pass this second inspection are also shipped (See Schematic 1-1, Appendix A).

Parts have interarrival times that are exponentially distributed with an initial mean equal to the inverse function of the rate. 50% of incoming parts are of part number 1, 25% are of part number 2 and 25% are of part number 3. Each part undergoes the same processing; however the processing times are different. Processing times are based on machine and part type (see Table 1-1). There is a 70% chance that the part will pass the initial inspection. If this happens, the part is sent to the shipping station. The part is then shipped out and exited from the system. There is an 85% chance that the part sent to the rework station will pass the rework inspection and be shipped otherwise the part is scrapped.

3. The Learning Historian

"The aim of the Learning Historian is to provide a richer environment to learners while they freely explore the behavior of a simulation" (Historian page 1) The Learning Historian allows user to review their interaction with a simulation. The users can change parameters (such as the rate and capacity) and observe the results of the changes. Reviewing the history might help users to decide what changes can be made to improve the simulated process. The Historian also allows the user to compare simulation runs by placing the results side by side. The history can then be annotated and sent to a professor for review and comments. The Learning Historian acts as a teaching aid for professors because it facilitates collaboration between the student and the professor. The professor can provide tutorials and demonstrations for the student. Thus the Learning Historian would serve as an educational supplement to a lecture rather than a tool to teach simulation modeling. It would provide computer-enriched

instruction to the student and help them to understand how changes in variability affect performances of manufacturing systems.

4. Arena and the Learning Historian

In order to attach the Arena model to the Learning Historian the following events must occur. First an Arena model is created using Arena. Then the Arena model is then written to a Siman file. The Siman file is read by a configuration utility and the file is converted to a configuration file. The configuration file allows the instructor to display the input and output variables that he/she wants in the Historian. The Historian then reads the configuration files and displays these variables (see Figure 1-1). Several variables were created within the Arena model and later incorporated into the Learning Historian. The input variables that the user was able to manipulate based on designer configuration were the number of machines (capacity) for each type of machine and the rate (part/min.) The min and max value for each type of machine (the drill press, deburring, cleaning, welding and rework machines) were 1 and 5 respectively. An initial value of 1 was assigned to all the machines. Thus the user has ability to change the number of welding machines from 1 to 2 and observe the results of that change. The output variables that were displayed in the Historian were “Net Profit”, “Total Parts Completed”, and “Average Cycle Time” (Please see Appendix 2 for cost calculations the above output variables).

5. The Controls of the Learning Historian

The Historian has various controls that allow the user to see a visual and numerical display of the input and output variables. The Learning Historian control panel is divided into three parts. There are the “Trial Controls”, the “Historian Controls” and the “Experiment Controls” and “Experiment Outputs”. The “Trial Controls” allow the user to execute a new experiment or revise a previous experiment. In order to manipulate the experiment controls after reviewing a history, the user must select *New Experiment* to execute a new experiment or *Revise Experiment* to revise a previous experiment prior to clicking on the *Execute* button (See Figure 1-2). The “Historian Controls” allow the user to save and restore histories. The *Show/Hide History* button allows the user to hide or show the “Trial History Graph” (see Figure 1-3 for display of trial history graph). The Trial History Graph” shows a visual display of the input and output variables by means of a bar graph. The graph is color-coded and corresponds with the colors used

