Interactive Risk Management Approach: A Simulation Game "RIG"

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Oil and gas projects require extensive experience in project management in order to successfully fulfil project objectives. A number of computer-aided tools were developed and became effectively used in educating and training engineers on different aspects of the project management domain. However, none of these tools were developed specifically for the petroleum industry. Although this kind of projects incorporates high-risk standards requiring well-trained engineers on risk management. A computer simulation tool is developed in the form of a game for the purpose of training and enhancing engineers' capabilities in risk management. The tool named RIG (Risk-management Interactive Game). RIG simulates the construction phase for a petroleum development project involving the effect of the different risk factors on cost of the main project milestones. RIG was evaluated and the model was validated through: performing multiple replications and sensitivity analysis. RIG, additionally, was tested by less experienced engineers to validate its simplicity, comprehensiveness and applicability as an educational tool. Findings show that RIG can contribute risk management training as well as decision-making skills for petroleum projects. The model was successfully giving reasonable results reflecting reality.

Keywords: oil and gas projects, Risk management, simulations games, decision-making skills.

Introduction

Construction project is a multidisciplinary activity that encompasses: many parties with decisions' that will impact the project tasks to be done along with their related factors on either cost or time (Chan and Park 2005). Consequently, acceptable and professional management for the project from early stages is very critical and imperative for the success of the project. In large-scale projects, as well as complicated projects, project management is a vital mission, especially with projects that require highly technical approaches such as oil and gas projects. Furthermore, for such multi millions investment projects, a project manager should be acquainted with the latest technological managing and controlling tools and skills of the project budget.

In recent decades, project management and time management have not become as good as expected (Weaver 2010). For instance, - as indicated in Weaver 2010's research findings that was conducted in between December 2007 and January 2008 - most of the mega projects failed in the time management process especially in monitoring and controlling. Moreover, most of the construction companies, from the performed survey, are usually preparing schedule only for winning bids not to control and manage the project execution. In addition to that, it was noticed that in oil and gas industry, only 19% of the projects were completed within or ahead of the planned schedule. While about 74%of oil and gas projects were completed with a delay of about 3 months. Moreover, based on that survey, engineers need more training in project management, especially time management under uncertainty, either in undergraduate courses, post graduate or training hired engineers. Noticing that, time management in oil and gas projects has a major impact on the overall investments and the projects' budgets especially those related to production. It is worth mentioning that, training engineers needs to include on-site training which requires high safety precautions. Keeping in mind that it is difficult to acquire security permits for offshore petroleum sites.

Risk management has become a very necessary task and inevitable in almost all types of projects. Risk assessment should be implemented whenever there is a threat or anticipated hazard whatever the expected impact of that hazard would be (Aven 2011). Considering the nature of the petroleum development projects, risk assessment cannot be ignored as one of the project managers planning and monitoring vital task. The main reason for that is the risky nature of the petroleum development site and the equipment that is used either in construction or in operation. A Total Risk Assessment "TRA" can be performed in the planning phase of any project (Vinnem 2007). Then after the design is almost finished, the Quantitative Risk Assessment QRA and a Hazards and Operability study "HAZOP" can be performed. As well as a Safety and Operability study “SAFOB” that can be conducted by the Health and Safety teamwork.

In order to achieve a good quality risk assessment study, as shown in figure (1), a certain procedure has to be followed. First, Risk management planning through deciding how to approach, plan and execute the risk management activities for the project. Second, identifying possible risks associated with the project and their probabilities to materialize. Third, conducting risk qualitative analysis and prioritizing risks according to their severity. Then proceeding with quantitative analysis is by creating the models and analyzing the risk impact on the overall project objectives. Fourth, reducing threats through risk response planning is by deciding the proper control measures along with their impact. Finally, the decided control measures can be implemented, supervised and reviewed frequently along the project time through risk monitoring and controlling.

