MODELLING AN INTRODUCTORY PROJECT MANAGEMENT SIMULATION IN UNDERGRADUATE COURSES

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ABSTRACT

This paper presents a model of a simulation to teach introductory project management in undergraduate courses. This is an early stage of an ongoing project. The intention in this paper is to present the model to be criticized. The participants will work in teams; initially taking over a company with financial difficulty. The simulation will be split into three phases: a) in the first phase, participants should write a bid, take part in the bidding procedures and plan the project execution; b) in the second phase, participants will execute the project, planning and re-planning the project, as necessary; and c) in the last phase, participants will compare results with assessment criteria. The assessment criteria will be: a) the project should be concluded in time; b) the project should generate net profit; and c) the teams should revert the financial situation of the company. They will be expected to achieve this result regardless some ethical and time pressure. Furthermore, the teams will have to deal with complicate and unpredictable situations that will be presented to them through cases.

INTRODUCTION

Projects are essential in our lives and management can be defined as a multi-project activity. The Project Management Institute (2004, p. 5) defines projects "as a temporary endeavor undertaken to create a unique product, service, or result". Projects can be short or long term, specific or large, simple or complex. Many of our desired outcomes can be considered projects: organizing a weekend party for friends; making a tour to a different country or going on a diet to lose weight; all these future desired states can be considered projects, or specific goals to achieve.

In this paper, the author develops a model of a simulation to teach introductory project management in undergraduate courses. This is the first stage of an on going project. In the near future, the model will be transformed into a computer-based simulation. The simulation will be part of the programme of a discipline named "Introduction to Project Management". The discipline is part of the curriculum in a management course. The intention is to introduce students to the concepts, problems and uncertainties of managing a project. The discipline will be one semester long (sixty hours in classroom) with around thirty students who have completed the disciplines in management functional areas (Marketing, Human Resources, Finance and Operations). It is expected that the simulation will spend approximately fifty percent of classroom time. As Hall (1994, p. 174) puts it, "the problems, uncertainties and dynamics associated with project management make it an ideal topic for simulation."

The simulation will not replicate a real object: a road to be built, a piece of software to be developed or a medical service to be provided. The project object will incorporate the characteristics existing in any project, irrespective of its nature. For example, every project consists of activities that interact and depend on each other. Every project consumes resources and every project should come to an end. So, whatever the project, it can be described as an interdependent series of components, consuming resources and providing a desired outcome. The simulation described here will preserve the logic of a project but the situations and the cases used will have no duty to resemble real projects. Indeed, the ability to generalize and not the ability to apply a solution to an isolated problem is the special feature which makes human beings so good at learning.

In the sections below, the author aims to explain the model, including the context in which the simulation will take place and the variables that affect the results. After the team formation, the simulation will be split into 3 phases:

a) Phase 1: Bidding and Planning the Project;
b) Phase 2: Executing the Project;
c) Phase 3: Debriefing the Results.

a) Bidding and Planning the Project

This step consists of three sub-steps. Firstly, teams must be aware of the company's current situation and the legacy left by the previous administration. This is done by delivering teams a *Consulting report* at the beginning of the simulation, showing the difficult financial situation which the company faces. After that, teams should read the Government's Invitation For Bid (IFB) carefully and write a proposal, following the rules and regulations of the bid. They should fill out some required forms and submit a sealed bid. Finally, in class, the sealed envelopes are opened, the bids are evaluated and the contract is awarded

to the bidder whose bid has been determined to be the lowest evaluated responsive bid.

b) Executing the Project

Even though the bidding will have a winner, the prize for the winning team will be a bonus. In fact, all teams will execute the project. The execution phase corresponds to simulating the project activities, that is, what happens as the project is being executed. Activities will be divided into four to five sub-phases, each corresponding approximately to 25% of the total project activities. In each sub-phase, through a simulated process, the actual time of each activity will be generated as well as the actual cost. Between two sub-phases, the teams may make decisions to re-plan and adjust parameters which are necessary to complete the project.

c) Debriefing the Results

In this phase, the teams will make a presentation to the Board of Directors regarding the Company's performance in the simulation. After the presentation, the performance indicators of each company will be unveiled to the class, according to established criteria.

In each stage above, the participants will confront a series of new situations and problems that will be presented to them in the form of *simulated mini-cases*. In the sections below, these phases are better explained. First, however, information about the context and the company is presented.