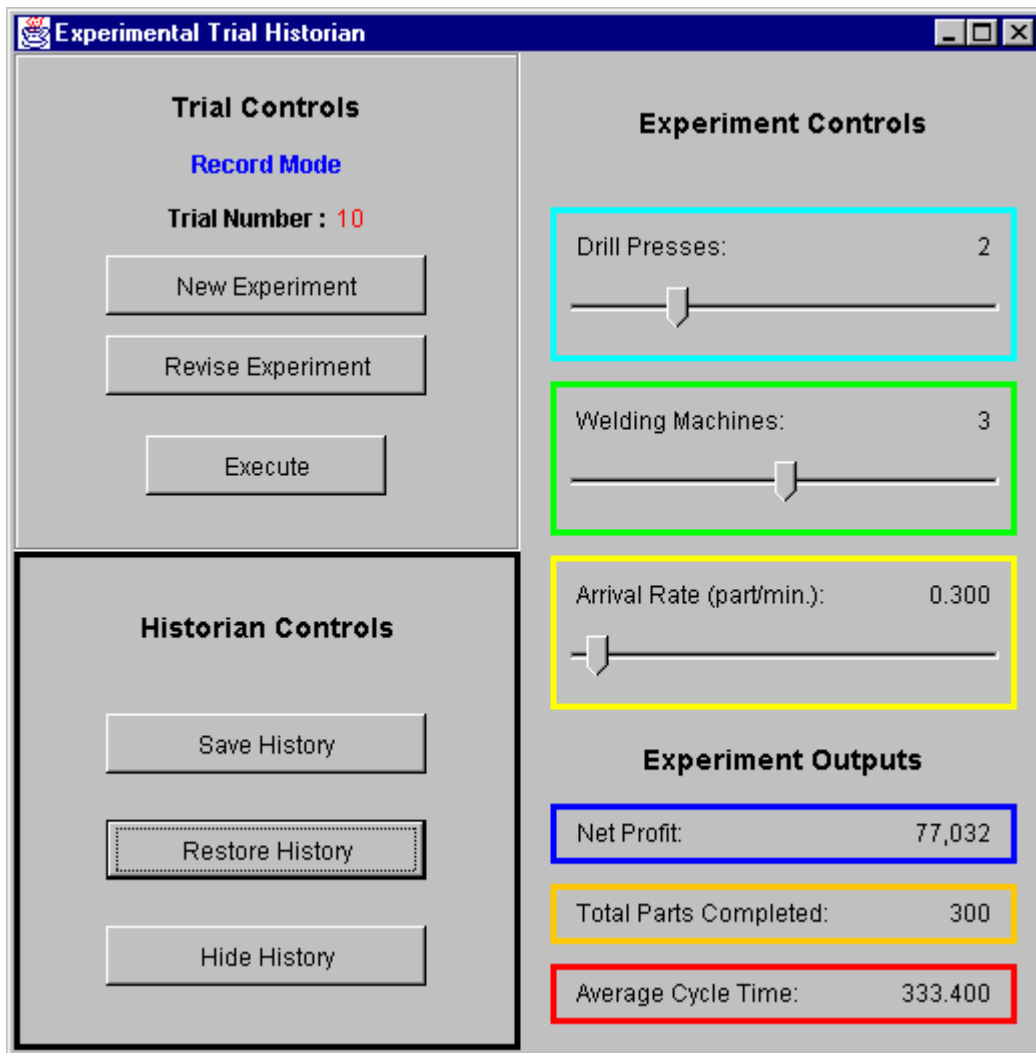


Figure 1-2

to outline the “Experiment Controls” and “Experiment Outputs”. This visual display allows the user to have a visual perception of the changes in variables. The “Experiment Controls” display the input variables that were configured by the instructor. The sliders allow the user to change these inputs. Figure 1-2 displays the Historian Control Panel for one of the exercises that was used in the usability study. Here, the “Experiment Controls” are Drill Presses, Welding Machines, and Arrival Rate. Notice that the user can change these controls, execute the experiment and observe the changes in Net Profit, Total Parts Completed, and Average Cycle Time.

