CONSTRUCTION RISK MANAGEMENT: APPLICATION AND EDUCATION

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Abstract

Construction risk management emphasizes the application of risk management in the construction industry, focusing on large scale and innovative projects. The application of risk management in construction projects is still less than its true value. The present study compares the level of the needs of the construction industry and the current level of acquired risk management knowledge and skills. The study demonstrates the response of many industrial foundations in Kuwait that contribute to construction projects, focusing on infrastructure projects. The responses were used to deduce the major elements required to implement construction risk management in the market. Moreover, the current levels of knowledge and skills of those elements were assessed, also based on the collected data. The requirements to narrow the gap between needs and actual education level are discussed. Finally, factor analysis methodology was used to categorize and evaluate the parameters that affect the implementation of risk management in the construction industry in Kuwait.

Key words: Construction, risk, education, management, Kuwait

1. Introduction

Construction management education has been of interest for more than forty years. Most university civil engineering departments offer fundamental construction management courses for undergraduate students. Some departments offer specialized courses, such as contracts, specifications, equipment, scheduling, and/or computer applications. Meanwhile, the subject of construction risk management has received little attention in undergraduate curricula. On the other hand, more universities offer graduate courses that focus on risk management in the construction industry [1-7].

Risk management is a complicated process that interrelates with many other processes in the construction industry and on construction projects [8-11]. Investigating project risks includes studying potential events that may affect the scope, cost, time, or performance of the project's objectives. Investigating potential risks requires the collaboration of all disciplines contributing to the project. Technical, managerial, financial, and administrative departments of the participating firms need to cooperate to identify and respond to expected risk events. This integrative process needs practical experience to adapt the required environment [12-14]. This is the main reason for the reduced risk management content taught to undergraduate students.

The target of the present study is to compare the current level of knowledge and skills with that required to implement risk management in the construction industry based on the opinions of construction practitioners in Kuwait. The study considered the following steps:

- identifying the knowledge required to conduct the process of risk management in the construction industry and on construction projects;
- assessing levels of awareness and implementation of risk management;

- assessing the level of risk management knowledge required to improve its implementation;
- comparing the required knowledge to the current status of implementing risk management (comparing the previous two items); and
- determining the major parameters that contribute to progress in implementing risk management in construction projects and the construction industry.

2. Method of study

A simple model is proposed for the parameters required to implement the risk management process. The model was prepared based on preliminary discussions with construction practitioners and academics. A questionnaire was developed based on preliminary discussions and the proposed model. Participants with more than 15 years of experience in construction projects and currently working on mega projects were selected to ensure a good understanding of risk management requirements. The items of the model were discussed with 52 participants to clarify any misunderstandings regarding the issues under investigation. The sample included 32 participants from the government and 20 from the private sector.

The questionnaire included two categories of questions:

1. The current level of awareness and implementation of risk management concepts and tools in construction projects; and
2. The target level of awareness and implementation.

The questions included evaluations of the required level of knowledge and skills for junior engineers with up to five years of experience and senior engineers with more than five years of experience for each of the previous two categories. The levels found for junior engineers show a trend that satisfaction is strongly related to undergraduate education level. On the other hand, senior engineers' satisfaction with implementation is strongly correlated to postgraduate education, training programs, and interactive experience.

3. Risk management processes

The risk management requirements model presented in Figure (1) illustrates the main requirements to implement the process of risk management. The risk management process is divided into four subprocesses, which are identification, analysis, response, and review.

3.1. Risk planning and identification

Identification of potential risks is usually the first practical process and the most crucial one in the risk management process. The risk identification process usually is a part of the project plan and is based on the collection of institutional policies and regulations that place many constraints on the process of risk management, such as budget contingencies, time delay thresholds, human resources rules of hiring and firing, rewards and penalties, performance control limits, reporting systems, and procurement policies.

A risk management environment is subject to the support of higher authorities in the project, the organization, and the construction industry. The support of governmental, educational, and industrial institutions helps to improve the awareness of risk management. This awareness leads to a better collaborative environment that improves risk planning and the identification process.