THE CONTEXT

In the simulation, participants will take over a company which dedicates exclusively to infrastructure projects. The company is called *Simulon*. Currently, the shareholders are very worried with Simulon's financial indicators. The company is losing market share and presenting a very weak financial performance. Consequently, the company's CEO decided to fire all previous directors, hiring a whole new Board of Directors (participants' teams) to replace them. The CEO has also hired a consulting firm to raise the current data and present a report to the new Board of Directors. In the kick-off meeting, the new Board of Directors should read and assimilate as quickly as possible the information provided in the consulting report and decide which new guidelines should be adopted to make the company profitable. The priority task is the preparation of a bid to a new IFB from the federal government. It is vital for the company to win the bid, as failure in doing so would likely compel owners to close the firm.

THE COMPANY

Simulon was founded in January 2004 by a group of investors interested in participating in the development of projects for the federal government. The owners are private investors and national companies from small and midsize economic sectors. The company is located in a fictional country called Brazon. Brazon government has been widely criticized internationally for the authoritarian style and several episodes of corruption in its management.

The company is in a difficult financial situation. There is only one contract in final phase of execution. The consultancy firm reports that staff is numerous and inadequate; the company needs a functional reorganization and new directions and administrative policies. A new organizational chart is also welcomed.

Depending on the quality of the team's planning phase decisions, the task of managing the company will be easier or harder. If the planning is thought carefully, what teams will have to do will be to hire personnel, purchase raw material, allocate resources to implement activities and manage tasks. Teams will need also to take care of external and unexpected situations, which may interfere in what was planned. If the planning phase decisions are neglected however, teams should expect a bunch of additional hard work ahead.

PHASE 1: BIDDING AND PLANNING THE PROJECT

Periodically, the government of Brazon launches IFB

TABLE 1
Human Resource Costs

Code	Monthly Salary	Code	Monthly Salary
HR1	3,250.00	**HR6**	1,147.79
HR2	968.43	**HR7**	5,510.00
HR3	652.00	**HR8**	1,367.18
HR4	1,785.00	**HR9**	3,500.00
HR5	2,341.00	**HR10**	2,500.00

Note: The teams should consider a 60% (sixty percent) tax over the payroll.

for the execution of projects in sectors which Simulon operates. Currently, the government is receiving proposals for an ambitious Sustainable Development Program, encompassing diverse industries. Simulon should submit a bid for this project.

Simulon will be acting in an oligopolistic market, constituted by the companies formed in the classroom. All companies in the class begin the simulation with the same financial situation, competing for the same government project. All businesses should submit a bid and, although only one company will win the bid, all companies will execute the same project. The competitive advantage to the winning company the bid will be a 20% bonus over the total price, offered by the government.

To plan the company's bid for the government's contract, teams need to work on a set of design parameters. Some parameters are known upfront and some are unexpected situations presented by the teacher, along the simulation.

KNOWN PARAMETERS

Known parameters are those set of information about the activities which teams know upfront. These parameters refer to information such as the cost of resources (human resources, materials and technology, (shown in tables 1, 2 and 3). Another known parameter is the Work Breakdown Structure (WBS). The WBS is a basic principle of project management and is defined by Passenheim (2009:30) as "a grouping of the work involved in a project oriented towards the deliverables that defines the total scope of the project". The WBS breaks down the project scope into a logical series of activities, smaller and clearly identifiable. The WBS of the simulation project comprises 89 activities. A sample of five activities is presented in table 1. Teams should analyze the project activities and build the project network, taking into account the variation of time each activity may last and the kinds of resources they need: a) human resources, b) material resources and c) technological resources. According to the company's project engineers and taking into account only technical variables, the estimated time needed for each activity will be established considering the optimistic time (Minimum Expected Time) and the pessimistic time (Maximum Expected Time). External variables (such as political interference, climatic conditions or otherwise) should also be taken into account in the project budget and will be introduced in the simulations as random variables or unknown parameters.

There are other known parameters which will also affect the cost of the project. These parameters are:

a) Administrative Expenses;
b) Cost of Processing Decisions;
c) Simulated Cases Costs;
d) Costs Related to Qualitative Aspects of Team Performance.

Administrative Expenses: to support the operations of the project, the company employs several clerks - including the directors and management staff (this is fully explained and shown in the consulting report). Monthly payments related to these employees should be considered as administrative expenses.