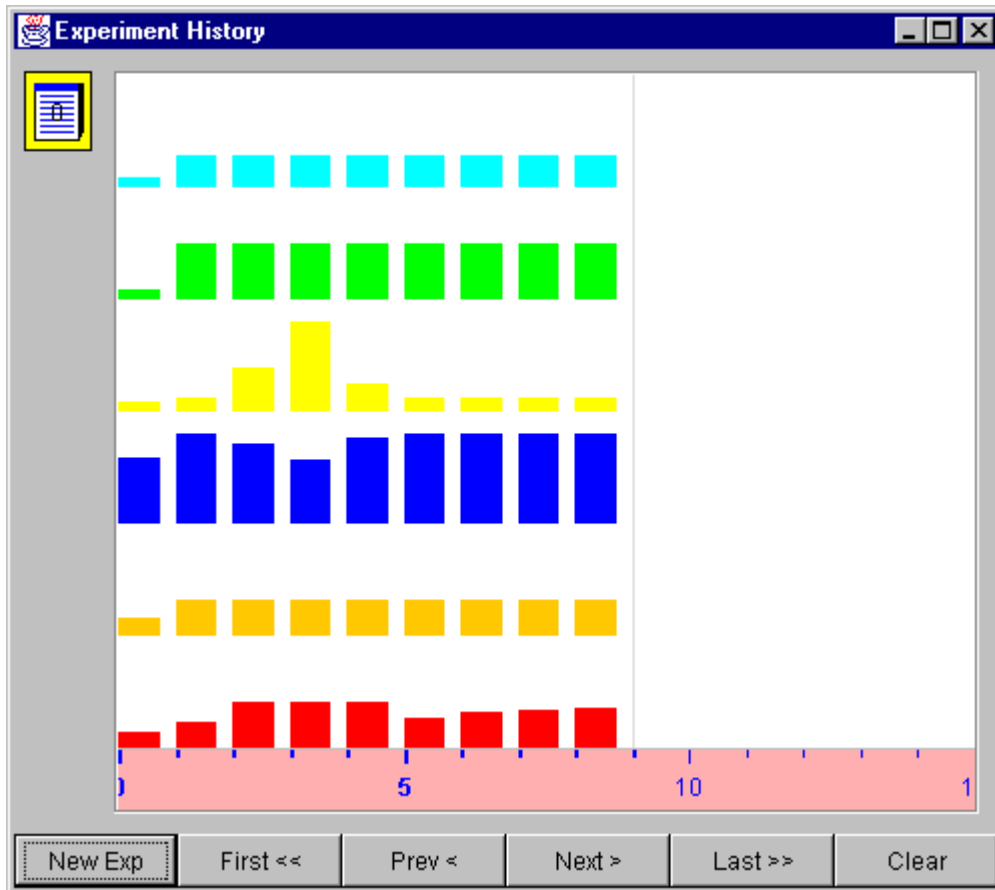


Figure 1-3

6. Usability Studies

“Usability studies are important in the context of ...any type of educational software”. (Anjaneyulu, et. al page 207). They aid in helping to evaluate whether the interface is effectively accomplishing its goal. If the interface is difficult to use, the user may have trouble understanding the system that is being explained because too much time may be spent on figuring out the mechanics of the interface so that the objective of learning the material somehow gets lost. On the other hand, if the interface is fairly simple to use and the information provided for understanding the domain if not adequate, the tool will not be effective in facilitating learning of the material.

7a. Learning Historian Usability Study

The goal of the usability study created for the Learning Historian was to evaluate the Learning Historian in terms of its interface usability. This evaluation was based on a pre-questionnaire form, a set of exercises, and a post-questionnaire form. Eight students participated in usability study. All of the students worked alone. After an introduction the students were asked to fill out a pre-questionnaire. They were then given guidance material on the Learning Historian and the manufacturing process modeled. They were next asked to experiment with the Historian prior to performing exercises to familiarize themselves with its controls. Next they performed exercises using the Learning Historian and answered questions based on the exercises (See Appendix 1 for entire usability study).

7b. The Pre-questionnaire Form

The objective of the pre-questionnaire form was to provide information on user's computer, simulation and manufacturing experience and to see if there is a possible correlation between the user's experience and his/her ability to complete the exercises (See Table 1-2 for User Experience Background Summary).

7c. The Exercises

The exercises were designed to see if the Historian met its goal of aiding the user in carrying out certain tasks. In the simple exercises, the user was to execute the experiment using the input default, manipulate the input parameters in the Historian, execute the new experiment and compare the results of the experiment using the History of the experiments. Once the user accomplished this, they were asked to answer a few questions about the exercise. These questions provided a way of seeing how easy or difficult these tasks could be accomplished with the aid of the Historian. More complex questions involved the user changing some input variable to optimizing some output variable. There were also questions that focused on whether the Historian was able to help the user establish certain relationships based on the information provided.

7d. The Post-Questionnaire Form

The objective of the post-questionnaire form was to provide feedback, comments and suggestions from the users.

8. Changes to The Historian and the Usability Study

After the first two users tested the Historian, some immediate changes were implemented based on their input. Initially the *Show/Hide History* button did not pop up when the Learning Historian control panel was opened. This confused the users. After

executing experiments they expected to see the History; however, they were unable to see this because they had not clicked on the *Show/Hide History* prior to executing the experiment. Having the Trial History Graph appear every time the Historian is opened solved this problem.

Another change made to the Historian after the first two users had tested it was changing the maximum value for number of machines. This value was initially set to three. This posed a two-part problem. First, the users found there was a large gap between each integer interval. The user would try to change the number of machines from one to two and find that he/she had not moved the slider over enough to reflect the change. Sliders proved not to be the most effective tool for changing values less than 5. A quick solution to this problem was to increase the maximum number of machines from 3 to 5. This would reduce the gap between the change in the number of machines. Increasing the maximum value for the number of machines to 5 also gave the user more variability. In the other words, the user could see the affect of adding more machines.