Risk identification depends on many other parameters, such as project management knowledge and skills, and technical, finance, accounting, economics, and legal capacities.

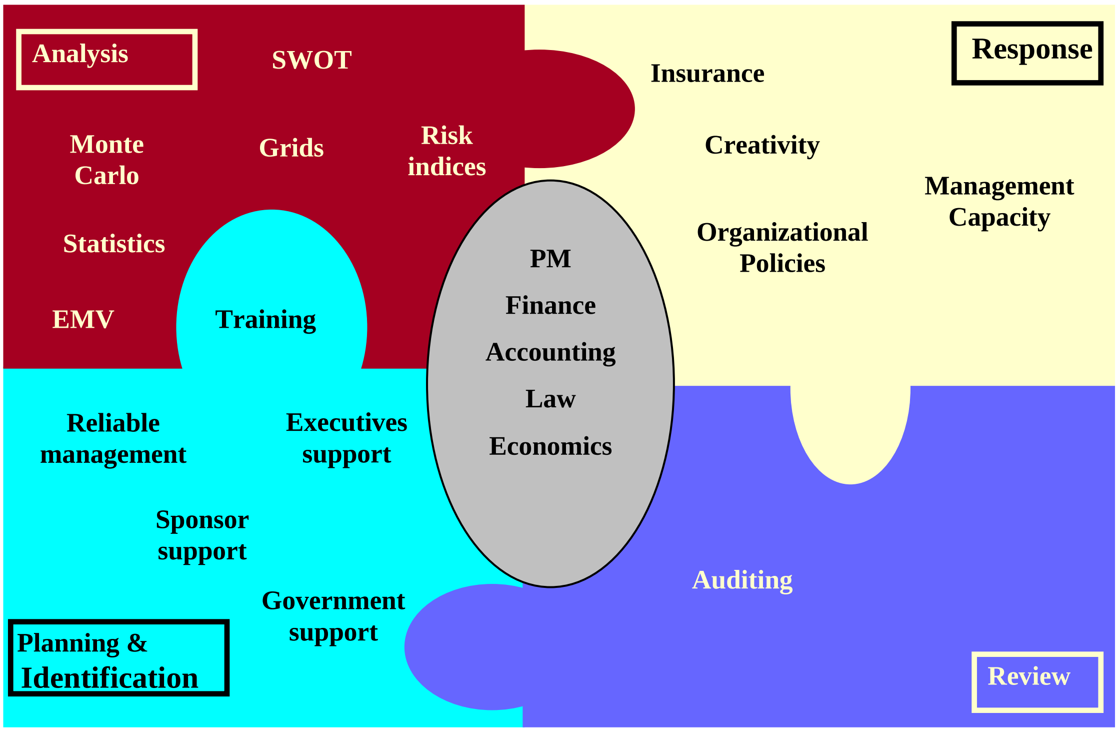

Figure 1. Risk management requirements

3.2. Risk Analysis

Risk analysis usually includes qualitative and quantitative analyses. Qualitative analysis is concerned with determining the prioritization of the expected risk events based on the anticipated possibility and impact of each. Quantitative analysis is concerned with numerical determination of the consequences of these risk events.

Many tools may be used in the qualitative and quantitative analysis, such as SWOT analyses (strengths, weaknesses, opportunities, threats), risk indices, grid analyses, Monte Carlo simulations, EMV analyses (expected monetary value), and statistical calculations.

3.3. Risk Response

The risk response process includes planning for the required action to be considered in case a risk event occurs. It also includes taking planned action if required and following up with the consequences of these actions to ensure that a risk plan results in the required outcome. Risk response is determined by proposing several alternatives to eliminate or mitigate an expected risk and assigning the optimum alternative as a response. Most risk responses are based on contractual agreements, insurance, and managerial solutions.