Cost of Processing Decisions: every decision made by the teams implies a *cost of processing that decision.* The cost of processing decision represents the costs associated with actions that the decision needs to be deployed. A decision to buy a product, for example, generates costs of searching for information on product availability, price quotation, purchase order and its processing and other charges until the good is at hand to be used. The cost of decision processing will depend on the type of decision taken and, despite they are known, sometimes they will not be informed to teams in advance.

Simulated Cases Costs: costs related to simulated cases represent the built-in costs regarding decisions in simulated cases. Each alternative decision-making in a simulated case has a specific cost associated to that alternative.

Costs Related to Qualitative Aspects of Team Performance: in the simulation, qualitative factors will also be considered. The qualitative variables are set by tutors and may include issues as late delivery of required

TABLE 2
Raw Material Costs

Code	Unt.	Price	Code	Unt.	Price
RM1	50Kg	219.00	**RM6**	Kg	69.40
RM2	Kg	1,198.00	**RM7**	m³	350.00
RM3	L	21.80	**RM8**	unt	135.00
RM4	m	73.00	**RM9**	Kg	100.00
RM5	m²	360.00	**RM10**	Unt	125.00

activities, inadequate leadership in group work or forms filled with incorrect information, among others. Such situations will lead to a score of nonconformities that will affect the company's final evaluation (see section on Executing the Project).

UNKOWN PARAMETERS:

Unknown parameters are those which may influence the planning and execution of the project, though they are not known or available at the time of the planning. Typical situations are the *simulated mini-cases* that will be presented to participants at some stages of the simulation, prompting the group to make decisions, which will influence the execution and the cost of the project. Another example is climate. On rainy days, certain project activities cannot be performed (this is indicated in table 1 with the symbol ❖).

The project also suffers strong pressure from environmental groups who are against the project implementation. The project will affect some rural communities, although the government promises they will be relocated and compensated. Furthermore, some activities may require a third part action when, for example, a special license needs to be issued by the government's Agency for Sanitary Vigilance. Under normal circumstances this license can take up to two months to be released. However, with political interference, it may come out in a week.

To make a proposal for the bidding, teams should be able to diagram the project, which will allow them to have a view of the activity network, the minimum delivery time and the costs of the project. Participants are strongly recommended to use some type of software to do this. For example, the OpenProj software can be downloaded on the Internet for free.

PHASE 2: EXECUTING THE PROJECT

Congratulations! Although only one team has won the bidding, all teams will be contracted to execute the project. What happens now? Now, it's time to roll up the sleeves and get the work done. The execution of the project will be divided in four phases as shown in table 5. Each phase consists of up to 25% of project activities which teams should plan, execute and control. Each phase begins with team's decisions for that phase, goes through the simulation of those activities and ends up with the feedback report. In the decision phase, teams should hire, bought or rent resources and make decisions about unexpected situations. Then, the tutor will run the software to simulate the duration and the costs of each activity. And, finally, the tutor will give participants the feedback reports to show them the results of the company up to now.

Here is some other information about these steps in each phase.

MAKING DECISIONS

To execute the project, teams need to make a series of decisions. In summary, these decisions comprise:

a) Hire and / or Dismiss Personnel;
b) Buy Raw Materials;
c) Buy or Rent Technology;
d) Allocate Resources to Activities;
e) Make Payments to the Employees Regarding the Previous Phase;
f) Make Payments to Suppliers Regarding the Previous Period;
g) Obtain Financing;
h) Take Ad-hoc Decisions.

a) **Hire and/or Dismiss Staff**: in each new phase of the project, teams may hire and/or fire personnel. If personnel are not enough to perform the activity, it cannot be executed or run time will be higher than planned.
b) **Buy Raw Material**: in each new phase of the project, teams should buy raw materials needed to complete the activities of the phase. If there are not enough raw materials, the activity is not completed.
c) **Buy or Rent Technology**: in each new phase of the project, teams should buy or lease the technology

TABLE 3
Technology Costs

Code	Current Price (Unt)	Code	Current Price (Unt)
TECH1	69,000.00	**TECH6**	75,000.00
TECH2	395.00	**TECH7**	1,773.96
TECH3	242.90	**TECH8**	52,179.90
TECH4	3,349.50	**TECH9**	1,441.65
TECH5	1,997.15	**TECH10**	12,000.00

needed to carry out the activities of that phase. If there is not enough technology, the activity is not completed.

