The Engineering Project Organization Journal, 2013
Vol. 3, No. 1, 32–50, http://dx.doi.org/10.1080/21573727.2012.717531

A tool for enhancing innovation in construction organizations

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Received 22 November 2011; accepted 26 July 2012

A 12-person-sponsored research team consisting of three academic researchers and nine experienced practitioners conducted a three-year investigation into ways to enhance innovation within engineering-procurement-construction organizations. Data from the literature combined with over 150 surveys of active practitioners were used to identify and classify factors that influence an organization's ability to generate and implement new ideas that improve business performance. The salient factors were then identified and their relative impact was rated using the nominal group technique. Finally, these data were organized into a maturity model tool that was pilot tested on four active construction organizations. The results of this study can be used by construction organizations to identify and respond to their innovation-related weaknesses. The hundreds of hours of discussions of the 12-member research team and the fairly large set of empirical data collected by the team confirm the value of the existing construction innovation literature, but suggest the knowledge has not been effectively implemented within the industry.

Keywords: Innovation, strategic management, organizational learning.

Introduction

Although the ability to innovate is considered to be a fundamental requirement for long-term business success in nearly all industries, the need for innovation has been overlooked and undervalued within engineering-procurement-construction (EPC) organizations. The EPC industry is noticeably lagging behind industries such as aerospace and manufacturing in terms of fostering the development and implementation of innovative products, processes, technologies and services (LePatner, 2007). An increase in client dissatisfaction is becoming evident based on the construction industry's inability to deliver quality products and services on time, and at a reasonable price (Seaden *et al.*, 2003).

Given that the industry is facing new challenges such as an ageing workforce, globalization, economic fluctuations and international partnering (Chinowsky and Songer, 2011), underperformance in the area of innovation may become an industrial crisis. Although individual exceptions exist, study of the EPC industry has demonstrated that there are significant economic, organization and industry structural barriers within construction organizations of all sizes (Tatum, 1986; Miozzo and Dewick, 2002; Manley and McFallan, 2006).

To respond to these challenges, a research team of three academic researchers and nine industry professionals was established to explore and document the current levels of innovation in the EPC industry, identify opportunities for enhanced levels of innovation and identify best practices for EPC companies individually (and the industry collectively) to become more innovative. The three-year research effort was split into three discrete phases. The first phase involved surveying on a broad level the state of innovation within the EPC industry and identifying the factors that influence intra-organizational innovation (i.e., the organizational practices that positively influence innovation). In the second phase, an innovation maturity model (IMM) tool was created to allow organizations to evaluate and improve their innovation capabilities. This tool was

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based on the results of the first phase. In the third and final phase, the IMM tool was tested with case study construction organizations to validate the input data and identify trends in strengths and weaknesses in the industry.

Literature review

The research team adopted the following definition of innovation, which represents a synthesis of the definitions presented by the Civil Engineering Research Foundation (2000, cited in Sexton and Barrett, 2003), Dikmen *et al.* (2005) and the OECD/Eurostat (2005, cited in Manley and McFallan, 2006):

> Innovation is the act of introducing a significant improvement in a process, product, or system that is novel to the organization, may cause individuals to view things differently, and results in competitive advantage, increased value for the client or benefit to stockholders.

To achieve the aforementioned research objectives, seven specific research questions were posed, which served to guide the effort and provide points of departure, not to serve as requirements for a response. The specific research questions and key literature relating to each question is summarized below. Note that the research questions focus on enhancing innovation in individual EPC organizations. Literature addressing government mechanisms to increase innovation or whether the rate of innovation in construction is sufficient, for example, are not included below.

Research question 1. Is innovation perceived to lead to higher profit margins?

Classical economics literature (Schumpeter, 1942; Schmookler, 1966; Freeman, 1989) has established a positive relationship between innovation and financial performance. Within the EPC industry, it is generally assumed that innovation is necessary to lower costs, increase functionality and maintain market share (Seaden *et al.*, 2003; Thomas *et al.*, 2004; El-Mashaleh *et al.*, 2006). Yet the link between investment in innovation and enhanced business performance in EPC is indirect in part because innovation-related metrics and statistics have limitations, as discussed below.

Research question 2. How is innovation measured?

Metrics for assessing the success and impact of an innovation have been identified and discussed in the construction literature, but the practical application of these metrics is limited. Metrics that focus on research and development (R&D) expenditures and patents can be misleading because these activities are only a small subset of innovation activities (Seaden and Manseau, 2001). Egbu (2004) and Tucker (2004) suggest tracking innovation success by measuring lagging indicators such as the percentage of profit/sale derived from the innovation. Dikmen *et al.* (2005) built upon these studies by identifying trailing indicators of innovation such as technological advancements, improvements in schedule, budget and quality, and increased effectiveness of the firm.

Research question 3. What are the key perceived drivers of innovation?

Older literature on construction innovation framed the factors that drive innovation in terms of (client) demand-pull versus (contractor) capability-push. Tatum (1989), Arditi *et al.* (1997) and Bossink (2004) discuss and provide evidence that both demand-pull and technology-push factors are relevant in the construction industry, although Gann (2000) suggested that demand-pull is a stronger driver in construction (cited in Ling, 2003). Toole (1998) suggests that the adoption of innovative construction products and processes is driven by the desire to directly improve the achievement of project and firm goals because they can decrease project cost and duration and increase the performance of the final structure or system. Further, the factors that influence the development of technical innovations, diffusion of these innovations within the industry and their benefits to their developers were studied through interviews with construction product developers (Gambatese and Hallowell, 2011). However, Dikmen *et al.* (2005) point out that the benefits of innovation transcend products and services. For example, innovation can lead to competitive advantage through improved firm reputation, easier work processes and improved ability to attract new employees (Slaughter, 1998).

Research question 4. What are the key perceived barriers to innovation?

It has been highlighted that the construction industry is infamous for the barriers it places in the way of innovation (Sexton and Barrett, 2003). Many researchers have pointed harshly at the contracting strategies chosen by owners that result in a fragmented and disjointed design and construction process (Slaughter, 1998; Gann, 2000; Harty, 2005; Manley and McFallan, 2006; LePatner, 2007) and the choice of firms based on low bid (Miozzo and Dewick, 2002). Toole (1998,

2001) and Mitropoulos and Tatum (1999) identify technological, financial and employee resistance risks that hinder innovation. Sawhney and Wolcott (2004), Kanter (2006) and Hamel (2006) focus on tight organizational controls that hamper pursuit of radical innovations with potentially large paybacks for construction organizations.

Research question 5. What are the management characteristics that promote innovation?