3.4. Reviews

Reviewing the risk plan is a continuous process that starts with initial planning and continues into identification, analysis, and response processes. However, the review of the overall risk management lifecycle is fundamental to the subsequent step of whether to change the risk plan or to plan for another risk event in the same or different project. Auditing is the usual form of review at the end of the risk management lifecycle, while other forms like checklists could be used at particular times during the process.

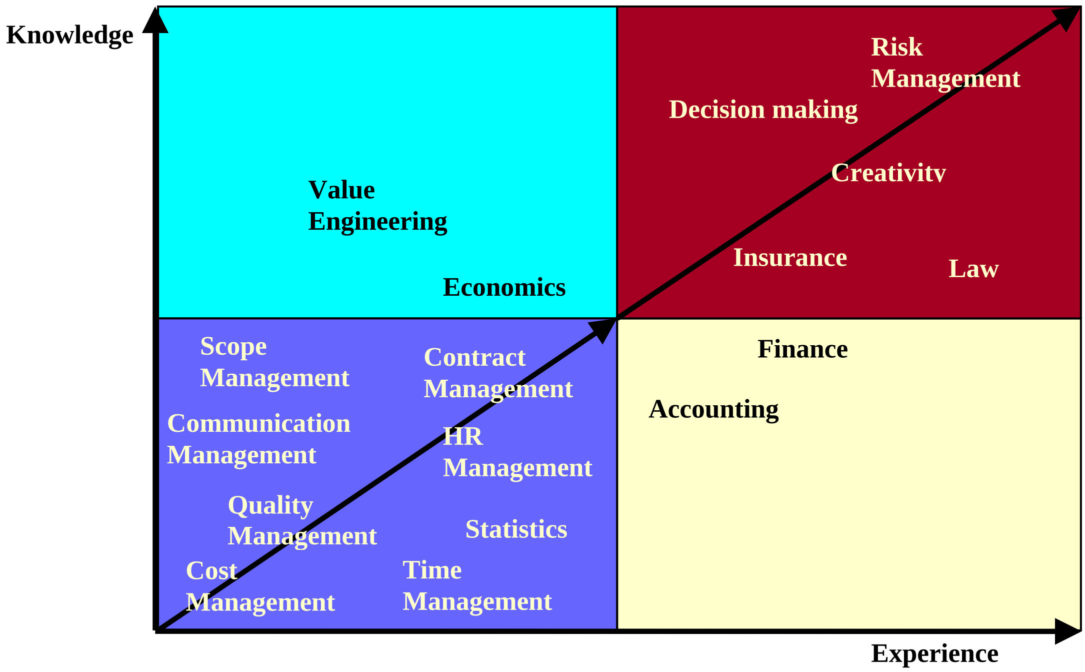

Figure 2. Risk management body of knowledge

4. Risk management body of knowledge

A construction project risk management body of knowledge integrates with that of the management of other projects. Figure (2) shows schematically the constituents of a body of knowledge. These items are distributed in the figure according to proposed requirements of knowledge and experience. The proposed distribution is configured specifically for construction engineers. These constituents can be rearranged with respect to level of education as follows:

4.1. Undergraduate level

a. Time management
b. Cost management
c. Quality management
d. Scope management
e. Statistics

4.2. Postgraduate level (including professional training and practice)

a. Human resources management
b. Communication management
c. Contract management
d. Finance
e. Accounting
f. Law

g. Economics
h. Value engineering.

5. Results and analysis

The data collected from the questionnaire was analyzed using statistical descriptive analysis to compare the results for each parameter and then analyzed using the factor analysis method to facilitate categorization of the considered parameters.

Statistical descriptive analysis

The data collected considered the requirements for risk management in terms of level of education and skill required for application. The questionnaire developed included three categories for each item as follows (Table 1):

a. The current implementation level, which represents the awareness level of the specified item;
b. The required level for a junior engineer involved in risk management, which represents the education and skills of freshly graduated engineers; and
c. The required level for a senior engineer involved in risk management, which represents the education, knowledge, and skills of engineers with more than five years of experience in the construction field.

