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Building absorptive capacity in an alliance: Process improvement through lessons learned

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Abstract

Lessons learned provide the greatest value when they form part of a continuous learning process and should be: documented, communicated, archived, throughout all stages of a project. This can enable a project to maximize its 'absorptive capacity' (i.e. its ability to value, assimilate and apply new knowledge). With this in mind, the development and implementation of continuous 'lessons learned' process adopted by a program alliance that was able to improve its safety and quality performance is presented. The alliance was able to shift its mindset from single to double loop learning fuelling its absorptive capacity. The paper examines 'how' the lessons learned process was implemented and presents examples of learning that were implemented. The alliance's experiences in enabling the acquisition and transfer of knowledge through their 'lessons learned' initiative provides a learning opportunity for organizations seeking to ameliorate the performance of the projects that they are charged with delivering.
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1. Introduction

"There's only one thing more painful than learning from experience, and that is not learning from experience." Archibald MacLeish (1892–1982).

Experience is a pivotal part of the learning process for professionals and trades people in the construction industry. This process is referred to as 'experiential learning', which is the process of learning through experience, and is defined as "learning through reflection on doing" (Felicia, 2011, p.1003). Such learning forms an integral part of the improvement process of construction organizations and the projects that they are involved with delivering (Love et al., 2000a). The stimulus for learning is enabled by the acquisition and transfer of knowledge within intra-and-inter organizational members (Love et al., 2000b). Yet the temporal and unique nature of construction often hinders team members from transferring their acquired knowledge from one-project to the next unless processes are developed to embed 'new learnings' that are derived from individuals' experiences and reflections. Capturing and leveraging knowledge from previous projects can significantly contribute to improving the productivity and performance of new projects (Kotnour, 2000; Prencipe and Tell, 2001; Brady et al., 2002; Schindler and Eppler, 2003; Williams, 2008).

The underlying research question that this paper seeks to address is to determine how an alliance is able to maximize its 'absorptive capacity' (i.e. its ability to value, assimilate and apply new knowledge) through instigating a lesson learned. In addressing this question, the experiences of a program alliance

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that developed a lesson learned initiative to specifically combat safety and quality issues are examined. The lessons learned initiative juxtaposed with an organizational change program facilitated by the alliance to improve its 'absorptive capacity' by shifting from a *single-loop* (i.e. correcting an action to solve or avoid a mistake) to *double-loop* (i.e. correcting the underlying causes behind the problematic action) learning environment. As a result, an array of benefits materialized including a significant reduction in rework, non-conformances (NCRs) and safety incidents being experienced. The implementation of a lesson learned initiative provided a mechanism for enabling collective learning between alliance members and the contractors to occur. It is promulgated that the alliance's experiences in enabling the acquisition and transfer to knowledge through their 'lessons learned' initiative presented in this paper provides a learning opportunity for those organizations that are seeking to ameliorate the performance of the projects that they are charged with delivering.

The paper commences with a review of the lessons learned literature and then examines issues associated with the transfer of knowledge within projects with emphasis being placed on the need to embrace situated learning. An exploratory case study of a program alliance that sought to build its absorptive capacity through engaging process and technological change is examined under the following four emergent themes: (1) implementing change; (2) learning climate; (3) learning from lessons learned; and (4) learning in action. The findings are then used to determine the essential ingredients that were required to enable its absorptive capacity to increase so that knowledge that had been acquired could be used to improve its safety and quality performance. In addressing the need to ensure 'relevance' (i.e. practicality and socially applicable), the experiences that emerged from 'practice' are presented. Thus, the paper does not seek to inform practitioners about 'what to do' but rather provide an avenue for 'what they might do' to improve safety and quality performance through implementing a continuous lessons learned initiative. To the authors' knowledge, this is the first example in construction where organizations have actually used their knowledge recombination capabilities to absorb knowledge and learn to reduce rework while improving safety.

2. Literature review

2.1 Lessons learned

A plethora of research examining the nature of lessons learned practices used by organizations and project-based firms to capture, leverage and disseminate tacit and explicit knowledge has been undertaken (e.g. Zedtwitz, 2002; Schindler and Eppler, 2003; Williams, 2008; Caldas et al., 2009; Milton, 2010; Carrillo et al., 2013; Duffield and Whitty, 2015). While lessons learned practices such as post-project reviews and knowledge repositories may be implemented in construction projects, their effectiveness in disseminating new knowledge to enable process improvement has been questioned (Carrillo et al., 2013).

