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A SIMULATION OF RISK MANAGEMENT IN INFORMATION SYSTEM PROJECTS FOR INDUSTRIAL ENGINEERING POSTGRADUATES

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ABSTRACT: Risks management is an essential element which can help increasing success rate in engineering projects. Undeniably, efficient implementation of this process requires not only knowledge but also real experience in the project context. In information system projects, which are widely known for its challenging and unique nature, the importance of risk management increase substantially. It is significant that all stakeholders, either at technical, management or other levels, need to realize the potentials of major risks. This research reports a result from an implementation of a simulation on risk management in information system projects based on a simulation called ARMI: A Risk Management Incorporation for industrial engineering postgraduate students. The results show that the simulation can be effectively implemented for participants with non-technical background.

Keywords: Information system development, Risk management, Simulation, Case study

1. INTRODUCTION

Information system is arguably one of the most important foundation of modern business. An efficient information system can provide a sharp competitive edge for organizations [1], [2]. However, interestingly, it has been reported that the success rate of information system development is rather unsatisfactory. The report by Standish Group shows that the overall success rate of software projects was only 19% in 2015 which is inferior to the years before [3], [4]. The numbers reveals that, although with current technologies, approaches, attempts and advanced development processes, this mediocre rate of success shows no significant improvement.

It is obvious that risks, although usually undesired, inhibit in most engineering projects [5]. Different type of projects involve in different types and effects of risks [6]. Management of risks in an unfamiliar project context could be more than challenging. Such difficulties could escalate in projects which is highly intangible such as information system projects [7]. Indeed, increase in knowledge towards the project nature could help increasing the chance of success [8]. Additionally, since these projects usually involve a number of stakeholders, e.g. executives, managers, consultants, users, engineers, sponsors and vendors, it is important that all of them realize the potential risks so they can contribute their efforts towards appropriate mitigation strategies [9].

ARMI: A Risk Management Incorporation is a simulation based on risk management and information system development processes [10]. Originally, it was developed as a tool for teaching risk management in project management course for undergraduate computer engineering student. The results of past simulations show that this simulation can help moderating the participants' perception towards risks. After completing the activity, the participants learn the process of risk management, information system development as well as potential risks and impact on the project.

This research implements ARMI in a different domain. Instead of computer engineers, industrial engineering students are the participants on this research. Thus, the results from this research is likely to reflect the viewpoints from the management side in an information system project than the usual technical counterpart. Statistical analyses reveal several interesting findings which are later discussed in this paper.

The second section of this paper reviews ARMI, the main simulation, and its past implementation. Then, the research methodology and background of the participants are described in section three. The fourth section discusses the results and findings. Finally, the fifth section concludes this paper.

2. INFORMATION SYSTEM DEVELOPMENT AND ASSOCIATED RISKS

The development of an information system is challenging. Reports reveal that their success rate is far from acceptable [3], [4]. Indeed, unlike other forms of engineering project, the development of information systems heavily relies on several intangible components, especially software [11]. This leads to unique risks and mitigation strategies. To improve the survival rate of the project, it is critical that all stakeholders need to realize the importance and nature of these challenges.

The phases of information system development are indifferent from general engineering projects. It involves collecting of requirements, translate the requirements into design, develop the system from the design and finally test for the product's quality [12]. Typical information systems consists of three major components, e.g. hardware, software and networking [13]. Indeed, the most mysterious part of the system is the software. Due to its intangibility, tracking progress of software can be complicated [14]. Moreover, although the hardware and networking seems be mainly related on physical equipment, they inevitably involve abstract processes such as configuration. This, too, could also lead to major drawbacks in the projects.

Both researchers and practitioners have been proposing major risks in information system development [6], [15]–[17]. From the technical point of view, continuously expanding of requirements or "Scope creep" has been perceived as the more, if not the most, important risk [18]. This is because many stakeholders do not realize that even minor changes can cause major impact to the structure of the information systems, which could further lead to other problems such as defects, delay and inefficiency of the products. This problem is not likely to happen often in other engineering scenarios which almost every critical elements can be physically seen.

Inexperienced staff is another risk which highlight the uniqueness of information system development [19]. When developing an information system, every attempt which translates the inputs to the output in each phase is design. Requirement engineering, system analysis and designing, coding and testing all involve design of certain products. As such, unskilled labors are mostly irrelevant in information system project. Positioning staffs with inappropriate experiences could also cause damage to the project.

As aforementioned, realizing of potential risks could greatly moderate the perspectives of stakeholders in information system projects. A simulation could be an effective tool to bridge the gap between these perceptions. This not only improve the success but also the efficiency of the entire development.