Researchers have found that senior managers' tenure in position (Hambrick and Mason, 1984; Huber *et al.*, 1993), industry experience (Damanpour and Schneider, 2006), age (Huber *et al.*, 1993; Damanpour and Schneider, 2006), gender (Sonfield *et al.*, 2001), education (Hausman, 2005; Lee *et al.*, 2005), willingness and ability to manage conflicts (Hausman, 2005), and willingness to share control (Scott and Bruce, 1994; Timmons and Spinelli, 2004) highly influence the innovative capacity of an organization. In addition to these management characteristics, specific attributes of leadership have been found to encourage innovation. Strategic clarity and consistency are important for sustained innovation (Rosenbloom and Cusumano, 1987; Laborde and Sanvido, 1994; Oden, 1997; Ling, 2003; Delphi Group, 2006). Managers must take a long-term, holistic view of the innovation process (Oden, 1997; Sawhney and Wolcott, 2004). Top management must be visibly committed to innovation and there must be at least one champion (Nam and Tatum, 1997; Oden, 1997; Mitropoulos and Tatum, 2000; Ling, 2003; Bossink, 2004; Koebel *et al.*, 2004; Boston Consulting Group, 2007). The question for the EPC industry is whether these attributes are found in managers within this domain.

Research question 6. What are the organizational characteristics that promote innovation?

Researchers focusing on all industries as well as those focusing on EPC have identified a number of organizational characteristics that facilitate innovation. While many of these characteristics overlap, they can be grouped into those associated with culture, learning, collaboration, customer-focus and resources.

Culture: Many researchers have discussed the importance of organizational culture, especially an attitude of being open to new ideas (Dulaimi *et al.*, 2002; Blayse and Manley, 2004; Dikmen *et al.*, 2005; Manley and McFallan, 2006; Ling *et al.*, 2007). Sexton and Barrett (2003) discuss innovative culture in terms of employees' cognitive capabilities, namely their ability to balance between focusing on short-term efficiency and being open to changes needed for long-term improvement. Sawhney and Wolcott (2004) emphasize that all employees must constantly question the status quo. Chesborough (2003) suggests that all employees must recognize that innovation is not limited to R&D, but can encompass or be manifested in all aspects of the organization's activities.

Learning: Because effective innovation requires that knowledge gained from experimentation with change be transferred to other employees, organizational learning and knowledge management are considered to be critical for sustained innovation (Rosenbloom and Cusumano, 1987; Laborde and Sanvido, 1994; Oden, 1997; Miozzo and Dewick, 2002; Sexton and Barrett, 2003; Blayse and Manley, 2004; Dikmen *et al.*, 2005; Harty, 2005; Delphi Group, 2006; Boston Consulting Group, 2007).

Collaboration: Linkages within organizations and between organizations must be created to enable the collaboration and trust that are critical for innovation (Oden, 1997; Gann, 2000; Ling, 2003; Bossink, 2004; Sawhney and Wolcott, 2004; Hamel, 2006; Kanter, 2006; Ling *et al.*, 2007; Boston Consulting Group, 2007). Ideas must be brought into the firm from outside the firm, including from researchers and consultants (Bossink, 2004). Innovation networks are needed to share non-sensitive information (Dulaimi *et al.*, 2002; Blayse and Manley, 2004; Drejer and Vinding, 2006). A 'Not Invented Here' syndrome cannot be tolerated (Chesborough, 2003; *The Economist*, 2007).

Customer-focus: The organization must focus on customer needs and have close ties with customers (Rosenbloom and Cusumano, 1987; Oden, 1997; Seaden and Manseau, 2001; Dikmen *et al.*, 2005).

Resources: As mentioned for research question 5, many articles discuss the need for an innovation champion, both on the project and within the organization. Mitropoulos and Tatum (2000), Dulaimi *et al.* (2002) and Sexton and Barrett (2003) also discuss the need for slack resources to pursue innovation.

Research question 7. What are the project-related characteristics that promote innovation?

Literature that addresses barriers to innovation (research question 4 above) identify how owner project decisions can influence innovation. Dulaimi *et al.* (2002), Blayse and Manley (2004) and Dulaimi *et al.* (2005) identify ways that owners can enable the timely collaboration between project parties. Gambatese and Hallowell (2011) identify specific project-related factors that promote co-innovation including Owner vision; funding from the Owner; contractor input during the design phase; overlap of the different project development phases; an innovation 'champion' and entrepreneur and co-location of the project team.

Phase 1. Research method and findings

The first phase of the research involved identifying the organizational characteristics that enable innovation and assessing the extent to which EPC firms possess these characteristics. Several data collection methods were considered for the first research phase. Ideally, empirical data regarding the link between organizational innovation characteristics and financial performance would have been collected. Unfortunately, because EPC organizations do not manage metrics relating to innovation activity and results, the time and resources needed to collect a reasonable volume of valid empirical data would have been prohibitive. Both the Delphi and the nominal group techniques (NGTs) were considered because each method involves multiple rounds of structured surveys, an expert panel and controlled feedback between rounds. NGT was selected over Delphi because the research team had sufficient resources to assemble the expert panel in one physical location at multiple times during the research process. Additionally, NGT has been shown to be superior to Delphi because with NGT large amounts of knowledge can be exchanged between rounds in face-to-face meetings (Erffmeyer and Lane, 1984; Sample, 1984). Typically, the NGT process involves two or more rounds of brainstorming, open discussion of ideas, and voting to refine and prioritize influence factors. Ideally, consensus is achieved within the group with respect to the factors and their ratings or rankings. Gallagher *et al.* (1993) found that this method allows a researcher to collect quantitative data for complex influence factors in a group setting while avoiding problems of group dynamics associated with other expert opinion methods.

Nominal group technique

The NGT was originally developed in the 1960s from social-psychological studies of multi-factor decision studies and has since been applied in many research domains including medicine, aerospace, management and engineering (Delbecq and Van de Ven, 1971). According to Horton (2007), the NGT is a structured method of group decision-making which allows a rich generation of original ideas, balanced participation of all members of the group and a rank-ordered set of decisions. NGT is typically used to achieve decision acceptance and address complex problems with many confounding factors (Bartunek and Murninghan, 1984).

The key to a successful NGT study is ensuring that data are provided from a highly qualified panel that feels open to share ideas and conflicting opinions, providing controlled feedback to the panelists, and taking controls to minimize the effects of cognitive bias. As is well documented in the literature, expert panels must have a high level of collective expertise and each individual must meet a minimum threshold of experience. There are various, but conflicting, methods to identify and qualify potential participants as an 'expert'. Recently, Hallowell and Gambatese (2010) reviewed relevant literature and addressed inconsistencies when creating a new set of objective and flexible expertise requirements. According to their study, every expert must accumulate at least 12 points using the criteria in Table 1 to participate. These standards were adopted to qualify experts for the NGT panel. Because the primary objectives were to quantify the relative magnitude of innovation impact factors and create recommendations for improvement, the research team desired to have a panel with a high level of professional experience. Thus, professional management experience was desired over academic experience.

The panel for this study comprised Construction Industry Institute (CII) members, who volunteered based on their expertise in introducing new practices in their organizations. In total, the panel consisted of 12 experts, each of whom had responsibility for process issues in their organization. This meets the standards of the ideal panel according to Linstone and Turoff (1975) and Boje and Murnighan (1982), who stated that the ideal panel consists of a diverse and highly qualified group of 8 and 15 individuals.