The value for the maximum rate was initially set to .200 (part/min). The academic mode of Arena 3.0 wasn't able to handle values higher than this number (Arena would crash). This problem was fixed by conducting the experiment on a machine that had a training version of Arena 3.0. The maximum value for the rate was then changed to 5.0.

The *Record* button was confusing to users. Users did not understand how to use the button until after it was explained to them. After the third user tested the Historian, the *Record* button was replaced with a *New Experiment* button. Both buttons served the same purpose-to allow the user to begin a new experiment, however, the *New Experiment* button made its purpose more apparent. For the same reasons, *Duplicate Experiment* was changed to *Revise Experiment*. In addition to this a description of all the buttons was provided to the user for their reference (See Appendix A).

9. Results of Usability Study

9a. Pre-questionnaire Form

There was a broad range of users in terms of computer, simulation and manufacturing experience (Table 1-3 for Summary of Experience). Seventy-five percent of students had no simulation experience. Fifty percent of participants had no manufacturing experience.

9b. Exercises

Participants were able to complete simple exercises consisting of changing input variables and noting output changes with ease. With added trials, most participants were able to complete more complex exercises consisting of adjusting an input to optimize an output. Most participants had difficulty establishing the more complex relationship between cycle time and the number of parts completed. In many cases users clicked back and forth between experiments to see changes in outputs. The

users that clicked back and forth took a little more time to complete the exercises than those who wrote their comparisons down. It was suggested that the Historian allow the user to see the numerical value of the output by placing their mouse over the history they want displayed. This would reduce the number of mouse clicks. In general, users who had manufacturing experience wanted to see more information on how the outputs were calculated, whereas users with little to no experience wanted more information on terminology.

9c. Post-Questionnaire Form

Users had the following recommendations for improvement based on the information provided in the Post-questionnaire Form. A lot of the comments focused on the bar graph display. The bar graph display served as a visual tool to help users see the changes in variables. Users suggested that we change the resolution in the graph to more effectively capture small differences in output variables. For instance, if the user changed the rate by only a small amount, he/she may notice that the number of parts shipped only goes up or down by one unit. Using the graph to see the change in the number of parts was difficult because it seemed as if the graph had not reflected the change. Another suggestion was to use a line graph instead. This would allow all the variables to be superimposed on one graph and thus capture the increase or decrease in output.

Many of the users commented that the graph should be labeled more clearly. The x-axis of the graph is numbered to correspond with the each experiment. The y-axis is not labeled. Identification of the input and output variables located in the History Control Panel under “Experiment Controls” and “Experiment Outputs” are color-coded. The Trial Graph Bar displays the variables that correspond with the colors displayed for the input and output variables in “Experiment Controls” and “Experiment Outputs”(See Figure 1-2 and Figure 1-3). It took a while before users realized this relationship. Therefore, reinforcing this relationship with labels would help users identify it faster.

Users also stressed the need to have a better indication of which experiment is being viewed. Currently a line located on the left side of the bar graph of the selected experiment is used to identify the experiment being viewed. Users wanted to see this line either in the middle of the bar graph that is being viewed or it removed all together in place of highlighting the bar.

Most users suggested providing better guidance tools. They wanted to see more instruction on the controls. A solution to this problem that has already been implemented was providing a tutorial on the controls. The users were presented with a written copy of the location, function, and use of each control. This information will be placed within the historian in the near future. In addition to this, more information on the process being simulated, as suggested, will become a part of the Historian, as well as a Help button.

Users also suggested that there be some type of animation displayed in the historian to represent the system being modeled. Most of the users who suggested that animation be included had no manufacturing or animation experience. These users felt that there was a missing link between the Historian and the simulation.

10. Observations and Conclusions

Users had some initial trouble with the experiment controls. This supports the recommendation for more guidance tools. Most users who had used a simulation software before stated that the Historian displayed the input and output variables in a much clearer format than a regular simulation software and thus the relationship between the input and output variables were easier to discern. Even users without simulation experience mentioned the clear display of input and output variables. However, there seemed to be insufficient data for participants to complete the more complex task of relating cycle time to the number of parts. Based on the comments and observation of the users, the usability study demonstrated that the Historian is a usable interface though some changes must be made.