3. ARMI: A RISK MANAGEMENT INCORPORATION

ARMI is developed to serve as an activity which coaches computer engineering students on risk management of software project [10]. All six phases of risk management, i.e. identification, analysis, planning, tracking, control and learning, are represented and repeated. On the technical side, ARMI simulates an entire cycle of an information system development project. This development cycle follows the classic Waterfall Model for its simplicity. As a result, the stages of system development defined in this simulation involve requirement, design, implementation, testing, and maintenance. ARMI is designed to be ideally played by three teams of participants. Each team consists of 2-8 persons. An equal amount of risk management fund is distributed amongst them. The team which completes the simulation with the most remaining fund wins.

ARMI follows each stage of system development in sequence. This results in 5 turns of simulation. In each turn, the participants brainstorm and identify potential risks which may surface during that development stage from a list of 25 risks which are recognized as top threats in information system development project. The followings designate potential risks which could be materialized in ARMI:

- Inexperienced staff
- Delay of schedule
- Lacks of executive involvement
- Lacks of user involvement
- Lacks of user IT skills
- Scope creep
- Inadequate development facilities
- Inadequate staffing
- Staff turnover
- Inefficient management
- Missing of payment from clients
- Unable to fulfill customer's objectives
- Cost escalation
- Low software performance
- High number of defects
- User resistance

- Incompatibility to the legacy system
- Unable to integrate modules
- Increased number of users
- Inappropriate system design
- Inaccurate requirement analysis
- Conflicts between internal staffs
- Conflicts between stakeholders
- Low stability of new technology
- Lack of external communication

The participants are expected to analyze for potential impacts and probabilities of occurrence of the identified risks. In order to save the valuable resources, less important and irrelevant risks are expected to be ignored. Expert's opinions are given as a guideline to assist them in this process. They are notified that the expert's opinions could be wrong and misleading sometimes. After that, the teams prioritize the risks and choose the most appropriate mitigation strategies for each of them. There are four mitigation strategies to be chosen in ARMI. Firstly, Method A, this strategy costs most but can prevent any upcoming penalty if the risk actually surfaced. Secondly, Method B, this strategy costs less but can mitigate only 50% of the consequence. For instance, if the team choose this practice and the related risk is materialized, they are required to pay half of the damage caused by this risk. Thirdly, Method C costs even less but only cover 20% of the penalty. Finally, the teams can also choose to not pay for any protections and suffer the full impact of the risks.

After the mitigation bill is concluded, a representative from each team draws a number which indicates the number of materialized risks. Then, the representatives draw risk cards from the deck of risk. Although this seems random, the number of risks in the deck is actually controlled. Subsequently, the moderator announce the materialization of the risks. At this phase, the team can argue if they feel that certain risk is not relevant to that development stage. If they win the argument, the risk is considered void so they do not need to pay for penalties. Otherwise, the teams then pay for each impacts of the risks which they fail to mitigate. The participants learn the risk management process and nature of risk in information system development along with the repetition of these activities in each turn.

A pretest and a posttest revealed noticeable changes of the participants' risk pre- and post-analyses. Their perceptions towards risks seemed to be moderated by the ratio of risks in the deck. This suggests that ARMI may influence the players' risk perceptions therefore it could be an effective tool to help shaping stakeholders' perception towards risks in information system development projects.

4. RESEARCH METHODOLOGY

This research attempts to study the effectiveness of ARMI when being applied to less-technical groups of stakeholders. Seventeen postgraduate students on a master degree on logistics and supply chain management participated in the experiment, using the standard rules. Only one of them had some real experience in information system development, as a web developer. Others know about technologies and general knowledge on information systems but not from the development perspective. Prior to the simulation, the students were asked to anonymously rate each risk, on a scale of 1 to 5, for their overall probabilities and impacts on information system development project. Their perceived risk exposures were recorded and ranked. After the simulation, the students were asked to retake the survey. Some additional questions on their opinion towards the simulation was also inquired. Then, the results were comparatively analyzed and interpreted.

5. RESULTS AND DISCUSSION

Table 1 and Fig. 1 summarize risk exposures of the selected risks from the pre and post survey as well as their ranks.