Table 1 Expertise scoring system

Achievement or experience	Points (each)
Professional registration	3
Year of professional experience	1
Conference presentation	0.5
Member of a committee	1
Chair of a committee	3
Peer-reviewed journal article	2
Faculty member at an accredited university	3
Author/editor of a book	4
Author of a book chapter	2
Advanced degrees:	
BS	4
MS	2
PhD	4

Initial industry survey

The research team decided to apply NGT to results of a survey of industry practitioners regarding the drivers, barriers and enablers of innovation within their individual organizations. Based on the findings from the literature review, the team drafted an interview script and performed approximately 25 semi-structured interviews of EPC professionals using a convenience sample. This script was modified based on the feedback obtained through the interviews and converted to a survey. The written survey was initially completed by 46 members of the Construction Industry Institute (CII) Board of Advisors at their Spring 2007 meeting. The survey was subsequently converted into an online version. The 95 EPC practitioners who completed the anonymous survey represented a convenience survey of CII members, Charles Pankow Foundation members and alumni from the academic research team members' universities.

The survey data collected were analysed using Microsoft Excel for descriptive statistics and Minitab for inferential statistics. The descriptive statistics for the pilot sample were found to be very similar to the descriptive statistics for the wider survey; however, the two sets of data were not aggregated and analysed due to differences in the content, question order and wording between the two survey instruments. Inferential statistical analyses were conducted by comparing the means of responses from respondents who considered their firms to be innovative with the means of respondents who considered their firms to be non-innovative.

Findings from the industry survey

For brevity only findings that were most relevant to the development of the IMM tool will be summarized. These findings pertain to innovation-related processes, resources and risk perspective.

Innovation-related processes

The survey data confirmed the existing innovation literature that claims that implementation of processes that encourage and foster innovation is foundational to an organization's ability to innovate. The survey included questions about innovation decision-making on the project level and on the organizational level, as well as about various innovation-related processes. As illustrated in Table 2, the vast majority of respondents indicated their project-level innovation decision-making processes were *ad hoc* or vary widely. Only 14% of respondents indicated their firm had methodical or rigorous project innovation-related decision processes. Table 3 illustrates similar findings for how innovation decisions are made at the corporate level. The differences in mean scores for innovative firms versus non-innovative firms were statistically significant (i.e. p-value < 0.05).

Table 2 Which statement best describes your organization's process for making decisions relating to innovation *on individual projects*?

Answer	% answered
My firm does not make decisions relating to innovation	5
My firm has an *ad hoc* process for making innovation decisions	40
My firm has processes for making innovation decisions, but they vary widely with the innovation and the project	41
My firm has a methodical decision process for making innovation decisions but it does not involve analysing numbers	7
My firm has a rigorous, quantitative process for making innovation decisions, such as rate of return, payback period, net present worth, etc.	7

Table 3 Which statement best describes your organization's process for making decisions relating to innovation *on the corporate level*?

Answer	% answered
My firm does not make decisions relating to innovation	7
My firm has an *ad hoc* process for making innovation decisions	29
My firm has processes for making innovation decisions, but they vary widely with the innovation and the project	36
My firm has a methodical decision process for making innovation decisions but it does not involve analysing numbers	11
My firm has a rigorous, quantitative process for making innovation decisions, such as rate of return, payback period, net present worth, etc.	17

In terms of organization processes supporting and fostering innovation, the means of the questions relating to organizational processes conducive to innovation ranged from 2.7 to 3.4 on a Likert scale where 1 was very low and 5 was very high, indicating that the average respondent's organization has moderately appropriate innovation

Table 4 Please respond to each statement about your organization's processes

Question: % firms answering	Strongly disagree (%)	Slightly disagree (%)	I am neutral (%)	Slightly agree (%)	Strongly agree (%)	Mean
My firm values employee engagement and does regular surveys to measure it	18	18	18	30	16	3.1
My firm has a structured lessons learned programme that captures project results	20	20	8	34	17	3.1
My firm has a knowledge management system that 'pushes' innovation out to the organization	22	24	22	25	7	2.7
My firm has a structured process to capture and update practices and procedures to incorporate innovations	14	31	18	29	7	2.8
My firm has a formal employee suggestion system for generating ideas that lead to innovation	22	23	24	22	10	2.7
My firm has a structured process to deploy new systems	18	24	24	20	13	2.9
My firm looks for innovations that occur on specific projects then tries to share across projects	12	16	11	40	22	3.4
Innovation activities are explicitly included in annual personal evaluations	18	27	31	19	5	2.7

processes (Table 4). These statistics support the finding that innovation-related decision-making is *ad hoc* or varies widely. The comparison of the means between the innovative organizations and the non-innovative organizations was statistically significant for all of the questions except two.

Innovation-enabling resources

Another key finding was that most EPC organizations lack the resources to innovate. In terms of staffing commitments, three of the four questions in Table 5 relating to innovation-related staffing had means below 3.0, indicating the average respondent's organization

Table 5 Please respond to each statement about your organization's staffing

Question: % firms answering	Strongly disagree (%)	Slightly disagree (%)	I am neutral (%)	Slightly agree (%)	Strongly agree (%)	Mean
My firm has personnel explicitly tasked with promoting and facilitating innovation within the firm	24	28	14	19	14	2.7
Workloads are managed to ensure staff have sufficient time to pursue innovation	34	43	13	8	1	2.0
My company uses multiple-discipline teams (that is, teams with a mixture of professional backgrounds) to identify, analyse and facilitate the use of innovations	16	25	24	24	11	2.9
If a project team within my company needed help on an innovation matter from outside the team, they could easily get it	12	12	23	40	12	3.3

Table 6 What are the key perceived barriers to innovation within the capital projects portion of your organization?

Reason	% checked
Schedules and budgets are too tight to take a chance on something new	70
Lack of resources (including staff time)	61
Owner clients do not recognize the value	53
Lack of a firm strategy for innovating	41
Requiring project innovation costs to be born solely by the project	39
Lack of organizational structure to nurture and follow through	35
Potential reward is outweighed by the risk	33
Overly restrictive project specifications	29
Lack of communication between project participants	29
Too many players in the process	29
Lack of trust between project participants	22
Rigid top-down command and control hierarchy	12

lacked the staff resources needed to facilitate innovation. The mean score of 2.0 for the question regarding managing workloads to allow innovation indicates a serious deficiency. The comparison between innovative and non-innovative organizations indicated statistical significance for all of the questions, indicating that innovative firms are more apt to have an organizational staffing that is conducive to innovation. However, even the majority of innovative firms did not manage workloads to allow innovation to be pursued.

When asked about barriers to innovation, Table 6 shows that over 60% of respondents indicated two factors that mostly hinder innovation are 'lack of resources (including staff time)' and 'schedules and budgets are too tight to take a chance on something new'. Also relevant (but not shown in any table) is that the majority of innovations (60%) proposed on projects are funded from the original project budget. Less than 16% of project innovations are funded by corporate sources.