This is due to the absence of systematic organizational mechanisms that can capture and transfer knowledge within and between construction organizations and their projects (Carrillo, 2005; Kululanga and Kuotcha, 2008; Caldas et al., 2009; Paranagamage et al., 2012; Carrillo et al., 2013; Forcada et al., 2013; Shokri-Ghasabeh and Chileshe, 2014). Williams (2008), for example, revealed that while many organizations conduct lessons learned, they seldom implemented them in future projects due to a lack of clear guidelines for implementation, resources and management support. Table 1 provides a summary of the barriers that have been identified as to inhibiting lessons learned.

A major limitation to implementing lessons learned by employees are time constraints (Table 1). Invariably, team members are under constant pressure to adhere to pre-defined project deliverables that are more often than not overly optimistic. Consequently, they seldom have time to invest in additional activities they do not perceive to be of immediate value (Paranagamage et al., 2012). In fact, Paranagamage et al. (2012) suggests that there is a proclivity for formal lessons learned practices to be too process-driven as they are inherently dependent on completing documents and forms. Yet, processes can be designed to be efficient and not create excessive workload for team members (Love et al., 2015a). For example, recognition and rewards can be given to incentivise individuals and teams in the participation of lessons learned by actively sharing their reflections and experiences with a goal to ensuring project deliverables is met.

Within construction, there has been an absence of a culture that embraces and engenders learning (Love et al., 2000a, 2015a, 2015b). As a result, team members are often reluctant to openly share their experiences and knowledge, as well as seek advice due to issues of blame and internal competition (Carrillo et al., 2013). A climate that engenders mutual learning needs to be founded on trust and open communication (Holt et al., 2000).

According to Davis and Love (2011) and Love et al. (2011), relational contracting such as alliances provides a structure and environment for trust to materialize and incentives to be used to drive behaviour within a project. Research undertaken by Love et al. (2015a) has demonstrated that alliances can provide an environment for providing a mind-set change towards implementing lessons learned processes at the individual and organizational level. For such a change to occur, however, Love et al. (2016) observed that an authentic style of leadership was necessary to gain the trust and support of the project team so that learning could be facilitated through a no-blame culture being in place. Essentially, to enable the transfer and sharing of knowledge, team members need to feel 'safe' to admit mistakes and openly discuss solutions to problems.

2.2 Knowledge transfer

The organizational learning literature is sceptical about the effectiveness of routine knowledge management practices such as project closeout reviews (Williams, 2008). MacMaster (2004, cited in Williams, 2008, p. 248) points out that

Table 1
Barriers to implementing lessons learned.

Authors	Barriers to lessons learned
Williams (2007)	Lack of employee time, management support, incentive, human resources, and clear guidelines
Wiewiora et al. (2009)	Barriers related to social communication: • Lack of social communication between projects; • Sharing of 'bad news' is not encouraged; • Lack of time for social communication; and • Lack of willingness to share project faults caused by individual or group performance. Barriers related to inter-project transfer of documented lessons learned: • Lack of comprehensive approach to lessons learned; including processes of transfer of lessons learned beyond the project; • Transfer of lessons learned is fragmented; • Lessons learned are not included in the project scope and/or budget; • Lack of a lessons learned repository; and • Lack of time to produce lessons learned Barriers related to project manager: • Lessons learned have a low priority for the project manager • Young project managers, from generation Y are overconfident and are reluctant to take advice from others; • Project managers do not like sharing their expertise, and prefer to control the knowledge they possess; and • Project managers do not want to criticize processes or people from the organization.
Paranagamage et al. (2012)	Lack of incentives, learning culture, outlets to share lessons learned, and awareness of value added.
Forcada et al. (2013)	Change of mentality needed to introduce KM systems, involvement of employees, emphasis on individual rather than team work, lack of employee time, organizational culture
Carrillo et al. (2013)	Corporate staffs' view: process (quantity rather than quality), reluctance to obtain external advice, duplication of workload, lack of perceived value, internal competition, legal issues. Site staffs' view: inadequate communication. Silo environment, little value added, time constraints, too process driven, culture.
Henderson et al. (2013)	Short-term objectives, project mentality/focus, fragmentation of the industry (lack of integration between designers/contractors), project delivery methods, lack of emphasis on buildability within education system, temporary project participants/partnerships, architects and design engineers lack construction experience, contract type, client resistance, belief that learning leads to over standardization
Shokri-Ghasabeh and Chileshe (2014)	Identified six common barriers from literature: lack of resources, lack of incentive, inefficiency of the process, lack of clear guidelines, lack of employee time and lack of management support