Each item was evaluated using a scale from one (lowest level) to five (highest level). The number of choices from the participating 52 practitioners was multiplied by the chosen rank (from one to five) and the sum divided by 10. The calculation process could be presented in the mathematical form as follows:

$$WS = \frac{1*n_1 + 2*n_2 + 3*n_3 + 4*n_4 + 5*n_5}{10} \tag{1}$$

where WS is the weighed sum for the specified item and n_i is number of participants who voted (i) for this item. The results of these calculations are presented in Figures (3)–(6) in the form of a comparison among the weighed sums for the item's implementation level, required level for junior engineers, and required level for senior engineers. The data collected were categorized in the following four categories.

5.1.1. Risk management awareness

The first part of the collected data considered the general awareness of construction management and construction risk management specifically. The results, shown in Figure (3), indicate that the current level of knowledge is reasonable with respect to junior engineers. The allocated required level for freshly graduated engineers is less than the general current implementation level. On the other hand, the required level of senior engineers is higher than the implementation level. All categories show the same trend for the senior engineers, especially when it comes to strategic risk management, program risk management, and project risk management.

5.1.2. Risk analysis tools

Qualitative and quantitative risk analyses include many parameters that could be utilized. The items shown in Table (1) and Figure (4) were chosen because they are common tools in construction project risk management. Figure (4) shows the gap between the actual practice in using these tools and the required level of education and skills for the tools considered. Practitioners pointed out that CPM is the most necessary tool to be utilized in construction projects. Statistical calculations and EMV follow CPM in implementation importance. Figure (4) also shows that the difference between the required level of knowledge for junior engineers and the required level of knowledge for senior engineers is marginal. This slight difference could be attributed to the fact that the participants in the study were senior engineers and they considered that these technical processes are usually carried out by junior engineers while the seniors only review the processes. The other tools considered in the study (decision trees, grids, risk indices, and Monte Carlo simulation) received slightly less interest from the participating practitioners. The results in this category demonstrate the need to improve the level of the application of risk analysis tools in undergraduate courses and the corresponding practical training during study or during the early periods of junior engineers' construction careers.

	Implementation	Junior need	Seniors need
Construction management awareness			
CM experience	18.6	12.6	24.5
RM experience	15.3	9.2	18.9
Strategic Risk management	10.9	6.7	19.7
Program Risk Management	11.2	8.6	19.0
Project Risk management	13.3	12.6	20.3
Risk analysis tools			
EMV	10.4	17.6	19.3
Statistical sums	12.0	17.9	21.6
Monte Carlo	8.8	14.8	13.9
Decision Trees	9.6	16.2	17.3
Risk indices	9.1	15.5	15.1
Grids	12.5	17.2	17.9
CPM	18.4	21.6	24.3
Risk response capacity			
Insurance	10.1	9.7	18.0
Policies	13.7	13.0	19.3
Management	13.9	15.2	22.5
Auditing	14.1	12.5	17.4
Risk management knowledge			
PM experience	16.5	9.2	24.7
Finance	13.8	11.5	20.4
Accounting	13.7	10.6	18.2
Equipment management	15.1	11.9	18.6
Law	13.7	9.9	18.1
Economics	12.9	13.8	18.9

Table 1. Risk management items considered in the questionnaire and the corresponding weigh sum (WS)