11. Further Research

This pilot study is the first of many more usability studies that must be conducted to have more quantifiable results. The next step to this project is implement the changes suggested by the pilot users and conduct more formal testing on whether the Historian is a usable interface. Also instructor-based tutorials will be implemented in the Historian. Once its usability has been established, emphasis will be on evaluating whether the Learning Historian facilitates learning.

12. Acknowledgements

I would like to thank Dr. Jeffery Herman and Dr. Catherine Plaisant for all the assistance they provided in my research endeavors. I would also like to thank Anne Rose for her patience and assistance with finding information on the Learning Historian and answering all my computer questions and problems. In addition to this I greatly appreciated the help given to me by Sean Gahagan. If it weren't for him, I wouldn't know nearly as much about Arena as I do now. I would like to thank Gene Chipman for helping to understand and configure the Learning Historian. Finally I would like to thank Diane Ihasz and other member who were responsible for successfully coordinating the REU program.

Appendix A

Learning Historian Usability Study Pre-Questionnaire

Please answer the following questions to the best of your knowledge. Place an X or check mark where appropriate.

1. Age: _____ Sex _____
2. How many hours per week do you use a computer?
0-1 _____ 2-3 _____ 3-4 _____ Over 5 but less than 10 _____ over 10 _____
If over 10 please specify your average weekly amount _____
3. Please check the application(s) you use on a regular basis:
_____ Word Processing _____ E-mail
_____ Internet _____ Programming
_____ Graphics
4. How many years of computer experience do you have?
0-2 _____ 3-5 _____ 6+ _____ Over 10 _____
5. Have you taken a simulation class?
Yes _____ No _____
6. How many years of simulation experience do you have?
0-1 _____ 1-2 _____ Over 2 but less than 5 _____ 5+ _____
7. Have you designed a system using a simulation?
Yes _____ No _____
8. If you answered yes to question 7, what simulation package or software did you use?

9. Do you have any manufacturing experience? _____

Learning Historian

The Learning Historian allows users to review their interaction with a simulation. The users change parameters in the simulation and observe the results of the changes. Reviewing the history might help users to decide what changes can be made to improve the simulated process. The Historian allows the user to compare simulation runs by placing the results side by side. Finally the history can be annotated and sent to a professor for review and comments.

Trial Controls

New Experiment

Location: First button in the upper left hand corner underneath “Trial Controls” in the Experimental Trial Historian window.

Function: Acts as a reset button. Allows user to start a new experiment and allows them to manipulate “Experiment Controls”.

How to use:

1. Click on *New Experiment*.
2. Manipulate “Experiment Controls”.
3. Click on *Execute Experiment*.

Revise Experiment

Location: Upper left hand corner of Experimental Trial Historian window underneath “Trial Controls”.

Function: Allows user to revise a previous experiment (in some cases you may want to make minor changes to a previous trial to see how this affects your results).

How to use:

1. Select desired experiment by using *First, Prev, Next, or Last* button (located at the bottom of the Experiment History window).
2. Click on *Revise Experiment* (This will allow you to make changes to the “Experiment Controls”).
3. Make changes to the “Experiment Controls” (also known as input variables) by dragging the slider to the desired value.
4. Click on *Execute*.

Execute

Location: Upper left hand corner underneath “Trial Controls”.

Function: Allows user to execute or run an experiment.

How to use:

1. Make any change(s) to the experiment or leave experiment set to default values.
2. Single click on *Execute*.
3. Observe outputs numerically by looking under “Experiment Outputs” (located in the lower right hand corner of the Experimental Trial History window) or observe changes in bar graph.

Historian Controls

Save History

Location: First button in the lower left-hand corner of the Experimental Trial History window underneath “Historian Controls”.

Function: Allows user to save all experiments (history) under a file name .

How to use:

1. Click on *Save History*.
2. Type in a relevant file name.
3. Click on Save.

Restore History

Location: Second button on the lower left-hand corner of the Experimental Trial History window underneath “Historian Controls”.

Function: Allows user to open a previously saved file.

How to use:

1. Click on *Restore History*.
2. Type in file name that you want to restore.
3. Click on Open.

Hide History

Location: Third button in lower left-hand corner underneath “Historian Controls” in the Experimental Trial Historian window.

Function: Allows user to hide the Experimental History window.

How to use:

1. Click on *Hide History* (To show window again click on *Show History*).

Other Controls

First

Location: Second Button in the lower right hand corner of Experimental History window.

Function: Allows user to see first experiment.

How to use:

1. Click on *First*.

Prev

Location: Third Button in the lower right hand corner of Experimental History window.