Risk perspective

The fact that 70% of respondents indicated that 'Schedules and budgets are too tight to take a chance on something new' and 33% of respondents indicated 'Potential reward is outweighed by the risk' were among their top five barriers (Table 6) indicates that most firms lack the proper risk perspective on innovation. Innovation is viewed as simply too risky rather than as a necessary activity with inherent risk that must be effectively managed. Somewhat surprisingly, the responses of innovative firms did not differ substantially from those of non-innovative firms for both barriers relating to resources and to risk perspective.

Phase 2. Development of the IMM tool

The interviews and survey data discussed above resulted in eight key areas of innovation influences being identified as the basis for the remaining research phases. The eight areas included the three areas discussed above—processes, resource allocation and risk perspective—as well as five additional areas emphasized in the literature and included in the survey: culture, customer focus, learning, collaboration and leadership. A series of statements were developed to capture the different aspects of each key area that were identified in the literature and/or the survey data. In total, 61 statements were developed to reflect the various influences on innovation.

The development of the IMM tool required each of the 61 statements to be evaluated in terms of their relative influence on the innovation adoption process, i.e., to identify the appropriate weighting for each statement. Developing these weighting factors was achieved through the NGT process with the research team participants. Ratings were provided on a Likert scale where a score of 1 represents very small influence and a 5 represents a very high positive influence. The evaluation statements with impact factors over 4.0 are shown in Table 7 for each of the eight key areas.

The research followed a common NGT procedure with three main rounds of surveys and open discussion between rounds one and two and rounds two and three (Van de Ven and Delbecq, 1971). The expert panelists were asked to: (1) rate the relative magnitude of the 61 influence factors using a Likert scale and (2) write a brief improvement recommendation for each factor. Once the initial survey was completed by all panelists, the research team collected the surveys, aggregated the results and distributed the spreadsheet to the panel. The panel was then given the opportunity to discuss the ratings and recommendations for the factors with the greatest variance. Open discussion was conducted in face-to-face meetings and conference calls. At the conclusion of the first discussion period, the panelists were asked to reconsider their original data in a second survey round. The panelists were provided with the aggregated ratings from the second round of surveys and were asked to discuss the results once again. Once verbal consensus was achieved, panelists were given the opportunity to change their data a second time. After the three rounds of surveys and two discussions, consensus was achieved in the ratings

Table 7 The IMM's 61 evaluation statements and their respective impact factors for factors with a rating of 4 or higher on a five-point scale

	Rating
Culture	
3. Our organization is highly collaborative 'by employees, customers and suppliers'	4.50
5. Employees at all levels are encouraged to challenge current processes	4.00
6. Employees suggesting innovations can be confident the suggestions will be taken seriously	4.00
Resource allocation	
12. Leadership appoints and innovation champion	4.50
13. Innovative ideas are recognized and evaluated in employees' performance	4.00
14. Multi-discipline teams are used to identify, analyse and facilitate the use of innovations	4.00
15. Our organization encourages employee engagement in innovation-related activities	4.00
17. Funding for innovation is available from corporate sources, not just project budgets	5.00
18. Innovation-related activities can be pursued during normal working hours	4.00
Risk perspective	
19. Innovation-related decisions are managed at the organization level when appropriate	4.00
22. Our organization has incentives and indemnification when implementing an innovation	4.00
23. Risk-taking is recognized as a necessary part of encouraging and implementing new ideas	5.00
24. Failures and mistakes are viewed as opportunities for learning	4.00
25. Our organization spreads innovation-related risk across multiple projects	4.00
26. Leadership recognizes that innovation risks must be syndicated across multiple projects	4.50
Customer focus	
30. Project teams are focused on satisfying the needs of the end user	4.00
31. Our organization places an emphasis on learning the customer's business goals	4.50
Learning	
34. Individuals within the organization champions for new ideas	4.00
35. Leadership actively promotes and supports learning initiatives	4.00
38. Leadership removes technical or personnel obstacles that inhibit the sharing of knowledge	4.00
Collaboration	
45. Our organization partners with research organizations to foster new ideas	4.00

(*Continued*)

Table 7. Continued.

	Rating
46. Our organization actively integrates supply chain partners to enhance long-term performance	4.00
Leadership	
50. Leadership demonstrates that innovation is critical for meeting challenging project goals	4.00
51. Leadership demonstrates that innovation is critical for growing revenues and productivity	4.00
53. Leadership acknowledges that innovation requires investing substantial resources	4.00
54. Leadership demonstrates that innovation requires some failure to achieve long-term success	4.50
55. Leadership demonstrates that innovations may be initiated by lower-level employees	4.00
Processes	
60. Our organization has an established process for obtaining funds to support innovation	4.00

and recommendations. It should be noted that, throughout the entire process, each expert panelist's survey responses were kept confidential to avoid dominance bias.

Results of the NGT process

As shown in Table 7, the NGT process applied to the 61 statements in the IMM tool identified the most impactful factors as: recognition that risk taking is a necessary part of the innovation process (5.0), providing innovation-related funds from corporate resources instead of project resources (5.0), collaboration among employees, customers and suppliers (4.5), an appointed innovation champion (4.5), leaders who recognize that innovation-related risks must be syndicated across multiple projects (4.5) and an emphasis on learning and focusing on the goals of clients (4.5).

In addition to the ratings, a recommendation was developed through the NGT process for each factor to assist with improvement. A representative sample of five recommendations is provided in Table 8. Unfortunately, all recommendations cannot be provided due to the volume of the text but can be obtained through the CII's research report for research team 243. Each recommendation is concise, two to five sentences long, and based on the literature reviewed for the study.

The IMM tool process

The IMM tool incorporates the 61 innovation statements and the associated recommendations within a questionnaire-based environment. (The term 'model'

Table 8 Sample innovation improvement recommendations

Question	Recommendations for improvement
Project personnel are enabled to participate in learning experiences outside of prescribed job responsibilities	Innovative companies encourage employees to look outside of their day to day responsibilities for innovation opportunities. These companies overcome the 'not-invented here' syndrome. A low score in this area indicates the need for a change in management philosophy to encourage and allow employees time for these outside learning experiences, such as plant visits, technical seminars, trade association meetings, etc.
Project personnel are allowed to have non-billable hours throughout the year to focus on innovative ideas	During construction projects, managers tend to focus on encouraging organizational activities that can be claimed as billable hours. Managers must recognize that many activities that are not billable add tremendous value to the organization. Typically, innovation occurs when employees are engaging in non-billable activities. A low score in this area indicates that management should encourage activities that focus on process, product, or organizational improvement, even if they are not billable
Leadership includes someone explicitly tasked with fostering and leading innovation	Although individual companies may not have an employee who is dedicated 100% to fostering innovation, it is important to set the leadership example that innovation is important enough to appoint an individual with the task of fostering innovation. A low score in this area indicates that company leadership does not convey the message that innovation is being championed from the top of the organization. To quote the article 'Seven Highly Effective Ways to Kill Innovation (and Seven to make sure you don't):' 'Innovation/Change Champions must come from the top'
Funding for innovation is available from corporate sources, not just project budgets	Firms that value innovation as a core value put corporate level resources in place to fund innovation. A low score in this area indicates a need to consider ways to indemnify project managers with corporate support for innovations proposed at the project level. A second approach to applying corporate funding is to consider spreading costs of expenditures for innovations over multiple projects. Also consider joint ventures with owners, other contractors or equipment suppliers
Innovation-related activities can be pursued during normal working hours. Work days are not so full that innovation-related activities only occur outside normal working hours	Resources should not be so tightly allocated that there is no time available for activities that may not be tied directly to daily tasks. Time for innovative thinking should be available during the course of a project or the opportunity to obtain innovations will be greatly reduced. Organizations can consider including slightly higher overhead rates to allow for less than 100% utilization of employees on projects