Classroom environment can be depicted as boring unless teachers utilize some innovative ideas and tools to promote enthusiastic learning (Mekkawi 2006) and (Nassar 2001) agree on that. Allery 2004 illustrated that innovative approaches in education have become more applied in practice. Simulation tools are one of these approaches although some researchers questioning their effectiveness in education (Al-Jibouri 2001). However, Al-Jibouri agrees with Sawhney that students learn more effectively when they can participate in the learning process as a self-learning process (Doloi 2008); “Learning by Doing” is a very common sentence in the education literature (Sawhney 2001, Allery 2004, Al-Jibouri 2001). Using computers in educating and training students the principles of project management started as early as 1960’s as a part of the learning process (Mekkawi 2006, Nassar 2001). Moreover, computer aided programs have become the newly innovative tools in educating and training engineers to cope with the real life problems.

Figure (1) Risk Management Procedure

Problem Statement

Risks in oil and gas projects require implementing successful risk assessment procedure. However, in real practice, it's usually limited to health, safety and environmental risks. Training engineers on risk management requires in class education and on-site training for real life experience. Moreover, on-site training is very difficult to perform especially for offshore projects that for its risky environment for less experienced engineers. Therefore, using educational tools for on-site training could be a better alternative. The available educational and training simulation tools are usually limited to certain activities inside the projects or certain construction projects. Furthermore, nearly none of the available tools discussed the construction phase of a petroleum development project.

Objective

The objective of this research is to: introduce the concept of risk management to different participants involved in the oil and gas industry; increase their awareness of the vital need for proper risk assessment, and provide them with an educational tool to enhance their capability for efficiently managing risks. A computer simulation tool was developed in the form of a game to train and enhance engineers' capabilities in risk management. The tool named RIG (Risk management Interactive Game). RIG simulates the construction phase in a petroleum development project. It includes the effect of different risk factors on cost of the main project milestones: procurement, fabrication and installation. This tool is targeting less experienced engineers working in the field of petroleum projects.

***Risk Engine behind RIG**:* as shown in figure (2); the risk procedure followed in the RIG tool started by number of meetings with experienced engineers in petroleum companies. At that point, building risk probability / impact matrix from the gathered data was initiated. After that, risk numerical analysis was applied. Finally, response measures and different decisions were gathered through other meetings.

Figure (2) Risk Engine behind RIG Tool

Literature review

Simulation games have been developed early in 1969 by Au (Au, et al. 1969). (Bilsen 2010, Agapiou 2009, Nassar 2001) all agree that simulation games can be useful in training and providing graduate students with the required management skills. However, (Nassar 2001) argues that simulation games cannot replace the formal class meetings for teaching theories and different methods. Additionally, a simulation to real life problems may ignore some variables that cannot be simulated. Human behaviour can be an example for that. The developed tools are either targeting a certain activity, a specific skill, or integrating both as a level of complexity. Some simulation tools integrated web based tools utilizing the available database on the Internet in an interactive learning system (Tserng 2008, Sawhney 2001). Some of the recent developed tools can be discussed in Table (1):

Simulation tool	Purpose	Required user level	Programming platform	Self training	Visual/ interactive	No. of users	Additional information
Easy plan (Hegazy 2006)	Project management basics & time/cost control	Undergraduate & graduate students	Excel-based model	Applicable	N/A	Single player	______
CAL tool (Mekkawi 2006)	Decision making during construction phase of excavation	Undergraduate students	C++	Applicable	Applicable	Single player	Helping tool and consultant
SimPort (Bilsen 2010)	Problem solving skills and team working in planning of construction activities for a port area	Graduate students	Not clarified in literature	Applicable	Applicable	Multi-player	Students can save their work and proceed later
SIMPLE (Agapiou 2009)	Team working and decision-making skills in contract management	Undergraduate students	Not clarified in literature	Applicable	Applicable	Multi-player	Help through library and saved documents
PMT (Davidovitch 2006)	Project planning, management basics and decision-making skills through history keeping.	Undergraduate students and project managers	Not clarified in literature	Applicable *	Applicable	Single player	case studies database & integrating commercial software
VCON (Yaoyuenyong 2005)	Negotiation skills in construction contracts	Graduate students	Not clarified in literature	N/A	Applicable	Multi-player	Online game and provide levels of difficulties
C3M (Nassar 2002)	The tradeoff between the bid price and market share in a competitive way	Undergraduate students	Not clarified in literature	N/A	Limited	Multi-player	______
PARADE (Han 2011)	Dynamics of the construction production systems	Undergraduate students	JAVA	N/A	N/A	Single player	Internet based, but requires instructor assistance
Interactive multimedia case study (Nassar and Al-Khatib 2002)	Legal concepts of construction law	Undergraduate students	Flash	Applicable	Applicable	Single player	______
Scheduling tutorial (Nassar 2001)	Planning, scheduling and control basics for construction projects	Undergraduate students	Flash	Applicable	Applicable	Single player	Internet based
CSRAM (Okmen and Oztas 2008)	Evaluation of a building schedule under uncertainty	Experienced engineers	Excel & @Risk	N/A	N/A	Single player	______

