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THE OPERATIONS SIMULATION--A STUDY IN GAME DEVELOPMENT

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ABSTRACT

The following summarizes the development process for the game, OPSYM, including concepts, techniques, and user materials; also includes a digest of the game and an overview of its unique features for learning management and a report of classroom experience using the game.

INTRODUCTION

The impact of the common body of knowledge requirement of the American Assembly of Collegiate Schools of Business (AACSB) is being increasingly felt in the undergraduate and graduate business programs throughout the nation. At the same time, the challenge to business faculty, especially in the newly emphasized PUN area, has never been greater. The American Production and Inventory Control Society (AFICS) has taken the leadership in the development of pragmatically-oriented educational material and programs in forecasting, capacity planning and master scheduling, inventory management, material requirements planning, and Shop floor control. This leadership also has given the POM classroom a new jargon and, in many schools, a new emphasis--away from the classical teaching of quantitative techniques. Many examples from operations are being utilized and much greater realism and emphasis on manufacturing details is being incorporated. This new emphasis suggested that there was a need for a new operations simulation (OPSYM) which would include appropriate aspects of the APICS materials, and provide a current vehicle for experiential POM learning. This became the development goal of the three-year project reported here--to generate a framework and simulation text which would supplement and complement the more current POM texts, and which would aid the student user in integrating (and perhaps even enjoying) the now-required POM materials.

PROCEDURES

The details of OPSYM were developed over time. Gradual convictions about context came out of our classroom experiences acquired while teaching undergraduate and graduate POM modules, considerable case study teaching and writing experience, and the invaluable learning associated with presenting a series of executive development courses. The existing games in the Management Sciences/Production area were reviewed in light of our teaching experiences. Substantially all the Published games could be classified as detailed production management experiences as contrasted with the broader perspective called for by the AACSB Operations area. They were published between 1968 and 1975--all prior to the PUN requirement by AACSB.

OPSYM owes much to The Executive Simulation (ES) by Keys and Leftwich, and thanks to co-authorship, could be built on the successful presentation and format of that game. The paramount objective of OPSYN was to provide a completely controllable game environment and level of complexity so that the sophistication of the game would be matched to that of the participants. Thus, as contrasted with its predecessor/parent", OPSYM is created in modules (INITIALIZER, SIMULATOR, SYSTEM REPORT, EDITOR, STUDENT PERFORMANCE REPORT, and, for participants, the STUDENT REPORT, STUDENT DECISION, and, YEAR-END REPORT) which can be executed separately, modified separately, and, through the EDITOR function adjusted almost continuously from level to level. Level One includes a single product manufactured on a single line using all purchased components with a monthly decision period. The most complex level. Level Three, incorporates multiple products manufactured on common or specialized lines, using a combination of purchased and fabricated components, with weekly decision periods. The EDITOR allows the instructor not only to adjust the game conditions but also to make parametric changes in our economic index, costs, or the significant marketing variables such as advertising, price, and distribution centers. None of these are controllable by the student team, but all of them affect company results. Further, it is not required that all companies be given the sane adjustments to the marketing variables--thus allowing the instructor to experiment with the game as a master participant, controlling the marketing environment and thus creating varying demands on operations executives in the teams.

Consistent with modern programming/data philosophy, the program contains very little "embedded" data. Relatively little time is required to adjust parameters so that each semester of team play has a completely fresh experience.

Programming in OPSYM includes three "generations" of games, that of The Executive Simulation (ES) which was laboriously analyzed and modified to suit some of OPSYM's requirements; that of the structured coding but with much conversion from ES, maintaining the embedded values; and, finally, the version which will be published, with full parameter choice left to the instructor/administrator. These developments have taken much time and considerable in the way of faculty, programmer, and computer resources. A brief summary of the game and its variables will be presented next for illustrative purposes.

DIGEST OF OPSYM

The Operations Simulation is a text under contract which focuses on production and inventory management decisions made by a team of students for a manufacturing company which competes in an undifferentiated oligopoly. There are a number of unique features to the game, both in design and in execution. It includes a substantial amount of flexibility allowing single or multiple products; monthly or weekly decision periods; and several controllable levels of complexity. Several specific planning experiences are provided including material requirements planning (MRP), master production scheduling (MPS) , and manpower and capacity planning. These must be carried out in response to changes in the uncontrollable environment which consists of the economy and the marketing department. Student teams prepare their own decision sets and receive immediate feedback without penalty in an execute mode. After this feedback, they can revise and resubmit their decisions and

they can also "Static-execute" their decision set, obtaining a pro-forma simulation result for evaluative purposes.