Function: Allows user to see previous experiment.

How to use:

1. Click on *Prev*.

Next

Location: Fourth Button in the lower right hand corner of Experimental History window.

Function: Allows user to see next experiment.

How to use:

1. Click on *Next*.

Last

Location: Second Button in the lower right hand corner of Experimental History window.

Function: Allows user to see last experiment.

How to use:

1. Click on *Last*.

Clear

Location: Last Button in the lower right hand corner of Experimental History window.

Function: Clears all data (i.e. clears all experiments ran by user).

How to use:

1. Click on *Clear*.

Warning-This will clear everything!!!!!!

Annotate

Location: Upper left hand corner of Experiment History window

Function: Allows user to annotate

How to use:

1. Move cursor over icon
2. Drag rectangle to desired bar
3. Release Box by removing hand from mouse
4. Double click to open
5. Type message
6. Say okay

Learning Historian Usability Study Exercises

Exercise 1

1. Run the Learning Historian using the default values.
2. Change the number of drill press machines from 1 to 2.
3. Make the rate of arrival a larger number.
4. Compare the results of the default values with the changes you have made.
5. Save the History.

Question 1)

What happens to the output variables? Which ones increase?

Exercise 2

1. Change the number of machines in the welding machines from 1 to 3.

Question 1)

Is the cycle time shorter? _____

Question 2)

Does the number of completed parts increase? _____

Question 3)

How does changing the number of welding machines affect net profit?

Exercise 3

1. Now that you have changed the number of Drill presses from 1 to 2, changed the rate and changed the number of welding machines from 1 to 3, find the arrival rate that will maximize profit using these changes.
2. Save the History.

Question 1)

What did you choose as your arrival rate?

Question 2)

Was finding this optimization an easy task? _____

Exercise 4

1. You have space for 1 more machine. The number of cleaning and deburring machines are fixed. (Therefore you can only add one more drill press machine, one welding machine or one more rework machine.)
2. Find the machine that would increase the number of parts completed.
3. Annotate the trial that produced the largest number of parts completed.
4. Save the history.

Exercise 4

Question 1)

Which type of machine should you buy to increase the number of parts completed?

Question 2)

How did you arrive at your decision? _____

Exercise 5

1. Use the information from Exercise 4 to answer the following questions.

Question 1)

What is the relationship between cycle time and the number of parts completed?

Question 2)

How did you identify this? _____

Exercise 6

1. Run the Learning Historian with one drill press and one rework machine.
2. Observe the results.
3. Change the number of drill press and rework machines.
4. Save the History.

Question 1)

What is the relationship between cycle time and capacity (number of machines) for each machine?

Question 2)

Is there a different relationship between the two? If so, why?

Learning Historian Usability Study- Post Questionnaire

1. Did you understand the manufacturing process demonstrated in this simulation? _____

2. Please describe in your own words the manufacturing process demonstrated in this simulation. _____

3. If not, what would help you to understand it better? _____

4. Was finding the buttons, scroll downs, etc. fairly easy? _____

5. Was locating where to make the changes in the Historian fairly easy? _____

6. What tools would further aid you in finding the answer the exercises? _____

7. How does the learning historian compare to a regular simulation software package? _____

8. Did the Learning Historian increase your knowledge of the manufacturing process and how input variables effect output variables? _____