was adopted by the research team because the 61-question audit tool developed by the team indicates how close an organization is to a model innovative organization.) The IMM tool requires the user to follow a three-step data collection and input process to complete the questionnaire and evaluation process. First, the individual who is using the tool should engage a representative sample of employees from within the firm who are capable of providing a broad perspective (i.e., lower-level and upper-level employees representing different business units). The administrator then sends a survey to these employees requesting that they rate the organization's performance in each of the 61 impact factors. Specifically, each employee is asked to rate the extent to which they agree with each of the 61 statements using a Likert scale, where a score of 1 is completely disagree and a score of 5 is completely agree. Once these data have been collected, the administrator aggregates the data by calculating the average score for each impact factor and inputs the scores into the IMM system.

Achievement Summary

Once the individual response data have been entered, the IMM tool provides the user with several sets of analysis. One set is an Achievement Summary, which is a quantitative assessment of the organization in each of the eight innovation areas. The numerical scores obtained from the survey questions and the individual weightings assigned to each question provide the ability to calculate how an organization is performing in each of the eight focus areas using a weighted sum. This value could range from a 1 (average survey score of 1, criteria weight of 1) to a 25 in (average survey score of 5, criteria weight of 5). The sum of these values for the questions in an individual area provides the Raw Score of the total achievement that an organization has obtained. Dividing this Raw Score value by the potential number of points that can be achieved in the area provides an area achievement percentage. For example, an organization achieving 104 points in the culture section of the survey represents a 66% achievement of the total possible points in this area.

The achievement score can be interpreted in two different ways. First, the score can be used as a comparison against the case average obtained by the team in the study. Second, the score can be looked at as a report card. In these terms, the organization should be striving to achieve a mark of at least 80%, which indicates at least a Very Good result in a specific area. Given that the survey base as a whole did not demonstrate high marks in every area, the user should not set the low marks of the comparison group as an ultimate benchmark. Rather, these numbers should be used as a reference in setting milestones to reaching an intended or desired achievement level.

An important note for the user to consider when viewing these results is that the Achievement Summary scores are not intended to provide an indication of specific innovation results or be used to make comparisons among organizations. These scores are not equivalent to a project evaluation where a score above a certain threshold indicates that the project is in good health. Rather, these scores indicate a potential level of achievement that the organization has achieved in terms of fostering and supporting innovation. These scores should be interpreted in a context of a sentence such as,

> The organization has achieved 66% of its potential in establishing a culture that supports innovation, or The organization has only achieved 54% of its potential in leadership in terms of supporting innovation.

In this manner, the scores provide an indication of how the organization is performing in terms of supporting innovation. However, the improvement of these scores will over time result in an improvement of the organization's capacity to initiate and implement innovation.

Recognizing that practitioners often find graphics compelling, a second set of analysis generated by the macro-enabled Excel file is a spider diagram like the one shown in Figure 1. This figure indicates how close to 100% the organization scored for each innovation-enabling area. (A score of 100% for an area would require that all employees who completed the IMM survey gave a 5 for each question falling within that area.)

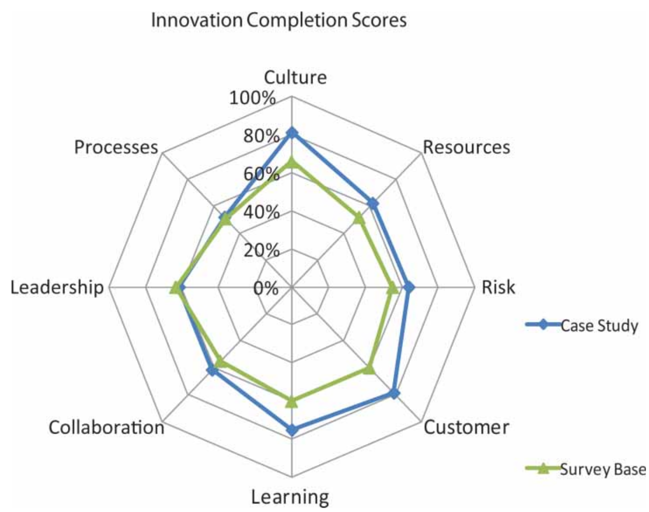

Figure 1 Innovation achievement graphic

Innovation potential

A third set of analysis is the innovation potential score. Based on the Achievement Summary, the IMM tool calculates the innovation potential for each impact factor based on Equation (1)

$$IP_j = (M_{\max} - \overline{M_j})^* w, \quad (1)$$

where IP_j is a relative measure of the organization's lost potential for criteria j, $M_{\max}$ is the maximum possible score for each influence factor, j (i.e. 5 on the Likert scale), $\overline{M_j}$ is the average score for factor j provided by a representative sample of employees within the organization and w_j is the relative weight of factor j according to the NGT results.

Once the innovation potential, IP_j, is calculated for each factor, the innovation potential for each of the eight areas (e.g. leadership, culture and resources) can be calculated by summing the innovation potential scores for the constituent criteria. The subsequent overall innovation potential for the firm is then calculated by summing the innovation potential for each influence factor. The purpose of these calculations is to measure the innovation potential for each factor and area to highlight areas where resource investment and management emphasis will be most effective. Once the analyses are performed, the IMM tool provides the user with a rank-ordered list of the top 10 factors with the greatest potential for improvement and the associated recommendations for improvement. As such, the IMM can be considered as a tool to audit the extent to which an organization possesses the necessary elements to effectively innovate.

It should be noted that the entire IMM process was automated by the research team using simple programming (i.e., macros) in Microsoft Excel.

Phase 3. IMM tool validation process, results and analysis

The development of the IMM tool completed the first and second phases of the research effort. However, validating the model to determine the efficacy of its results was required to develop reliable conclusions. Thus, the research team desired to test the model with case study organizations and contacted members of the CII and the Charles Pankow Foundation to solicit participants. Twenty firms agreed to participate and a purposeful sample of six organizations serving different sectors of the construction industry was created. Only organizations that met the following criteria were considered: (1) multiple offices in different geographical regions, (2) detailed organization objectives that include innovation as a priority and (3) a recent history of attempting innovations so that enablers and barriers can be accurately assessed by employees. Each of the case study organizations was asked to perform the following actions:

(1) Have a small set of employees review the format and overall content of the IMM evaluation questions and the specific wording of each question and provide the team with constructive criticism.
(2) Have a larger set of employees (25–100) complete the IMM evaluation tool, adding demographic questions as appropriate to allow the organization to identify statistically significant differences in data from different groups within the organization (such as supervisory versus non-supervisory personnel, geographic locations, etc.).
(3) Allow the research team to analyse the results and provide the organization with recommendations for improving the organizational characteristics that offered the most potential for improving the organization's innovation potential.
(4) Implement the recommendations within at least one portion of the organization and share the outcomes with the research team.
(5) Provide any feedback regarding the effectiveness of the IMM tool.