While the game is "structured" in three levels, all instructor changes to parameters are done through an EDIT function building on the basic Level One Game. This allows a complete customizing for emphasis of particular experiences in a simple fashion.

GAME VARIABLES - AN OVERVIEW

The Operations Simulation is a three-level game Involving many detailed production and inventory management decisions. Level One, the simplest form of the game, begins with a single product (A) and asks the team to decide about various activities to take place over three monthly periods and to plan similar actions to take place during the following three months. These decisions, described to detail in the text, relate to:
the level of production; the level of manpower; purchases of materials for three components; the amount of capacity to be utilized; or the amount of expansion to undertake. For the one-shift operations of Level One, decisions required include the amount of overtime to schedule, if any, to fulfill production targets. In addition to physical/materials action decisions, the team must make budget decisions on training, maintenance, quality control (QC) and research and development (R&D) expenditures, for each monthly period. These required eleven decisions are made for each monthly game period, after which the simulator provides results for each competing company. The game is run for three periods at a time in Level One.

Several features of the game require an explanation to the instructor so that maximum value will accrue to the student team participants and a minimum of harassment will be directed to the instructor/administrator.

Direct team input

Despite the caveats about keypunch errors, students will make mistakes. However, learning to detect such errors by seeing their consequences is an Important experience for the team members. The program is set up to receive input either from a CRT terminal or TX machine, or in batch mode from a card reader, one company at a time. Teams are given back a printout of their inputs automatically. A revised decision set can replace the one in memory any time before Instructor execution.

"Static" Execution

By a simple command, the simulator will provide a "run" based on the decisions made by the company whose data have been submitted, using as a starting point the combined positions of all the companies at the end of the last round of the game, and extending these positions without chan8e except for those new "trial" acts of the individual company. This pro-forma run has several purposes: it allows for debugging of decisions at minimal cost; it provides feedback as to the Possible consequences of the set of actions purposed; and it helps the student team "get involved" in the game. The game will disregard the trial data after the run except to record the cost ($250) of the simulation execution. Afterward additional runs can be made, but at a significantly higher cost until a limit of three runs is reached.

"New Run Data"

The team decision set after "static" debugging is not executed but remains stored in the game memory until the instructor requests execution of a new run. Teams which have not updated their planning decisions will have these executed without change, and the same data set will be re-entered into memory as planning decisions for the next new run. Instructor execution procedures are simple and involve little communication time with program.

Results

Results are obtained by having the instructor execute the program. The format of team results will correspond exactly with the example for Period 0 contained in the text. Each team receives a separate page for each decision period. The instructor receives a summary of the various team actions (System Summary) and an end-of-run comparison of the various teams.

Multiple Products

As soon as the instructor chooses, a simple parameter change will cause the game to run for each of three products (A, B, C). The same decisions are required for each product but expand from eleven per period to nineteen during game play for the additional components.

Multiple Shifts

The instructor may allow a second shift with the change of a parameter card. This allows more intensive use of capital equipment and may be timed to accompany projected surges in demand and discussions of manpower vs. capital expenditures in your lectures. Shift operations and overtime both cost a premium. They also require a larger training budget and bigger hiring activities, more maintenance and QC to maintain quality and larger volume.

Tine Buckets

Initial game conditions use monthly buckets, and all procurement and capacity lead times are in months. The Purchasing team member must do materials planning; first for one product; then for three, to enable production at the desired level to take place. About the time that MRP is introduced into the formal classroom activities, the instructor can shift over to weekly buckets and ask the student teams to work at the ga Level Two. Once this problem has been assessed, the team is sure to want some help with materials plrming.

"Automatic" MRP

The Level Two game provides MRY as an auxiliary output based on the production schedule. All existing open orders will have their Scheduled Receipts, Gross and Available and Net Requirements will be shown, and the Planned Orders, appropriately offset for Lead Time, will be given. Of course, direct Lot-for-Lot purchasing is easy. But with price breaks In the purchasing system, thinking will pay dividends and lecture on discrete lot sizing will find ready listeners and learners.

Lines

All production in Level One Is on a common line. The parameter card(s) may be changed at the instructor's discretion to allow purchase of capacity of special equipment which will only run Product B or Product C. There are clear advantages including a much simplified MPS, and a saving in set-up costs due to change-

over but at a cost for equipment and a more complex manpower management situation. Further, a decision to stay "tight" on capacity will result in at least occasional need to run some B or C on the common A line.