9. What overall recommendations would you make for improvement? _____

Appendix B

Software Components of Experimental Historian

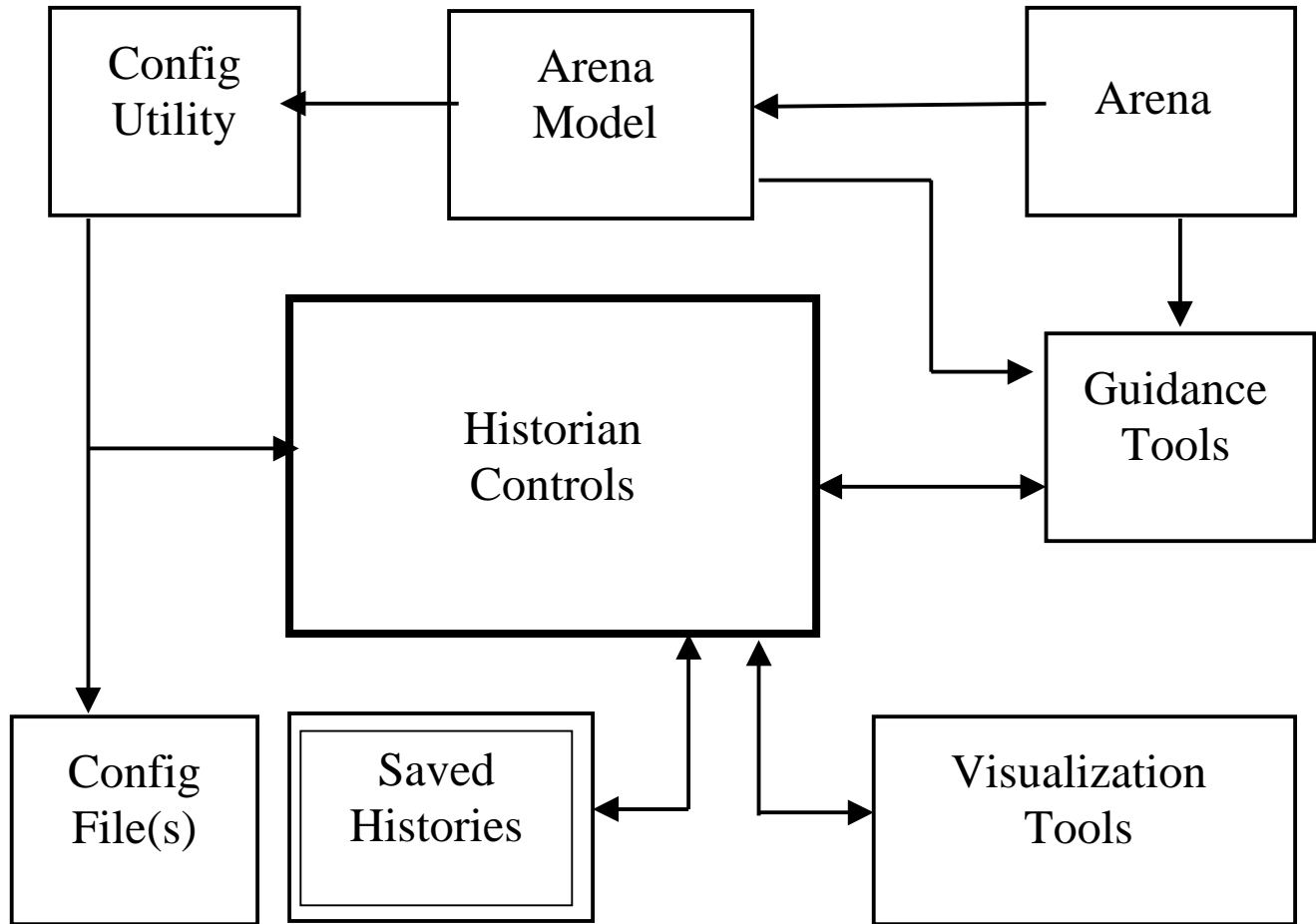


Figure 1-1

Part Processing Times					
Part Type	Drill Press	Deburring	Cleaning	Welding	Rework
1	EXPO(15)	EXPO(13)	EXPO(12)	EXPO(17)	EXPO(20)
2	EXPO(14)	EXPO(12)	EXPO(11)	EXPO(15)	EXPO(15)
3	EXPO(13)	EXPO(12)	EXPO(10)	EXPO(15)	EXPO(12)