The team acknowledged that, as was true for Phases one and two, it was important that the data associated with the third phase be collected anonymously such that neither the research team nor the case study organization could identify which employee provided specific answers on the IMM tool. It was also acknowledged that it is appropriate for competitive reasons not to disclose the identity of the firm associated with specific sets of IMM data collected. Based on this requirement, the firms are described here using a generic naming pattern that will be retained throughout the discussion of the case study results.

Each of the six firms agreed to distribute the IMM survey electronically to a group of individuals within the organization. The responses ranged from 20 to 90 responses in a single organization. Though the team provided each organization's administrator with guidance, the selection of the representative sample of respondents was left up to the administrator. In each case, the organizations selected a segment of the organization to focus upon, although this focus was different in each organization. Some companies focused on a particular division, while others made comparisons with geographic regions, business units or divisions.

Once the surveys were completed, the following four-step process was utilized for each organization:

(1) The results were analysed to determine the top 10 attributes with the highest potential for innovation improvement.
(2) The findings and specific recommendations for improvement were reported to the case study organization.
(3) The case study organization was told that they had complete autonomy regarding how the

specific recommendations were implemented. The research team stayed in contact with the organization to provide advice and recommendations, but remained outside the direct process to ensure that the implementation remained independent.

(4) Several months later, the case study organization communicated how the recommendations had been implemented and the perceived results of the implemented recommendations. In one case, case study B, the IMM survey was re-distributed to the employee population to determine any change in innovation perceptions that may have occurred. The results of this second round survey were then compared with the previous round to detect improvements of the targeted attributes.

Case study findings

Of the six firms requested to use the IMM tool, only four organizations did so before the research team was disbanded. The characteristics, use of the IMM tool and findings of these four case study organizations are summarized below. It should be noted that five of the case study organizations reviewed the 61-statement IMM survey closely and could not identify ways to improve either the overall content or the clarity of each statement. The sixth organization suggested minor changes to the wording of several statements to reflect their status as a non-profit organization, not as a for-profit firm.

Case study A: A multi-national engineering firm working in the heavy civil and industrial sectors. This firm is a leader in all sectors with a growing construction presence in the industry. Case study A had 50 employees in two groups complete the IMM evaluation tool. Case study A was found to have strengths in the areas of Culture, Customer Focus and Learning. Weaknesses were focused in the areas of Resources, Collaboration, Leadership and Processes. In discussions with the organization, it was determined that although the culture was focusing on innovation and bringing new solutions to the customer, resources were still lacking in terms of providing greater opportunities to bring innovations into the organization. Additionally, due to pressures from billing processes, the opportunities to spend significant time on issues such as redoing processes or sending individuals to conferences was limited. However, a commitment is in place to improve these areas and the organization is using the results of the study to focus on specific areas including:

- enhancing collaborative opportunities within the organization,
- providing greater resources for innovation and
- bringing leadership into a more active role in supporting innovation activities.

Case study B: A national mechanical engineering and construction firm with a heavy focus on commercial and hospitality projects. Case study B had 26 employees complete the IMM evaluation tool using CII's Select-Survey. Case study B was found to have similar strengths as those in case study A including the areas of Culture, Customer Focus and Learning. However, case study B differs from case study A in that it also has strength in Leadership. Weaknesses were similar to case study A in the areas of Resources, Collaboration and Processes. In discussions with the organization, it was determined that case study B had a very strong commitment from management to support innovation. This support included the establishment of Communities of Practice and a commitment to implement findings from the IMM tool.

As a further validation of the overall innovation findings, the research team worked with Firm B to analyse how the recognition of strengths and weaknesses in their organization and application of the recommendations may enhance innovation. In this effort, a senior vice-president appointed a manager who was already leading innovation efforts to select three specific areas of weakness in their organization as determined by the IMM.

- developing formalized processes to promote innovation,
- establishing a reward system for encouraging innovation development and
- establishing a formalized process to encourage collaboration among organization divisions.

The manager was then instructed to work with his production team to focus on improving those areas over an eight-week time period. During that time period, the research team had periodic review meetings with Firm B to assess progress and answer any issues that may have arisen during the process. At the conclusion of the eight weeks, a second sample of Firm B indicated significant improvement in 17 of the questions where the model had originally detected lower than average scores. Although this is not a statistical validation of the model, it provides an external validation of the potential for the IMM tool to detect weaknesses and provide a path for improvement.

Case study C: A multi-national engineering-construction firm with a significant presence in all geographic sections of the world. The company works in all sectors, but is considered a leader in the industrial sector. Case study C had 90 employees complete the

IMM evaluation tool. The firm was found to have a very balanced evaluation with almost equal scores in all eight IMM areas. Although no single area is considered to be a particular area of strength, the overall balance is a very positive indicator for case study C. In discussions with the organization, it was determined that case study C had an extended history of supporting innovation and believed it has a competitive advantage for them in delivering project solutions to customers. However, case study C believed that areas could be improved including increasing the commitment from management to support innovation and improving the risk perspective on innovation. Case study C focused on the following areas to improve innovation scores:

- developing a formalized process to provide resources to innovation,
- reducing the risk barriers to innovation and
- establishing a formalized process to measure the results of innovation adoption.

Case study D: A multi-national engineering-construction firm focused on the industrial sector of the industry with numerous large clients in the energy sector. Case study D had 83 employees complete the IMM survey. Case study D follows the pattern established in the first three case studies with similar strengths and weaknesses. In this case, the balance reflects a solid foundation for innovation with a recognized need in specific areas for improvement. In discussions with the organization, it was determined that case study D had a very strong focus on learning and leadership which has established a culture focusing on innovation and customer focus. However, the organization required further focus re-evaluating its risk perspective and establishing formalized processes to support innovation. Case study D focused on the following areas to improve innovation scores:

- developing a formalized process to provide resources to innovation,
- reducing the risk barriers to innovation and
- engaging management to provide a greater explicit support for innovation.

IMM data analysis

The use of the IMM tool provided the research team with approximately 300 data points to analyse patterns among the case study organizations. Table 9 provides the average lost potential for each of the eight innovation-enabling areas for each of the four organizations. Table 10 provides an example of how the values in Table 9 were determined. Table 10 provides the average scores for all organization C employees who completed the IMM tool for the nine statements in the Culture area. The lost potential column on the right is equal to the product of the weighting factor in the middle column multiplied by the value of the maximum value possible (always 5) less the average score. For example, the lost potential value of 2.18 for question 1 is the product of the weighting factor of 3.0 multiplied by (5–4.27). The average lost potential values for these nine statements were then averaged (3.39) and inserted in the appropriate cell in Table 9.