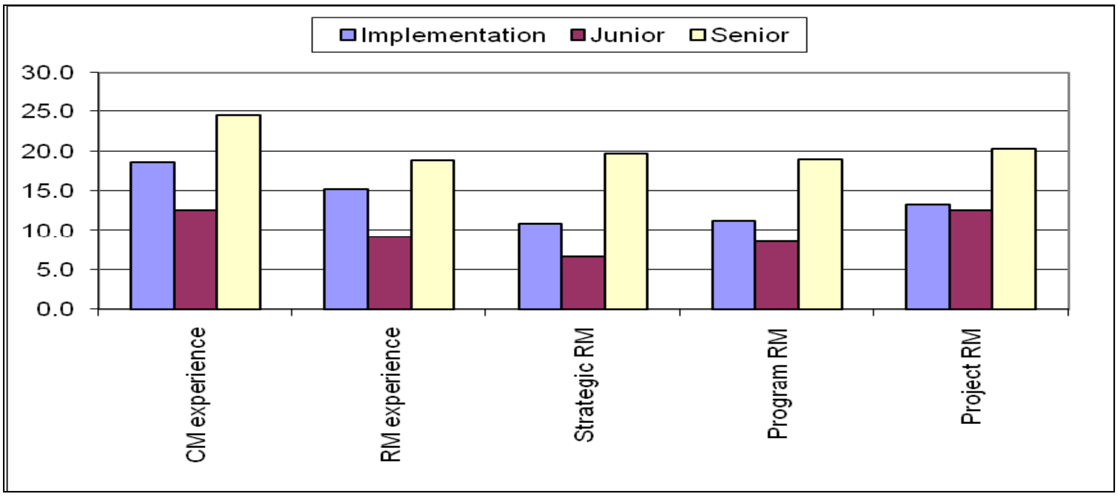

Figure 3. Evaluation of construction risk awareness level versus requirements

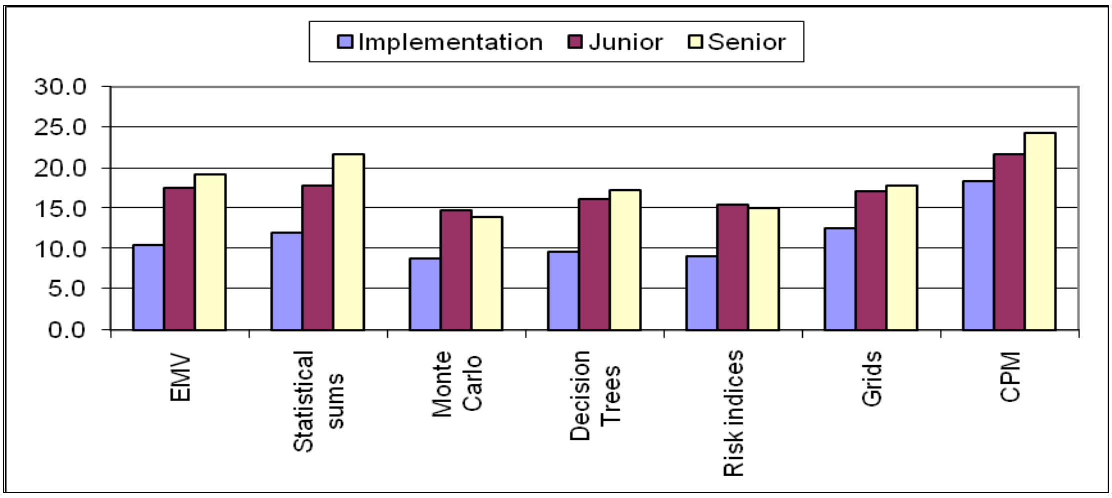

Figure 4. Evaluation of risk analysis tools implementation versus requirements

5.1.3 Risk response capacity

Risk response is a cyclical process that includes planning, execution, and control. This process requires a high level of managerial knowledge and skills. These requirements are evaluated quantitatively in the results of the collected data. Figure (5) shows the results of this partial study. The most necessary knowledge area is found to be the capacity to manage project risks by utilizing acquired knowledge and skills. Next to management come organizational policies, such as distribution of roles and responsibilities, risk management strategy, and risk threshold. The results show that the required level of knowledge of insurance is slightly below that of organizational policies and slightly higher than that of auditing processes. The insurance culture is still weak in the construction field. The manipulation coverage of insurance in construction is usually limited to physical losses like accidents, injuries, fatalities, and construction damage. Project managers and sponsors seldom exploit insurance for other managerial risks like liquidation damages, cost overruns, and schedule delays. The assignment of appropriate premium and determination of the conditions required for the insurance agreement vary from one project to another depending on the complexity, managerial capacity, experience, and stakes of the project. These are the major barriers to expanding insurance to cover similar risks. Establishing a systematic approach to calculating an insurance premium and insurance contract clauses could be performed in a well-documented construction environment but not in developing countries.