* Concluded from literature because of the database provided but not confim

Table (1) Recent Developed Tools

Model Development and Characteristics

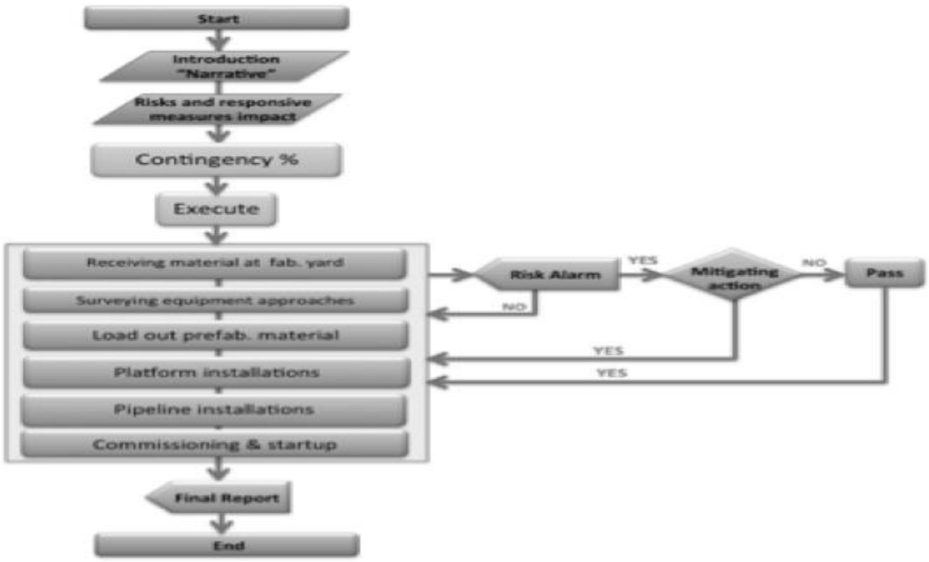

Figure (3) RIG Flowchart

For developing the tool as shown in RIG flowchart in figure (3), the first vital issue considered was identifying the factors affecting the project cost. From literature, many researchers were developing models to estimate the impact of different factors on project cost (Chan and Park 2005). These factors may include type of contract, type of project, required technology, project completion on time, staff levels needed, equipment availability, and many other factors that are related to cost directly or indirectly. Hence, the main factors considered in developing RIG tool were uncertainties impact, contingency value - assuming that it will include the mark up, and any management decisions to prevent or mitigate the uncertainties. The developed model RIG is a single player model. Additionally, it is a multi-try model, but "non-zero sum". The model is interactive and it has visual videos clarifies the construction activities. RIG is developed to be a self-learning tool. Therefore, a narrative part was added before starting the project execution explaining the purpose and the components of the project, and help tables providing the user with some useful information before and during the game. The tool is time scaled and the whole game can be over in about 15-20 minutes. The programming language used is the "Flash script". The shown flowchart in figure (2) will be explained in the RIG scenario.