d) **Allocate Resources to Activities**: in each new phase of the project, teams should allocate/reallocate resources to activities.
e) **Make Payments to Personnel**: in each new phase of the project, teams should make the payroll of existing employees in the previous phase.
f) **Make Payments to Suppliers**: in each new phase of the project, teams should make payments to suppliers regarding raw materials bought in the previous phase.
g) **Get Financing**: in each new phase of the project, teams may get a loan from a bank. The interest rate is 7% (seven per cent) over the amount. Funding is due in the last period of the simulation.
h) **Ad-Hoc Decisions**: teams may also make decisions, which are not mentioned above, consisting of any aspects regarding the company. These decisions are called *ad-hoc decisions*. There is not a pattern to these decisions, although teams should describe what the decision is about and give a rationale for that decision. Moreover, teams should attach a description of how the decision will be implemented. For example, suppose that a team has decided to offer a bonus to the firm's managers. The team should prepare a draft explaining the decision and submit it to teacher. The teacher answers the ad-hoc decision-taking providing details about the consequences of that decision.

SIMULATING TIME AND COSTS OF ACTIVITIES

After companies' decision making, the tutor runs the software to simulate what happened to the first set of activities of the execution phase (see table 5). For example, maybe teams have planned to carry out Activity 1 in two days. However, Activity 1 actually will take four days to be accomplished. This will require teams to analyze the implications of this delay to the project as a whole, that is, after each set of simulated events, teams should reevaluate the planning and modify, if necessary, the conditions under which the next activities will be carried out.

Participants should also notice that the actual time of each activity will depend on two kinds of variables. On the one hand, the actual time will depend on a random process which will generate a sequence of 10 numbers based on the minimum and the maximum expected time for the activity. On the other hand, the actual time will depend on the company's quality index (CQI). The teacher will be responsible to attribute a quality index to companies based on attributes such as readiness, quality of team discussion and other characteristics s/he finds useful. Companies with high quality index will benefit. Companies will be divided into three groups, according to their CQI:

a) Companies with high CQI;
b) Companies with medium CQI;
c) Companies with low CQI.

The actual time of each activity will be considered as follows:

TABLE 04
Project Activities Characteristics (A Sample)

Activity	Prev.	H.R. Type	Min. (Days)	Max. (Days)	R.M. Type	Quant.	Tech. Type	Quant.	Symbol
A1	-	1	1	10	1	10	5	1	
A2	-	3	2	20	2	15	3	1	
A3	A1	3	2	15	4	20	1	1	
A4	A1	1	3	20	4	2	10	4	
A5	A2	5	2	15	1	37	1	5	❖

- Activity. = Name of the Project Activity.
- Prev. = Name of the Previous Activity.
- H.R. = Type of Human Resource Needed to Run the Activity (See Table 2).
- Min. =Expected Minimum Time for implementing the Activity. (Total in Days).
- Max. = Expected Maximum Time for Implementing the Activity. (Total in Days).
- R.M. = Type of Raw Material Required for Implementation the Activity (see Table 3).
- Quant. = Quantity of Raw Material Needed for Implementing the Activity.
- Tech = Type of Technology Needed for Implementing the Activity (see Table 4).
- Quant. = Quantity of Technology Units Needed for Implementing the Activity.
- ❖ = The Activity Cannot be Executed on Rainy Days.

a) *Companies with high CQI*: consider the activity occurred under the column Min (minimum value of occurrences);
b) *Companies with Medium CQI*: consider the activity occurred under the column Med (average value of occurrences);
c) *Companies with low CQI*: consider the activity occurred according to column Max (maximum value of occurrences).

GIVING AND RECEIVING FEEDBACK

After each set of simulated activities, the tutor gives students feedback about their performance in that phase. Teams get together to discuss and relocate resources for the next set of activities, if necessary. This is also the time when new mini-cases will be introduced to participants.