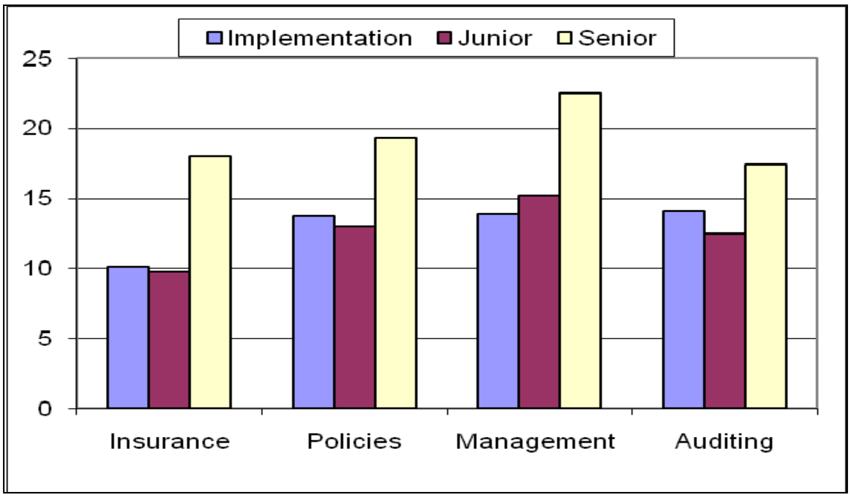

Figure 5. Evaluation of risk response capacities implementation versus requirements

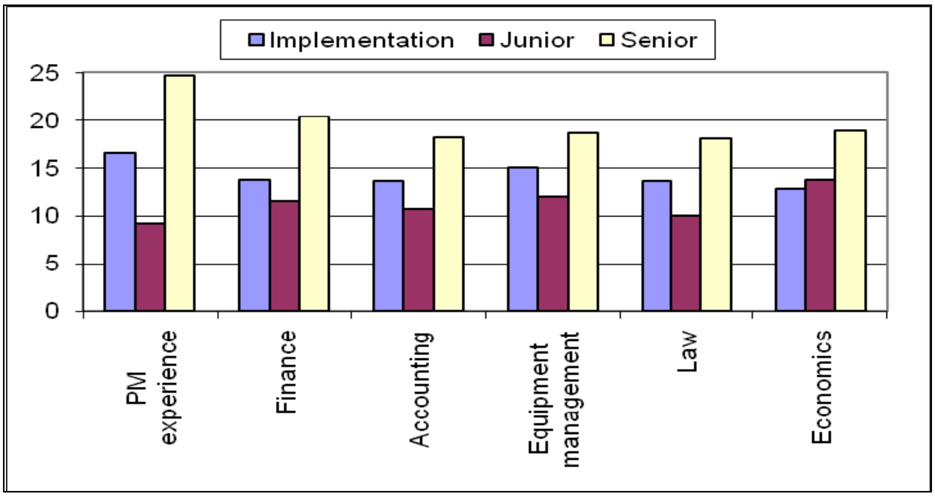

Figure 6. Evaluation of risk knowledge areas implementation versus requirements

5.1.4. Risk management knowledge

Construction risk management body of knowledge includes a diversity of knowledge areas (Figure 2) that are difficult for an individual engineer to accumulate. Hence, risk management is a cooperative process that must be carried out by a management team that acquires the required knowledge. The study considered the major required branches of knowledge, including project management, finance, economics, accounting, equipment management, and law. Figure (6) illustrates the collected data for the implemented and required levels of risk management body of knowledge.