Model Input Data and Scenario

The data gathered regarding the sample project and the possible threats through the historical database of a petroleum company. Additionally, number of meetings was performed with four experienced project managers with field experience of about fifteen to twenty years in two of the major petroleum companies in Egypt. A questionnaire form was filled out including the main activities and the possible risks in which the project managers were requested to determine the impact of the risks, prevention and mitigation actions. RIG starts with the narrative part telling users basic information to recognize the purpose of the tool, information about the project and conditions that may causes some risks. After that, the table of the associated risks is accessible to the user before he/she decides the "contingency" value. In that table the possible measures to prevent or mitigate those risks along with their impact on both cost and schedule of the sample project are clarified. Noticing that, only in RIG, the contingency should include the profit margin and cover uncertainties since the owner does not want the project cost to exceed the planned budget under any circumstances. Subsequently, the user identifies a list of preventative actions that could neutralize one or more risk factors. Noticing that, each preventative action is associated with a certain cost that is deducted from the contingency amount decided earlier. Just then, the project execution phase can be started and the random occurrence of risks is on-going. The number of the risks appear to the user during RIG operating can be controlled by the instructor from an exterior file by changing one number. The exterior file contains the probability value "p" of which the random choice of the risks will start from. For example: for p is 60, then the random choice will start to choose risks that has probability of occurrence equals to 60 or more.

The project execution phase starts and time is stepped. During the execution, illustrative movies are played for the user to scrutinize the offshore installations. And the original link of these movies can be seen for all of them for the user if he/she would like to check out the source. Additionally, explanation text appears in the right side of the screen could help the user to get some information about the steps shown in the movies. Noticing that, the text are in separate files and editable for the instructor to add more information if needed. Some of the possible risk factors appear to the user randomly from the risk factors list. When a risk happened the movie is paused and the user has to decide either to choose a mitigating action that could minimize the risk impact or pass to bear the full impact.

Finally, the final report appears at the end of the game in two forms. The first report summarizes the main data of the project's duration, base cost and the base contingency, the final contingency and final duration. In addition to that, the net value of variation NETVAR (Chan 2001) is calculated, which is the difference between the final contingency and the base contingency. NETVAR is used in RIG to only measure the contingency variation since the user performance is evaluated mainly through his/her decisions. The reason of using the NETVAR from the Key Performance Indicators KPI is that the user can sense the impact of his/her decisions. The second results screen is the full detailed results of the cash-time behaviour. That screen is showing the different variables of the game such as the number of preventive actions decided and paid interest rate number of times. In addition to that, the number of mitigating actions and pass actions decided for risks occurred during the game are in the final report. The cash flow and contingency along the project duration are also included in the final report. From the final results screen, the instructor can evaluate and analyze the performance of each user and compare users' decisions. The full results data can be copied and analyzed by using Microsoft Excel spread sheet.

Decisions that the user has to consider are:

1. Assign a contingency amount that will be fixed throughout the game (could be more or less than the sum of the costs of the preventative actions);
2. Select from the preventative actions which risks to prevent. Knowing that, each preventative action has a certain cost deducted from the contingency.
3. After the game starts, mitigating measures have to be considered to manage risks occurred.

Noticing that, the user's decisions can't be undone simulating real life decisions.

An example of Risk Mitigation measure:

The owner may not be able to pay the invoice in time as agreed, thus the user is allowed to take a loan from the bank with an interest rate of (8%). The interest rate is deducted from the contingency similar to all the mitigating actions. Then, the user can pay back the loan as soon as the owner pays the invoice. Noticing that, timing is essence for number of repetitions of this risk and number of times that the interest rate will be deducted from the contingency amount.

Evaluation and Analysis

1. *Simulation analysis*

A 500 random replications of the RIG tool were mainly aiming at two main streams: the first one is to validate the tool and examine the used equations in the model, the second is to compare the users' decisions and the results are shown in figure (3).