organizational learning from projects rarely occurs in practice, and when it does, it often fails to deliver the intended results. Williams (2008, p. 261) found that the transfer of lessons learned within projects, and from a project to the parent organization, is the least successful aspect of learning. Williams (2008) revealed that undertaking a lessons learned exercise at the end of a project tended to benefit individuals rather than the project or parent organization. On this basis, the current practice is lacking in capturing and transferring lessons learnt, especially 'learnings' that are tacit. Thus, considering this prevailing practice, Williams (2008) suggested that there is a need to have an understanding of the context of lessons and gain generalizable lessons (isomorphic learning), rather than one-off lessons that often occurs. For this to happen, however, requires deliberate attention, commitment, and continuous investment of resources by all organizations involved with delivering a specific project.

Whilst explicit knowledge can be obtained and expressed readily, tacit knowledge is gained through informal interpersonal contacts and sharing knowledge in a social and situated setting (Bresnen et al., 2003; Fernie et al., 2003; Sense, 2008, 2009, 2011; Jugdev and Mathur, 2013). As tacit knowledge is embedded in specific social contexts, Fernie et al. (2003) suggest that sharing (rather than transfer of) should occur through a process of socialization. Bresnen et al. (2003) acknowledge the importance of learning through social patterns, practices and processes, but place emphasis on adopting a community-based approach to managing knowledge. Such an approach can provide an appropriate platform for situated learning, which is akin to learning-on-the job (Sense, 2009), to materialize through the processes of observation, dialogue, storytelling and conversations between people as they participate and interact within one another (Sense, 2011, p. 988).

2.3 Absorptive capacity and organizational learning

To improve the performance and productivity of construction projects there is a need for firms to learn and draw upon lessons that have been acquired from the experiences of individuals, teams and organizations. Alliances have been identified as providing an environment conducive for learning in construction (e.g., Holt et al., 2000; Walker and Lloyd-Walker, 2015). The ability of organizations to value, assimilate and apply new knowledge is referred to as 'absorptive capacity' (Cohen and Levinthal, 1990). Zahra and George (2002) refer to absorptive capacity as an organization's dynamic capability whereby its processes and routines have embedded within them the dimensions of acquisition, assimilation, transformation, and exploitation. Having such a dynamic capability in place can provide an organization with the ability identify and gather knowledge from different sources, interpret and analyse the information that is acquired, and transform processes (Cohen and Levinthal, 1990). Zahra and George (2002) also point out that acquisition and assimilation constitutes potential capacity, and to absorb knowledge or realized capacity (transformation and exploitation) requires social integration mechanisms to facilitate knowledge sharing and improve the efficiency of assimilation and transformation (e.g. authentic leadership, and learning climate). This is in line with the emphasis of learning through the process of socialization within the organizational learning literature.

Absorptive capacity is a function of organizational learning and requires learning capabilities to assimilate knowledge for problem-solving skills and knowledge creation (Kim, 1998). Lane et al. (2006) identified a recursive relationship between organizational learning and absorptive capacity, where increased learning in an area can enhance a firm's knowledge base and help to build greater absorptive capacity, which in turn can improve learning. From a learning perspective, the extent of absorptive capacity of an organization is dependent on three forms of learning, which are: (1) exploratory, (2) transformative and (3) exploitative (Lane et al., 2006).

In examining 'how' a program alliance values, assimilates and applies new knowledge from lessons learned, an case study is undertaken as there has been a paucity of research that has sought to address the research question that is sought to be addressed in this paper. Noteworthy, a program alliance involves the delivery of a number of projects that are bundled into a single program (Walker and Harley, 2014; Walker and Lloyd-Walker, 2014). For example, it may involve a series of smaller projects, each of similar scope, where performance criteria can only be assessed on a program-wide basis (Department of Treasury and Finance, 2006).

3. Case study

A case study is an ideal methodology when a holistic, in-depth investigation is needed to examine phenomena that have received limited attention (Feagin et al., 1991). Case studies are designed to bring out the details from the viewpoint of the participants by using multiple sources of data (Tellis, 1997). A case study is suitable for "exploring situations where the intervention being evaluated has no clear single set of outcomes" (Yin, 2009, p.20). Various approaches for conducting case studies have been identified by Yin (2009) as being: descriptive, exploratory or explanatory.