As can be seen in Figure (6), project management knowledge and skills are currently the most commonly implemented knowledge areas, followed by equipment management. The other knowledge areas, considerably behind the previous two areas, are at a similar level. The importance placed on equipment management could be attributed to participants' background as senior engineers. The results (Figure 6) show that the required knowledge level for project management is most necessary for senior engineers. The engineering practitioners affirmed that finance is the second most important area and economics is the third. The lack of importance reported for law reflects low awareness of the very strong relation between construction risk on one side and contract clauses, construction changes, and dispute resolution on the other. The gap between the actual, practical level and the requirements for senior engineers is significant for all areas considered, especially project management. The required improvement in project management is reported mainly as risk management and contract management capabilities, which was concluded from individual notes and discussions with the participants. The self-assessment of the senior practitioners in this regard is greatly appreciated. It reflects awareness of the great need for more effective acquisition and implementation of management knowledge.

The required level of knowledge for the junior engineers was satisfying, as shown in Figure (6). However, participant practitioners noted that acquiring higher levels of knowledge and skills by juniors is usually attained through practical implementation. These results direct the strategies of the construction industry in developing countries toward improving the capabilities of the top and middle management personnel to attain the required competition through long training courses by international experts, gaining experience from benchmark firms, or intermingling with well-established firms in local projects.

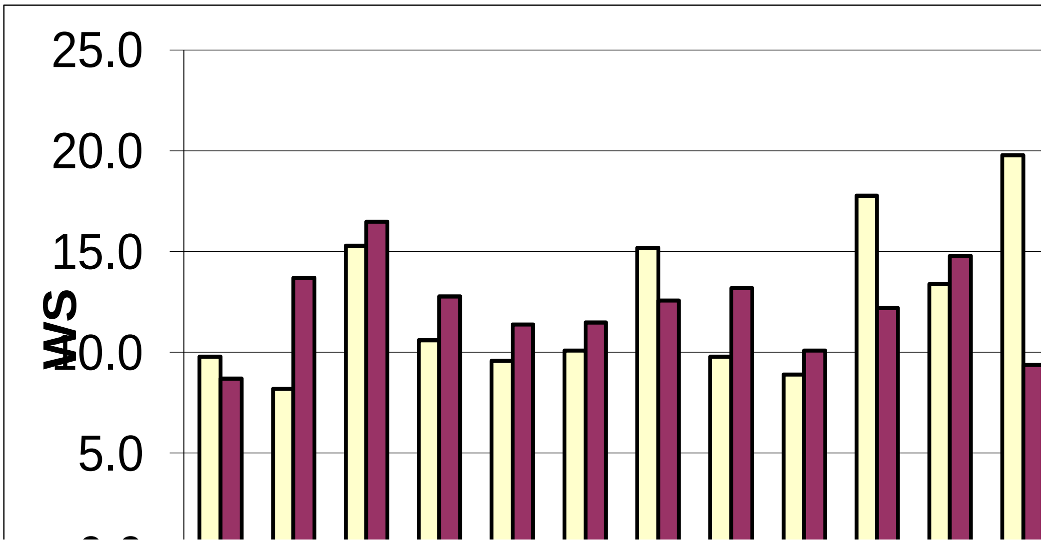

Figure 7. Positive contribution to risk management processes

5.2 Factor analysis

The results of the factor analysis show three main factors that contribute to the variability of the data collected. These three factors and the corresponding parameters are discussed below in sequence that accord to the variability encountered in the factor analysis process. Figure (7) presents the weighed sums (WS) for these parameters. The responses in this regard were on a scale from one to five, where a score of five meant the implementation of the item was the highest positive contribution. It could be noticed from the figure that the financial aspects and security are the main contributions in the governmental sector. On the other hand, Standardization and the support from senior management are the main contribution in the private sector. The three parameters encountered by the deduced factors are introduced in the following discussion:

5.2.1 Culture of the organization

The first factor considers the parameters correlated to organizational culture. Table (2) introduces theses parameters and the correlations among these parameters. All the correlations have positive values which points to the strong correlations among these parameters. The highest value is between Standardization of the organization and implementing quality standards. The relationship between quality and standardization is obvious and convincing.