PHASE 3: DEBRIEFING THE RESULTS

After all sets of activities are simulated in the execution phase, a debriefing session will be carried out to question participants about their performance and learning in the simulation as a whole. The tutor will then present teams their performance indicators. Six performance indicators will be used. They are:

a) The Net Profit of the Project;
b) The Accumulated Profit or Loss of the Company at the End of the Simulation;
c) The Project Delay;
d) The Volume of the Assets;
e) The Company Quality Index;
f) The Volume of Wages Paid to the Board.

a) The Net Profit of the Project (NPP)

The net profit earned in the project will be calculated according to the following formula:

NPP = (CP + B) - (CPA + F)

Where:

Contracted Price (CP): the contracted price will be equal to the overall price offered by the company in the bidding.

Bonus (B): The amount of money the company receives if it wins the bidding. The value will be 20% of the contracted price.

Cost of Project Activities (CPA): the cost of the project activities is the sum of all direct costs of the project. The cost of the project activities comprises a) cost of labor force, b) cost of raw materials, c) cost of technology, d) administrative cost, and e) costs associated to decision making.

Fine (F): Fine regarding the delay in delivering the project**.**

b) The Accumulated Profit or Loss of the Company at the End of the Simulation

The Accumulated Profit or Loss of the Company at the End of the Simulation is the Balance Sheet result of the Company at the end of the simulation.

c) The Project Delay

The days of delay in delivering the Project.

d) The Volume of Assets

The volume of Assets represents the total current assets at the end of the simulation.

e) The Company Quality Index

The value of the Company Quality Index at the end of the simulation.

f) Board Members Pay

The board members pay means the total wages paid to the Board of Directors at the end of the simulation.

EXPECTED PERFORMANCE IN EACH PERFORMANCE CRITERION

The expected performance in each performance criterion is:

TABLE 5
Sets of Activities to be Simulated in Each Phase

Phase 1	Phase 2	Phase 3	Phase 4
A1 to A12	A13 to A22	A46 to A55	A56 to A67
A23 to A32	A33 to A35	A68 to A81	A82 to A89
A36 and A37	A38 to A45		

a) **Net Profit in the Project:** it is expected that teams generate more than 5% profit out of the total value of the project.
b) **Company Profit at the End of the Simulation:** it is expected that teams finish the simulation with profit in the Balance Sheet.
c) **Delay in the Project Delivery:** it is expected that teams deliver the project within the contractual time.
d) **Company Quality Index:** it is expected that teams finish the simulation with a positive Company Quality Index.
e) **Board Members Pay:** it is expected that teams finish the simulation with board members pay over 1% of the project cost.

GRADING TEAMS IN THE SIMULATION

The teams will be graded in the simulation according to the following criteria:

- **Fantastic:** reached the expected performance in all six criteria;
- **Excellent:** reached the expected performance in five out of six criteria;
- **Good:** reached the expected performance in four out of six criteria;
- **Regular:** reached the expected performance in three out of six criteria.
- **Poor:** reached the expected performance in two or less out of six criteria.

After grading participants in the simulation, a debriefing meeting will be held to provide participants with the opportunity to criticize their experience in the simulation and criticize the simulation itself.

CONCLUSION

The simulation model presented in this paper intends to teach undergraduate students how to manage a project under financial pressure. After taking over the company, teams have to bid for a government contract and execute the project on time. After the bidding, a bonus will be attributed to the winning team and then all teams will be contracted to build the project. The execution phase will be divided into five sets of activities. Each set of activities will be simulated to generate the actual time and cost of each activity. Between two sets of activities, teams will be requested to analyze results and make decisions as necessary. At the end, teams will be assessed according to six performance indicators.

The simulation is an introductory activity in project management trainning. It is not required that participants have expertise in project management beforehand, as the essential concepts will be introduced to them by the tutor. After taking part in the simulation, it is expected that participants understand the interrelated nature of managing a project and the importance of teamwork.

This is not a competitive exercise. Teams are not competing against each other in the simulation (except to win the bidding). Even loosing the bidding, all teams will execute the project and their performance criteria will only take into consideration factors inherent to their own project.

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TABLE 6
Simulating the Activities Actual Time

Act.	Prev.	TMin	TMax	Oc1	Oc2	OC3	OC4	Oc5	Oc6	Min.	Med.	Max.
A1	-	1	10	7	1	1	4	2	2	1	2	7
A2	-	2	20	8	21	18	4	13	13	4	12	21
A3	A1	2	15	11	12	16	11	4	4	4	9	16
A4	A1	3	20	20	15	19	6	18	11	6	14	20
A5	A2	2	15	11	10	14	7	3	11	3	9	14