A program alliance was selected as they involve the delivery of a number of projects that are bundled into a single program. As a result, an environment for learning through knowledge acquisition and transfer from completed projects is potentially created. The alliance was charged with delivering 129 projects over a five-year period. Rework and safety concerns were being experienced in projects and triggered the alliance to address the underlying causes of these issues. A process and technological change initiative was undertaken within the alliance.

3.1. Data collection

Case study is known as a triangulated research strategy. Tellis (1997) has suggested that triangulation can occur with data, investigators, theories, and even methodologies. Stake (1995) stated that the protocols that are used to ensure accuracy and alternative explanations are called triangulation. The need for triangulation arises from the ethical need to confirm the validity of the processes, which is undertaken using multiple sources of data (Yin, 2009). As a result, triangulation formed the basis of the data collection, as it can be used to overcome problems associated with bias and validity (Patton, 1990).

A series of unstructured interviews, documentary sources (e.g., lessons learned register, workshop notes, and reports), non-participant observation, which involved site visits, formed the cornerstones of the data collection process. Table 2 summarizes the different types of data sources and site visits, and Table 3 lists the number of interviews and workshop undertaken.

Initially, twenty-six unstructured interviews were conducted with a variety of personnel such as the Alliance Manager, Design Manager, Safety Quality and Environment (SQE) Manager, Commercial Manager, Site Supervisors and contractors. Purposeful sampling was employed to select the interviewees from various functional areas (e.g. commercial, design, delivery and project support) who were actively involved in initiating and implementing the process and technological changes undertaken within the alliance.

Interviews were used as the mechanism to examine why change was initiated and how the alliance initiated process improvement through implementing a lessons learned initiative. Interviews were conducted at the interviewees' offices and on-site and were digitally recorded, and then transcribed verbatim, to allow for any finer nuances to be detected. Interviews were kept open using phrases such as 'tell me about it' or 'can you give me an example'. The open nature of the questions stimulated avenues of interest to be pursued as they arose without introducing bias in the response. Additional notes were taken during interviews to support the digital transcription process to maintain validity and safeguard against the digital recorder's failure. Each interview varied in length from 10 min to 2 h and a conscientious effort was made to breakdown any

Table 2
Types of data sources.

Data sources	Participants
Database	• Lessons learned and innovations database • Accident and incident database • Non-conformances (NCR) actions database • Rework prevention actions register
Reports	• Lessons learned and rework forum reports • Contractor's forum notes, and reports • Key Performance Indicator (KPI) briefing paper • Rework prevention report
Site visits	• Pump station and manhole • Basin upgrade • Pump station and reservoir works

Table 3
Details of interviews and workshop.

Interviewees	No. of interviews	Duration (min)
Alliance Manager (ALT/M)	1	42
Project Director (ALT)	1	52
Chairman (ALT)	1	20
Design Manager (Design Team)	2	66
Delivery Manager (Delivery Team)	1	24
Design team leader (Design Team)	1	78
Commercial Manager (Commercial Team)	2	79
Systems Engineer (Support Team)	1	24
Risk, quality and support team leader (Support Team)	2	37
SQE Manager (Support Team)	2	31
Project managers (Delivery Team)	5	141
Construction manager (Delivery Team)	1	15
Project engineers (Delivery Team)	1	21
Site managers (Delivery Team)	2	29
Site supervisor (Delivery Team)	1	10
Project and site managers (Delivery Team)	1	60
Site manager and foremen (Delivery Team)	1	44
Contractors forum workshop (Approx. 35 participants from the alliance, consultants and subcontractors)	-	90
Total	26	700

barriers that may have existed between the interviewers and interviewee. Data from workshops conducted by the alliance team members with contractors was made available for analysis. Moreover, the researchers acted as non-participant observers during several of these workshops and recorded their observations, particularly ideas and the emergent discourse that arose from participants interacting with the facilitator.

3.2 Description of lessons learned data

The alliance team members had meticulously recorded the lessons learned by providing a detailed description of each lesson, as well as the amounts of savings (if any), and the date and phase in the project that they occurred. A total of 88 out of 129 projects that were delivered recorded lessons learned in the register. The majority of the projects were pipeline works (43%) and pump stations (27%), as denoted in Fig. 1.

A total of 1063 lessons were recorded, and a detailed breakdown for each project type, is presented in Table 4. Water tank projects documented the highest number of lessons per project, followed by storage, pump station, channel, pipelines and treatment works, respectively.