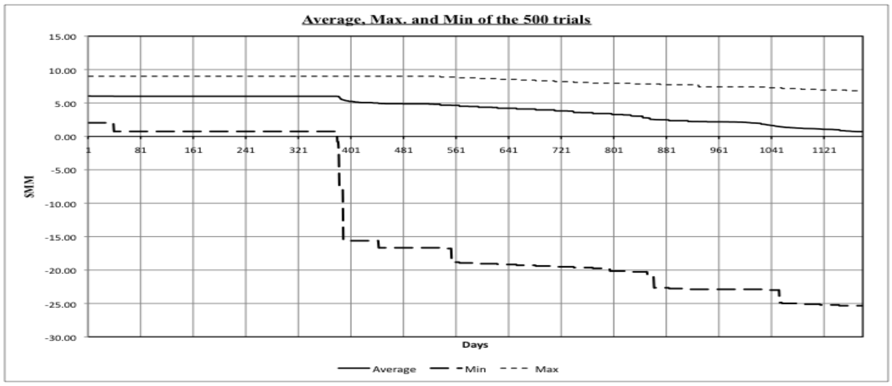

Figure (4) Average, Max, and Min of the 500 simulation results

Figure (4) is showing the average of the 500 trial's results along the game with random risks occurrences and random decisions. Noticing that, some of the trials presume profits and others losses. On the same curve, the average of the maximum and the average of the minimum results are plotted too in order to get the whole area of the possible decisions. Noticing that, the average of the minimum curve shows losses as in sudden points, not always gradually, because of the cash flow risk where the owner fails to pay the invoice to the project manager in addition to the occurrence of other random risk factors. Although the cash flow risk timing should be uncertain, it seems that from the results, in most of the trials this risk happened at the first invoice, and in a few number of the results it occur again. Infrequently, this risk never happened at all.

2. Sensitivity analysis

First, 500 runs was performed for contingency values from 0.03 to 0.15 to get the final profit; the increment is 0.01. For every (50 runs) the contingency is constant and no prevention or mitigating actions. However, the risks occur randomly as programmed. The findings of the sensitivity analysis for the contingency variable were as follows:

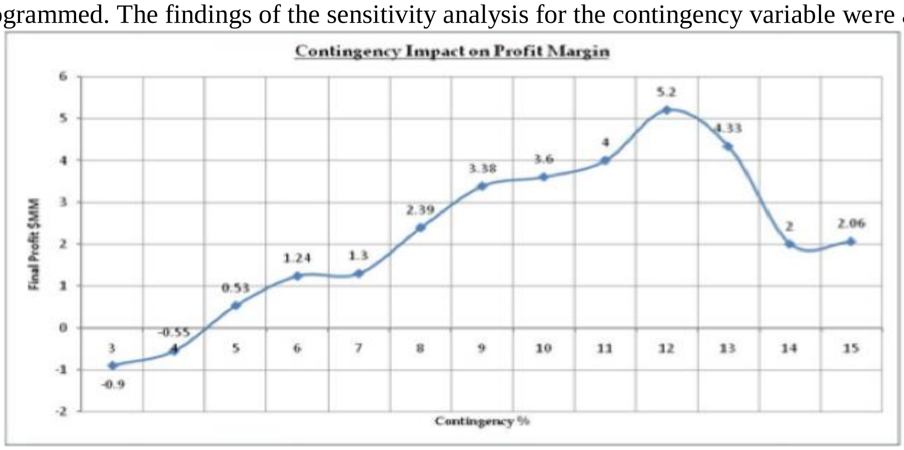

Figure (5) Contingency impact on profit

From Figure (5) it can be concluded that:

- The higher contingency percentage, the higher profit value, but to a certain limit. The meaning of that is assigning extra money by the user to account for risks is not a smart way of thinking.
- Risks occurred randomly as the model is programmed, therefore, ensuring higher profits and/or minimize losses require risk identification prior to determining the contingency percentage.
- From the results, the higher profit was successfully met at contingency value of 12%, but for higher contingency percentages profits decreases noticeably.

The previous results lead to perform a sensitivity analysis for the impact of prevention action on profit margin. The analysis was performed by choosing to prevent risks from 1 to 13 and run the RIG tool for about 500 times to get the final profit. In the 500 iterations the contingency is constant and equal to 15%. The risks occur randomly as programmed, as shown in figure (6).