	Sponsors	Culture	Standards	RAM	Innovation	Quality
Sponsors	1.000	0.589	0.424	0.333	0.143	0.530
Culture	0.589	1.000	0.699	0.387	0.549	0.407
Standards	0.424	0.699	1.000	0.593	0.475	0.804
RAM	0.333	0.387	0.593	1.000	0.209	0.741
Innovation	0.143	0.549	0.475	0.209	1.000	0.486
Quality	0.530	0.407	0.804	0.741	0.486	1.000

Table 2. Correlation matrix for parameters considered by the first factor

1. *The contribution of sponsors*.
2. *The culture of the construction organizations.*
3. *Standardization of the organization.*
4. *Responsibility assignment matrix.*
5. *Encouraging innovative attitude.*
6. *Implementing quality standards.*

5.2.2. Motivation and development

The second factor considers the parameters correlated to the motivation and development of the personnel who are supposed to participate in risk management processes. Table (3) shows the correlations among these parameters. The correlation values are even higher than those obtained for the first factor. The highest correlation is between sufficiency of training programs and support from direct and senior management staff. Both parameters show that the participants in need for more technical and managerial support to enhance their performance.

1. *S*ufficiency of training programs.
2. Encouraging organizational policies.
3. Availability of appropriate positions.
4. Adequate job security.
5. Support from *direct and senior management staff.*

	Training	Policies	Positions	Security	Management
Training	1.000	0.609	0.572	0.459	0.763
Policies	0.609	1.000	0.641	0.375	0.591
Positions	0.572	0.641	1.000	0.483	0.303
Security	0.459	0.375	0.483	1.000	0.670
Management	0.763	0.591	0.303	0.670	1.000

Table 3. Correlation matrix for parameters considered by the second factor

5.2.3. Risk management retention.

Table (4) shows the correlations among these parameters. The correlation values in this set of parameters are less than the previous two sets. The highest correlation is between rigidity of change rejection environment and sufficient reward system. There is no distinguished relationship between these two parameters and the other two parameters.

	Funds	Change	Reward	Motivation
Funds	1.000	0.197	0.316	0.390
Change	0.197	1.000	0.406	0.223
Reward	0.316	0.406	1.000	0.110
Motivation	0.390	0.223	0.110	1.000

Table 4. Correlation matrix for parameters considered by the third factor

1. *Availability of funds required for development.*
2. *Rigidity of change rejection environment.*
3. *Sufficient reward system.*
4. *Enthusiasm and ambition.*

6. Conclusions

The following are the conclusions from this study, which was conducted to assess the current level of, and the improvements required to enhance the implementation of, construction risk management in Kuwait.

- The current level of construction project management knowledge at B.S. level is satisfactory based on the multidisciplinary interaction required to acquire an advanced level of risk management skills.
- More practical training is required for college students and junior engineers to acquire know-how in utilizing risk management tools.
- More awareness is required for senior engineers working in construction project risk management with respect to the following fields:
  - Insurance;
  - Organizational policy planning and implementation;
  - Project management and general management skills; and
  - Finance, economics, law, and accounting.
- Both government and private construction organizations need to be reengineered to reflect the importance of risk management in their systems.
  - Top management must encourage innovative solutions to enhance earned value through risk management processes.
  - Organizations' policies need to include clear motivational clauses to encourage employees to develop themselves and to acquire new techniques.
  - Organizations must construct and enforce a standardized system for all managerial and technical processes in their work flow.

- Construction organizations need to define well-organized responsibilities and authorities for all stakeholders, by which risk management processes can be established.
- Training programs should be controlled by monitoring the outputs of these programs to achieve the required added value.

Reward systems should be provided for employees who acquire knowledge of risk management through academic or training programs. In addition, there should be a reward system for the implementation of this knowledge and skills.

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