Table 1-1

Cost Calculation for Arena model of The Manufacturing Process of a Cast Iron Metal Part	
Length of System 1640 minutes	
Machine Costs	
Drill Press Machine Cost= \$15/hr	$\$15/\text{hr} \times 1\text{hr}/60\text{min} \times 1640 = 410$ *The Number of Drill Press Machines
Deburring Machine Cost=\$14/hr	= \$383*The number of Deburring Machines
Cleaning Machine Cost=\$13/hr	= \$355*The Number of Cleaning Machines
Welding Machine Cost=\$17/hr	= \$465*The Number of Welding Machines
Rework Machine Cost=\$18/hr	= \$492*The Number of Rework Machines
Total Machine Cost	(410* The Number of Drill Press Machines + 383*The number of Deburring Machines+ 355* The Number of Cleaning Machines + 465* The Number of Welding Machines+ 492* The Number of Rework Machines)
Material Costs	
Material Cost Part 1=	10*Number of Parts That Enter the System
Material Cost Part 2=	8*Number of Parts That Enter the System
Material Cost Part 3=	6*Number of Parts That Enter the System
Total Material Cost=	(10*Number of Part That Enter the System + 8*Number of Parts That Enter the System + 6* Number of Parts That Enter the System)
Holding Costs	
Holding Factor = .001	
Holding Cost for Shipped Part 1=	Average Cycle Time for Part 1*10* Number of Part 1 Shipped*Holding Factor
Holding Cost for Shipped Part 2=	Average Cycle Time for Part 2*8* Number of Part 2 Shipped*Holding Factor
Holding Cost for Shipped Part 3=	Average Cycle Time for Part 3*6* Number of Part 3 Shipped*Holding Factor
Holding Cost for Scrapped Part 1=	Average Cycle Time for Part 1*10* Number of Part 1 Scrapped*Holding Factor
Holding Cost for Scrapped Part 2=	Average Cycle Time for Part 2*8* Number of Part 2 Scrapped*Holding Factor
Holding Cost for Scrapped Part 3=	Average Cycle Time for Part 3*6* Number of Part 3 Scrapped*Holding Factor
Total Holding Costs=	(Holding Cost for Shipped Part 1 + Holding Cost for Shipped Part 2 + Holding Cost for Shipped Part 3 + Holding Cost for Scrapped Part 1 + Holding Cost for Scrapped Part 2 + Holding Cost for Scrapped Part 3)
Revenue	
Price of Part 1 = 300	
Price of Part 2 =275	
Price of Part 3 = 250	
Revenue for Part 1= 300* No of Part 1 Shipped	
Revenue for Part 2= 275* No of Part 2 Shipped	
Revenue for Part 3= 250* No of Part 3 Shipped	
Total Revenue=	Revenue for Part 1 + Revenue for Part 2 + Revenue for Part 3
Overhead Costs	
Overhead Costs=Total Machine Cost + Holding Cost	
Net Profit	
Net Profit= Revenue -Overhead Costs-Material Cost	

Table 1-2

Summary of Pre-Questionnaire Form								
	Computer Use Hours/Week	Applications Used	Computer Experience (yrs)	Simulation Class	Simulation Experience (yrs)	System Design	Simulation Packaging Experience	Manufacturing Experience
User 1	25	WP, Internet, E-mail	10+	Yes	1-2	Yes	Slam	Yes
User 2	40	WP, Internet, e-mail Graphics, Programming	10+	No	0	No	-	No
User 3	40-50	WP, Internet, e-mail Graphics, Programming	10+	No	0	No	-	No
User 4	60	WP, Internet, e-mail Graphics, Programming	3-5	No	0	No	-	Yes
User 5	25	WP, Internet, e-mail Graphics, Programming	10+	No	over 2 less than 5	No	-	Yes
User 6	45	WP, Internet, e-mail	0-2	No	0	No	-	No
User 7	40	WP, Internet, e-mail Graphics, Programming	6+	No	1	Yes	Visim, Delphi	No
User 8	60	WP, Internet, e-mail Graphics, Programming	6+	Yes	1	Yes	Simscrip II	Yes

Table 1-2

Learning Historian Observation Summary

Learning Historian Usability Study

- 8 students participated in usability study
- Filled out pre-questionnaire
- Given guidance material on the Learning Historian and the manufacturing process modeled
- Experimented with Historian prior to performing exercises
- Performed exercises using Historian and answered question based on exercises
- Worked alone
- Filled out post-questionnaire form
- Study took approximately 45 minutes to 1-1/2 hours

Observations

- Some students spent a long time in the experimental phase
- Some created exercises for themselves in the experimental phase such as optimizing profit
- Most students didn't realize that the color outline in the experiment controls and experiment outputs corresponded to the colors in the bar graph
- Some had trouble remembering that if you reviewed the history you would have to click on *New Experiment* or *Revise Experiment* to be able to manipulate the input parameters
- Students wanted to be able to click on the bar graph instead of clicking on the *Prev*, *First*, *Next*, *Last* buttons to review history
- In cases where there was only a small change in the results of one history to the next, the user had a hard time using the bar graph to see this distinction.
- Students felt that there is a missing link that may have helped them to better understand the manufacturing system. Some suggested that link be an animated simulation of the process.

Suggested Improvements

- Provide more instruction in the beginning of the study
- Provide animation
- Adjust the resolution of the bar graph so that distinctions could be made when reviewing histories that have only small changes in the results or use line graph
- Label the bar graph in conjunction with the color coding so that the user will understand that the colors outlined in the input and output variables correspond to the colors in the bar graph a lot faster

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