Table 1 Risk exposures (RE) and rank (#) of the selected risks from the pre and post survey

Risk	Pretest		Posttest	
	RE	#	RE	#
Scope creep	15.1	1	23.1	1
Delay of schedule	14.5	2	21.4	2
Cost escalation	13.2	4	20.3	3
Lack of ex. commun.	13.3	3	17.2	4
Conflict b/w staffs	10.8	20	15.9	5
High number of defects	12.9	6	15.8	6
Low stability of tech.	11.9	11	14.8	7
Missing of payment	13.1	5	14.7	8
Conflict b/w stakehold.	11.9	12	14.7	9
Inaccurate req. analysis	11.2	16	14.7	10
Staff turnover	9.2	24	14.4	11
Inappropriate design	12.6	9	14.2	12
Inexperienced staff	11.8	13	14.1	13
Lacks of user involve.	12.8	7	13.8	14
Incompat. to the legacy	11.5	14	13.8	15
Unable to fulfill obj.	10.9	17	13.6	16
Unable to integrate	11.5	15	13.5	17
Inefficient management	12.8	8	13.3	18
Low soft. performance	10.8	19	13.2	19
Inadequate facilities	10.5	21	13.2	20
Lacks of exec. Involve.	10.4	22	12.6	21
Lacks of user IT skills	12.3	10	11.9	22
User resistance	10.9	18	11.1	23
Inadequate staffing	9.7	23	10.6	24
Increased users	8.4	25	8.6	25

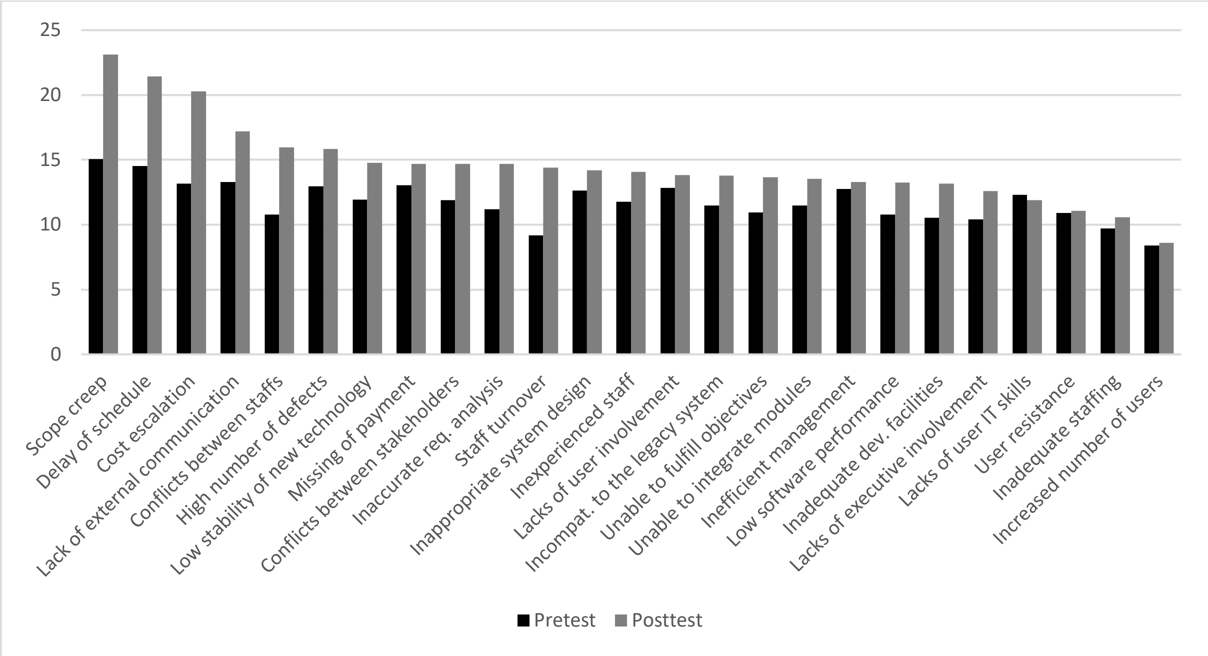

Fig.1 Risk exposures of the selected risks from the pre and post survey

It can be seen from Table 1 that, although the order of the top four perceived risks remains almost the same, several changes can be found in the lower ranked risks. Some of these changes are significant. Few notable mentions include the plunge in ranking of incompatibility to the legacy system (from 7th to 14th), user resistance (from 8th to 18th) and lacks of executive involvement (from 10th to 22nd). On the other hand, sharp rises in rankings are found in missing of payment from clients (from 20th to 5th), lacks of user involvement (from 11th to 7th) and lacks of user IT skills (from 16th to 10th). As previously denoted, all of these changes reflects the materialized risks during the simulation. Since the risks were randomly drawn during the simulation, some of them unexpectedly materialized while other of them did not. Likewise, some of them had more impact than the participants' anticipation while other of them did not cause much problems to the project. As a result, the more often the risk occurs, the higher scores they earn at the posttest. Among these, the missing of payment from clients is exceptional. Although it only occurred once during the entire simulation, this risk brought the highest loss on the project. One of the team almost went bankrupt from this single risk because they failed to mitigate. This scenario alone proves that the simulation can effectively moderate the perception of the participants. Further customization to specific environment can help bridging the perception of the project stakeholders.