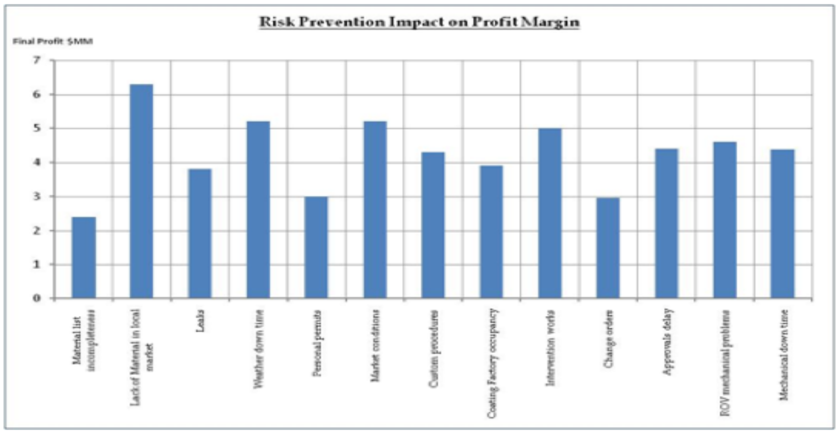

Figure (6) Risk prevention impact on profit margin

From Figure (6) it can be concluded that:

- The highest profit was achieved when preventing the risk called "lack of material in local market". That would leads to the conclusion that this is the most probable risk and requires a responsive measure.
- Preventing risks in general is securing profit margin ranging in between two and six million USD in respect to the model data. Therefore, risk prevention would be beneficial and could secure enough profits at the end of the project.
- Although it may not be able to be concluded from the chart, but choosing not to prevent any of the given risks does not necessarily generating losses since risk occurrence is not a must; however, this may not be a good choice.

3. Experts validation

A number of graduate engineers were chosen to evaluate the RIG tool. This number represents about 5% of the total number of engineers working in a petroleum company. The evaluation performed during a training session. Engineers who evaluated the RIG tool have got two to five years of field experience. The final results were gathered and plotted on the 500-simulation figure (4) for analysis as shown in figure (7). Then, a questionnaire was filled out by them after testing the RIG along with a quick discussion among them regarding the effectiveness of the tool and some suggestions for improvements.

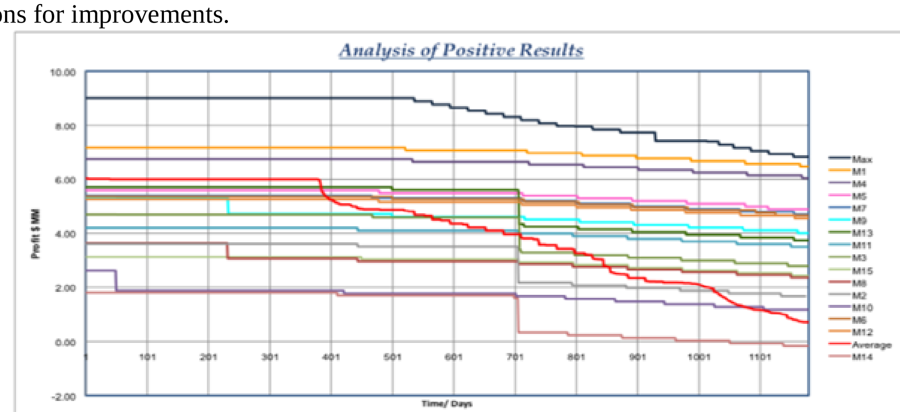

Figure (7) Analysis of Experts results

As shown in figure (6) most of the engineers' results were seem to start with values less than the average, but only one of them completed the game with losses. Although they have some background on risk management, only a few of them ended the project in time.

The questionnaire results were encouraging since almost all the users agreed that the RIG tool reflects real risk problems. About 20% were neutral when they answered the question if RIG provides enjoyment. and 40% of the users found the RIG a successful tool that could have a contribution in training on and/or learning about risk management. Additionally, 85% were satisfied and agree that RIG promotes self-learning.

Conclusion

The developed RIG tool has succeeded to introduce a new model in risk management as well as a new methodology in training less experienced engineers. Furthermore, RIG contributes in providing users by the basics in managing uncertainties in the construction phase for petroleum projects. Providing a safe environment for on-site training is one of the achieved objectives of the RIG tool for a petroleum project, which is hazardous by its nature. The decision making while experiencing reality since no decision can be undone was the overwhelming idea for the users at first. Users were adapting and enjoying using the RIG and found it very simple with no complicated tasks.

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