Capacity

Teams may increase capacity, choose special lines, work overtime, run on shifts, add people. or reduce capacity, shifts, and/or personnel. Availability of these options is under the instructor's control via parameter cards.

Randomness

The final game enhancement available is that of introducing uncertainty into the works, especially with respect to Scheduled Receipts of materials from the vendors. A random routine can be entered directly when the "receipts" probabilities are changed from 1.0 for on-time to, for example, .1 for a week early, .7 for on-time, and .2 for a week late.

Variations

The Level Three game is designed for either "automatic" or off-line MRP. That Is, a Cost is associated with an MRP rum now, and students may prefer to use an available package and do their own input to save the money. The Level Three game also introduces an in- plant component fabrication step, with the associated MRP and scheduling complications. More interesting variations are also instructor-controlled. For examples: by a message from Marketing, the price of any product, the level of the advertising budget, the number of salesmen, or the number of distribution centers, may be changed for any or all items. These instructor controlled elements should probably be reserved for experienced Executive Development users, or for advanced classes--or on a highly selective basis, to provide an enhanced learning experience for a team which is 'far Out in front' while at the same time accomplishing a little 'equalizing'.

OPERATIONS SIMULATION

TABLE 1

INDUSTRY:TEST0002 COMPANY: 2 PERIOD:0

OPERATING STATEMENT

SALES PRD1	$50,000.00
	$0.00
	$0.00
TOTAL SALES	$50,000.00
LESS: COGOLD	$23,000.00
GROSS MARGIN	$27,000.00
GC EXPENDITURES	$500.00
MAINTENANCE	$1,000.00
R & D EXPENDITURES	$1,500.00
TRAINING	$500.00
ADVERTISING	$2,000.00
CAPACITY INC COST	$0.00
UNUSED LABOR COST	$18,816.00
MISCELLANEOUS	$13,500.00
ADMINISTRATIVE	$1,680.00
CARRYING COSTS	$700.00
OPERATING INCOME	$-13,396.00

PARTIAL BALANCE SHEET

CASH ON HAND	$39,604.00	NOTES PAYABLE	$0.00
ACCOUNTS RECEIVABLE	$25,000.00	SPECIAL LOANS	$0.00
INVENTORY:PRODUCTS	$0.00	DEPRECIATION	$0.00
COMPONENTS	$14,000.00		

GENERAL SUMMARY

PLANT VALUE	$100,000.00
DIST. CENTERS	3
# OF SALESMEN	6
# OF EMPLOYEES	28
GRIEVANCES	0
UNUSED LABOR HOURS	4704
BACKLOG PRD1	0
	0
	0

PRODUCTION ANALYSIS

LINE	PRODUCT	PRODUCTION REQUESTED	STOCKOUT LOSSES	QCL LOSSES	STRAIGHT COST	OVERTIME COST	LABOR UTLZ	ACTUAL LABOR /PROD	LINE EFF	TOTAL PRODUCTION	TOTAL COST
LIN1	PRD1	0	0	0	$0.00	$0.00	0.0	0.0	0.0	0	$0.00
		0	0	0	$0.00	$0.00				0	$0.00

COMPONENT INVENTORY SUMMARY

COMPONENT	ORDERS	DUE IN	COST OF ORDER	RECEIPTS	ON HAND	UNIT COST OF ON HAND	VALUE OF ON HAND	CARRYING COSTS
CMP1	0	0	$0.00	0	1000	$6.00	$6,000.00	$30.00
CMP2	0	0	$0.00	0	3000	$3.00	$9,000.00	$100.00
CMP3	0	0	$0.00	0	1000	$2.00	$2,000.00	$30.00
	0		$0.00	0	4000		$14,000.00	$200.00

PRODUCT INVENTORY SUMMARY

	PRODUCT	QUANTITY ON HAND	UNIT COST	VALUE OF INVENTORY	TOTAL CARRYING COSTS
	PRD1	1000	$23.00	$23,000.00	$700.00
TOTALS		1000		$23,000.00	$700.00