Another major difference between the pretest and posttest is the degree of risk exposures. Figure 1 reveals that the exposures of most risks are significantly higher in the posttest. This suggests that the participants become more aware on each risk than before the simulation. Certain risks which were frequently materialized in the workshop, such as scope creep, delay of schedule and cost escalation, become major concerns for the students.

Table 2 further investigates the differences between pretest and posttest's perceptions. One-way ANOVA is used to compare the means of each risk exposure. Five significances are found between the means of pretest and posttest's risk exposures. This further fortifies that although the ranks of the top risks remain approximately the same after the simulation, participants became much more concern with them. At a p level of 0.05, it can be seen that means of scope creep, delay of schedule, cost escalation, conflicts between internal staffs and staff turnover between the pretest and the posttest are significant. This is a direct result from the quantity of risk cards drawn during the simulation.

Anonymous feedbacks from the participants suggested several benefits from the simulation. The players indicated that the simulation is not only educating but also stimulating. They found that the activities encourage communication, team working and exchanging of ideas. However, the participants criticized that although the probabilities of the risks are partly controlled, the materialized item could still be too random. They also suggested that an introducing of some beneficial risks could even improve the depth and strategic facet of the simulation.

Table 2 Comparison on perceptions toward risks from pre and post survey

Posttest Rank	Pretest Rank	Risks	F	Sig.
1 (-)	1	Scope creep	25.428	.000*
2 (-)	2	Delay of schedule	12.553	.001*
3 (↑)	4	Lack of external communication	3.405	.074
4 (↓)	3	Cost escalation	14.354	.001*
5 (↑)	20	Missing of payment from clients	.605	.443
6 (-)	6	High number of defects	1.682	.204
7 (↑)	11	Lacks of user involvement	.209	.650
8 (↓)	5	Inefficient management	.073	.789
9 (↑)	12	Inappropriate system design	.411	.526
10 (↑)	16	Lacks of user IT skills	.050	.824
11 (↑)	24	Low stability of new technology	2.130	.154
12 (↓)	9	Conflicts between stakeholders	1.617	.213
13 (-)	13	Inexperienced staff	2.169	.151
14 (↓)	7	Incompatibility to the legacy system	1.277	.267
15 (↓)	14	Unable to integrate modules	.937	.340
16 (↑)	17	Inaccurate requirement analysis	3.355	.076
17 (↓)	15	Unable to fulfill customer's objectives	2.450	.127
18 (↓)	8	User resistance	.008	.927
19 (-)	19	Low software performance	1.512	.228
20 (↑)	21	Conflicts between internal staffs	6.382	.017*
21 (↑)	22	Inadequate development facilities	2.272	.142
22 (↓)	10	Lacks of executive involvement	1.032	.317
23 (↓)	18	Inadequate staffing	.348	.559
24 (↓)	23	Staff turnover	7.003	.013*
25 (-)	25	Increased number of users	.010	.922

Note :* = Statistically significant at p=0.05, (-) = Unchanged in ranking, (↑) = Increased in ranking, (↓) = Decreased in ranking

When being asked whether they gain new knowledge on information system development from the simulation, the participants denoted that they gain insights on the phases of development, importance and impact of risks, and importance of communication. They also admitted that some of the critical risks were previously unforeseen and they realized that such risks can occur in every phase of the project.

The participants further stated that in the view of risk management, they learned the importance of each activity. Moreover, they acknowledged that appropriate management of risk could yield more benefits and losses. In addition, they realized that "learning" is the most important phase in risk management.

6. CONCLUSION

One major challenge of information system development is the gap between technical and management stakeholders. This is due to different perspectives and lack of knowledge on the nature of the project. Bridging this gap could be an efficient strategy to increase the success rate.

This research attempts to implement a risk management simulation which was originally for technical staff on the management counterpart. This includes seventeen postgraduate students on logistics and supply chain management from Chiang Mai University, Thailand. Most of them have little to none experience on actual software development. The results are analyzed from their pretest, posttest risk analysis as well as an anonymous questionnaire at the end of the session.

Statistical analyses reveal several interesting findings from the simulation. Firstly, the risk exposures from the posttest are generally higher than those from the pretest. This indicates the growing caution on the participants' perceptions. Some of these changes are statistically significant. Further analysis reveals that there are many changes in ranking of the risks between the pretest and posttest. This reflects the effectiveness of the controlled elements in the simulation.

The participants denote in the questionnaire that they experience several key learning points from the simulation. This includes the nature of information system development, its risks, as well as the importance of each risk management processes.

These results suggest that implementing the simulation could be a strategic step to bridge the gap between stakeholders and thus lead to improving rate of success in information system development projects.

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