Table 9 Average Innovation Potential Scores for the four case study organizations

	Organization				
Category	A	B	C	D	Average
Culture	4.07	4.03	3.39	3.82	3.83
Resources	7.29	6.32	4.27	3.43	5.33
Risk Perspective	6.75	5.85	5.17	3.53	5.33
Customer Focus	4.01	4.49	3.96	3.55	4.00
Learning	5.13	3.72	3.57	3.99	4.10
Collaboration	5.91	5.38	4.84	3.73	4.96
Leadership	5.99	5.15	4.00	3.55	4.67
Processes	7.55	5.47	6.22	3.55	5.40
Average	5.69	5.05	4.43	3.64	4.70

Table 9 indicates the variances between the organizations in terms of the eight overall categories were small indicating that the improvement potential scores for each of the eight IMM areas were consistent among the organizations. The largest variance between the organizations occurred in the Culture, Process and Collaboration categories. The organizations had the best performance in the areas of Culture, Learning, Customer Focus and Leadership, where the average scores were above the overall average for the eight areas. The weakest area for the organizations was in the Processes category where most of the respondents indicated difficulty in establishing processes to support and maintain innovation activities.

Given the overall similarity in the data, the team focused on evaluating trends in the 61 factors using the innovation potential (IP_j) scores for the factors in each organization. As illustrated in Figure 2, the top quartile of issues that appear consistently as weakness in the organization evaluations is predominantly associated with the areas of Resources and Risk Perspective. Similarly, the areas of Learning and Collaboration had lower innovation potential scores. The interesting finding from this analysis is the fact that each of these firms has a different client base, has a different sector focus and is located in a different geographic region.

Table 10 Example of how Average Innovation Lost Potential calculated for Culture for Organization C

Question	Average	Weighting	Lost potential
Q1. Our organization focuses on long-term relationships with employees at all levels	4.27	3.00	2.18
Q2. Innovations are discussed freely without regard to rank or position	4.50	3.50	1.75
Q3. Our organization is described as 'highly collaborative' by employees, customers and suppliers	4.05	4.50	4.30
Q4. Our organization actively solicits input from outside sources, including suppliers	3.86	3.50	3.98
Q5. Employees at all levels are encouraged to challenge current processes in order to continuously improve them	4.05	4.00	3.82
Q6. Employees suggesting innovations can be confident the suggestions will be taken seriously	4.05	4.00	3.82
Q7. Employees throughout the organization trust their supervisors	3.64	3.00	4.09
Q8. Our recognition and reward system encourages cooperation across departments or functions	3.50	3.00	4.50
Q9. Innovation is encouraged even if you can't prevent your competitors from copying the idea	4.32	3.00	2.05
Average			3.39

However, even with these differences, the innovation potential scores remain stable across organizational boundaries. Similar to the weaknesses, the data indicated that firms shared similar strengths as well (Figure 3). As illustrated, organizations find that culture and learning perspectives are potential strengths in allowing innovative processes to be introduced into the organization.

Recommendations

The findings of both the 150 surveys of EPC professionals and 300 completions of the IMM evaluation tool enabled the research team to conclude that EPC organizations share many common strengths and weaknesses related to innovation, as suggested in the innovation literature reviewed at the beginning of this article and/or suggested by the team's experienced industry professionals. The data collected show that innovation is espoused by the EPC leadership (Ling, 2003; Bossink, 2004) and often valued by employees throughout organizations and that mechanisms for organizational learning (Dikmen *et al.*, 2005) do exist. The literature and data analyses also allowed the team to identify recommendations for improving innovation capability within individual organizations. If EPC organizations are to become more innovative, the research reported here suggests several management actions need to be taken.

Budget allocations must be made in support of innovation

Innovation requires organizational support. An integral and foundational component of this support is an allocation of budget resources to innovation efforts. However, these budget allocations need to be more than just added contingency on individual projects, which the research indicates is a common approach in the construction industry. The following are key budget considerations:

(1) Predetermined project budgets cannot accommodate innovation-related costs that were not considered when the budgets were established. Even in firms that have project funds set aside for innovation-related activities, it is appropriate to have corporate funds available to pursue corporate-wide innovation activities.
(2) Once an innovation has been proven successful on one project, corporate budgets should be made available to diffuse the innovation to other projects.
(3) Corporate budgets should be allocated to identify innovations from outside the firm (including outside EPC) that could be implemented within the firm.

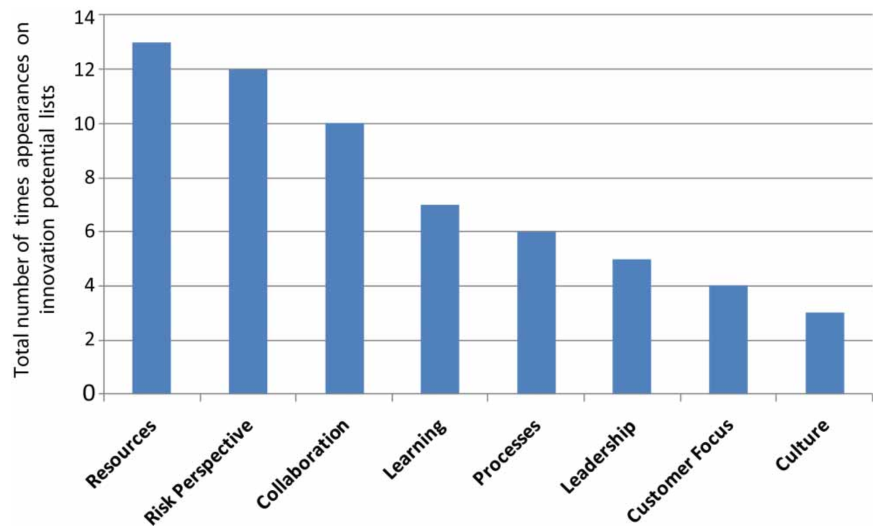

Figure 2 The total number of times a question within one of the eight IMM areas appears in the top quartile of the innovation potential lists for the four case studies (e.g. resource related questions appear 13 times in the top quartile of the four lists)