COMMON RESULTS FOR ALL TEAMS

	COMPANY 1	2	3	4
MKT SHR PRD1	0.250	0.250	0.250	0.250
	0.000	0.000	0.000	0.000
	0.000	0.000	0.000	0.000
SALES PRD1	$50,000.00	$50,000.00	$50,000.00	$50,000.00
	$0.00	$0.00	$0.00	$0.00
	$0.00	$0.00	$0.00	$0.00
CAPACITY	840	840	840	840
PLANT VALUE	$100,000.00	$100,000.00	$100,000.00	$100,000.00
NOTES PAYBLE	$0.00	$0.00	$0.00	$0.00
MARGIN	$27,000.00	$27,000.00	$27,000.00	$27,000.00
NET INCOME	$-13,396.00	$-13,396.00	$-13,396.00	$-13,396.00
ROI	-0.134	-0.134	-0.134	-0.134

Game Play

The simulation play is initiated by having teams complete a decision sheet illustrated by Table 2. Table 1 is returned to students from Data Processing. In most cases, more instructor experience with the game will enhance the class experiential learning as well. While we have "structured" the game into levels for text readability and report formats, we can envision that instructors choosing to do so Can completely customize the game to the needs and aspiration levels of their own student population.

TABLE 2

HEADER CARD

Simulation ID
Industry ID
Company Name

CARD TYPE 1

'EXP'
Number of New Employees (+)
Number of Employees Laidoff (-)
R & D Expenditures
Quality Control Expenditures
Training Expenditures
Maintenance Expenditures
Miscellaneous

CARD TYPE 2

(Period Separation Card)
'END'

CARD TYPE 3

P RD
Line ID
Product ID
Quantity to Produce
Production Sequence No.
Overtime Flag
T - Planned Overtime
F - No Planned Overtime

CARD TYPE 4

'PUR'
Component Name
Quantity Purchased
Expedited Purchase Flag
T-Expedited Order
F-Regular Order

CARD TYPE 5

CAP'
Line ID
Capacity Increase (+)
Capacity Decrease (-)

Miscellaneous Items Requested:

Signatures of Team

Operating Principles and Communication

The user documentation for OPSYM follows the time-honored principles for business games in asking for the execution of various planning worksheets leading to decision sheets. However, by bringing the teams much closer to OPSYM through direct data input, and by providing the static or pro-forms execution features, we believe that feedback features are enhanced, along the lines of the actual decision support systems (DDS) in business. It also has the happy consequence of getting the Administrator "out of the loop" and into a master participant role at an early stage of simulation play. In higher Levels of play the company teams may find themselves interacting with the Administrator in some "outside" role such as marketing manager or general manager, but never as the OPSYM program executioner. Further, at least in more advanced groups, it is not necessary to collect and evaluate the student planning worksheets. The SYSTEM REPORT and STUDENT PERFORMANCE REPORT provide the administrator with the specifics of team actions and results, as well as comparisons among teams in useful detail. This again facilitates the Master Participant stance and reduces the Student-Professor relationship in favor of Team- to-Management roles.

Report formats are in traditional financial statement form Including a partial balance sheet. They also include the planning and control information most frequently used in manufacturing such as reports of physical units, production rates, labor hours and efficiencies, and other values relevant to the teams. Periodic feedback on what other teams are accomplishing provides an incentive to study own-team practices, especially when taken together with the intermediate Status Reports mentioned earlier.

Personal Insights from the Development Process

As in most joint endeavors each author had to contribute an accordance with his strengths. One of the most important "givens" to the undertaking was the availability of a successfully running game (The Executive Simulation, by Keys and Leftwich) and access to both students and faculty who had substantial experience in its use. While very little of the programming was directly transferable substantially all of the framework and conceptual aspects were useable as a very advanced starting point for OPSYM.

The "technical" author was able to acquire a well- trained computer sciences major who had an interest in business simulation to do the detailed programming. Further, a graduate student in business in our MBA Program had participated in The Executive Simulation and was persuaded to provide assistance in what became a triangular relationship between the three "technical types" developing the OPSYM details and sequencing. The technical author had little experience with simulation as a learning tool and had frequent need to interact with the experienced game author and administrator--with very beneficial results. Since our goal was to provide a versatile learning tool to serve in both general management programs and in more advanced or specialized courses, we sought to identify and include those essential aspects of the object system which needed to be present in the minimum-complexity simulation, and then went on from there. We will be able to share the perceptions of some of the users of OPSYN with the ABSEL Conference attendees, and through other articles following up on our work in this new simulation model and its extensions.

REFERENCES

[1] Keys, J. Bernard and Howard Leftwich, The Executive Simulation (2nd ed.), (Kendall-Hunt, 1977).