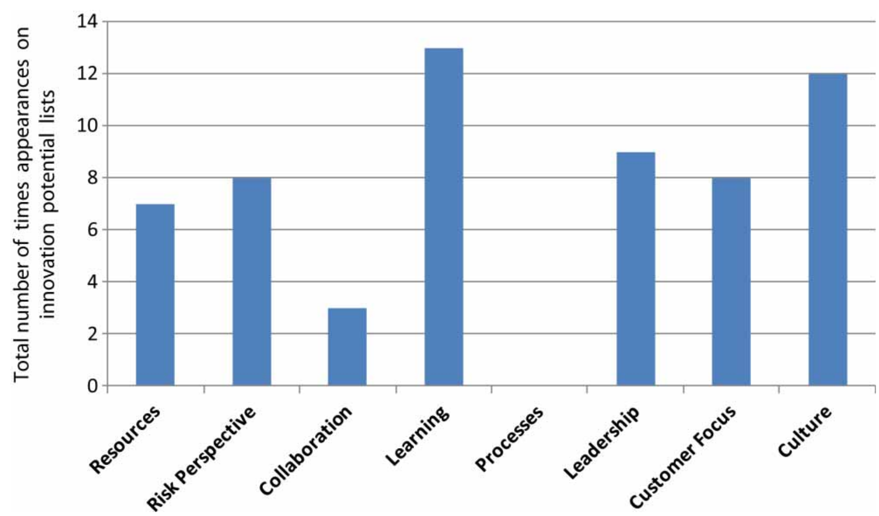

Figure 3 The total number of times a question within one of the eight IMM areas appears in the bottom quartile of the innovation potential lists for the four case studies (e.g. resource related questions appear seven times in the bottom quartile of the four lists)

Staff allocations must be made in support of innovation

Complementing budget allocations are the need for staff allocations (Dulaimi *et al.*, 2002; Sexton and Barrett, 2003). Specifically, organizations need to make a priority of tasking individuals with identifying opportunities for innovation on their projects. The clear picture that emerged from the research is that essentially no one in EPC firms has the time to spend on innovation-related activities because they are so busy fulfilling their primary operational duties. Key staffing considerations include the following:

(1) Tasking individuals with facilitating implementation innovations on individual projects.
(2) Tasking individuals with identifying innovations from outside the organization that might be applied within the organization.
(3) Tasking individuals with collaborating with individuals outside the organization (e.g. clients,

subcontractors and vendors) to pursue joint innovations.

Processes need to be put in place to support innovation

A key success element is the existence of repeatable innovation-related processes that employees understand and are able to follow (Gann, 2000; Sawhney and Wolcott, 2004; Ling *et al.*, 2007). Without such established processes, employees will be too busy achieving traditional project and departmental goals to pursue innovation, or they will focus only on following standard operating procedures that have worked on past projects but may not be the most efficient and effective way to complete their current projects. Young employees need to believe they can be promoted in part due to their willingness to pursue innovation. Specific innovation-related processes include:

(1) Repeatable processes need to be established relating to the identification, evaluation and implementation of innovation on project and corporate levels.
(2) Promotion and bonus pay should reflect employee involvement in innovation activities, even if innovations are unsuccessful.
(3) Processes should include facilitating creative thinking and decision-making.
(4) Processes should include identifying and meeting customer needs.

Collaboration needs to be enabled

Many promising EPC innovations involve information technology and only deliver their full benefits when adopted on a project by all project participants (Mitropoulos and Tatum, 2000). Processes must be established by the project owner to enable project participants to identify innovations well suited for a project before the project begins in order for project budgets and infrastructure to include the innovation. Communication between organizations must occur to ensure the innovation is implemented efficiently and effectively (Dulaimi *et al.*, 2002; Blayse and Manley, 2004). All project participants must feel the other participants are committed to the success of the project, not just to the success of their own organization. Ideally, many of the project participants have long-term relationships enabled by frequent communication. Organizations should examine the overall communication networks that include project participants to maximize communication opportunities (Chinowsky and Taylor, 2012).

A new risk perspective needs to be adopted

The final recommendation is the need to change the organizational risk perspective, which has not received significant attention in the construction innovation literature. Understanding that innovation involves an additional level of risk is a key to successful innovation implementation. Understanding and managing this risk requires a change in perspective from risk aversion to risk management. Specifically, EPC managers need to shift from a single event perspective to a portfolio perspective. Managers must not expect the benefits of an innovation to be achieved during its first use so project managers who first experiment with an innovation should not be punished if the results are less than ideal. A portfolio perspective will reduce the barrier to innovation associated with project managers avoiding innovation due to the perception that the risk of innovation failure outweighs the potential rewards. Collaborative environments must be created where project managers believe that an individual result that does not meet expectations will not result in a penalty. This change to a portfolio perspective will emphasize broad success versus individual achievement.

Conclusions

EPC owners focus on bringing capital projects in on time, under budget and without injury. EPC contractors pride themselves on making their customers happy by focusing on these same goals. Both sets of organizations believe the best way of achieving these goals are by implementing best practices, that is, by adopting what has worked on past projects and eliminating all unnecessary sources of risk to achieving project goals. Both sets of organizations believe profits can be maximized by eliminating unnecessary overhead and keeping operational staff busy with operational tasks. The trouble is that EPC firms' project management strengths are exactly what make them mostly inept at being innovative. The data collected for this research project indicate that EPC organizations like the idea of being innovative but nearly everyone is poor at identifying, nurturing, trying and managing knowledge regarding innovations within their organizations. New methods, processes and products are perceived to be too risky to pursue even on the smallest projects and innovation-related budgets are perceived to be too costly even in the largest organizations. These are barriers that have not received sufficient attention within the construction innovation literature.

For decades, EPC organizations have given lip service to innovation but secretly pointed at a plethora of factors—all external to their organization—that have kept them from being innovative (Toole, 1998). But today's volatile and global markets, today's ever increasingly complex capital projects and tomorrow's workforce will no longer allow EPC organizations to ignore opportunities for innovation (Chinowsky and Songer, 2011). EPC organizations who continue to focus solely on achieving short-term project goals at the expense of developing long-term capabilities to manage innovation and change will find themselves following the same path of the US shipbuilding industry: decreasing productivity, decreasing profit margins and decreasing market share.

The results presented in this article illustrate that the EPC industry has a significant opportunity to change this perspective and improve their innovation performance. However, the research results suggest that increasing innovation requires a shift in perspective by organization leaders. It requires a commitment to repeatable processes and resource allocation. The IMM tool introduced in this research effort provides a first step in evaluating current innovation levels and in providing recommendations to increase innovation. Although innovation levels in the EPC industry may currently be low as a general evaluation, there is nothing fundamentally preventing the industry from improving this status. The case study results revealed that there is a great level of consistency in the strengths and weaknesses among the case study firms. In fact, the attributes listed in the top quartile for each case study firm were almost identical despite the diversity among firms.

The challenge for most EPC organizations will be initiating the process to overcome these common weaknesses. The beginning of this article summarized relevant findings from over two dozen pieces of literature on construction innovation. The hundreds of hours of discussions of the 12-member research team and the fairly large set of empirical data collected by the team generally confirm the value of the existing construction innovation literature, but suggest the knowledge has not been effectively implemented within the industry. The IMM tool presented, which evaluates innovation capability and provides high-value recommendations for each individual organization, may be a promising resource for improving organization's innovation capabilities. The use of the IMM tool by four organizations indicates the IMM evaluation statements and recommendations are clear and thorough. The successful result of the implementation of the recommendations for case study B provides preliminary evidence that the recommendations can lead to improvement in the targeted attributes. Further testing and refinement of the IMM tool and of the recommendations presented here are warranted.

Acknowledgements

The authors gratefully acknowledged funding for the research by the Construction Industry Institute (Austin, TX) and the Charles Pankow Foundation.

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