Table 5 summarizes the lessons learned in accordance with the different phases of a project's life cycle. A large proportion of the lessons learned and/or innovations occurred during the construction (35%) and design phases (detailed design 25% and functional design at 12%) of a project.

4. Case background

The Barwon Water Alliance was established in 2009 to deliver 129 water infrastructure projects, comprising of pipelines, water

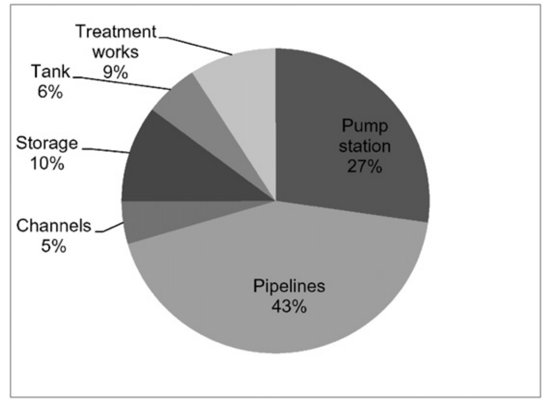

Fig. 1. Composition of project types in lessons learned register.

treatment plants, pump stations, tanks, storages and channel works throughout a regional area of Victoria in Australia. After an extended period of drought in 2008/2009 and significant growth in the region, the demand for water increased. As a result there was a need to up-grade existing and construct additional infrastructure to meet this demand. The alliance team was comprised of three organizations, the Owner Participant who was responsible for delivering water to its customers over an area of 8100 km^2 to five municipalities and 275,000 customers, an engineering consultancy who provided design, environmental and stakeholder management expertise, and a contractor who provided commercial and construction capabilities. The program of works to be undertaken was $375 million over a five-year period. At the onset of the alliance, a set of core values were established – Safety, Teamwork, Respect, Innovation, Vibrancy and Excellence, which were latter aligned to a set of Key Results Area (KRA) (e.g. environment (non-compliance criteria) 15%, delivery 30%, functionality 15%, regional benefit 15%, people and well-being 15%), which had a total of 21 KPI. In 2014, the program of works was transitioned to the Owner Participant, as it was always intended that during the alliances' life, both the engineering consultancy and contractor would provide the knowledge and capability to enable them to continue with their projects alone.

4.1 Program alliance

In 2011, approximately 2½ years into the five-year program, the Alliance Leadership and Alliance Management Team became aware that a number of projects were incurring unnecessary cost and time delays due to rework and issues relating to safety. This coincided with the first batch of projects, which reached the end of their two years 'Asset Proving Period' (i.e. defects liability). An average of a three-week delay per project was being experienced due to rework issues, which, at the time equated to in excess of AU$1 million in costs to the alliance alone (e.g., management and supervision). Over the life of the program, the estimated costs that would have been incurred by the alliance were estimated to be in excess of AU$3 million. The costs borne by contractors due to this rework were estimated to be at least five times this estimation. Noteworthy, the costs of rework did not

Table 4
Detailed breakdown of types of lessons.

Lesson types	Management	Channel	Pipeline	Pump station	Storage	Tank	Treatment works	Total	Percent
Lesson Learned	15	24	218	164	98	80	31	630	59%
Value Add	11	6	66	40	17	3	21	164	15%
Innovation	16	2	12	15	3	2	3	53	5%
Key Lesson		11	73	71	20	17	6	198	19%
Missing								18	2%
Total lessons	42	43	369	290	138	102	61	1063	100%
Project count		4	38	24	9	5	8	88	
Average lessons per project		11	10	12	15	20	8	12	

vary between the project types. Yet, the number of product quality NCRs formally raised and reported by contractors was zero, although it was clearly known this was not a reflection of reality, due largely to the fear of blame and damage to the organization's reputation. Moreover, rework was deemed to be a 'norm' and thus 'business as usual'. It was not until the contractors became aware of the problem that they began to work with the alliance to prevent its future occurrence.

The Alliance Leadership and Alliance Management Team knew that there were quality issues as a result of their inspections, but at the time felt the alliance lacked the systems, contractual power, relationships and culture to support and enable the contractors to identify errors and mistakes which could lead to rework. A concerted effort had been made within the alliance to report safety and environmental incidents, which improved over time, but the existing processes in place were inadequate to equally capture quality assurance (QA) and potential rework. Furthermore, no effort had been made to account for rework, as there was a perception it was a result of poor work practices and demonstrated failure. The alliance recognized that safety was being jeopardized as a result of a number of rework incidents. On average, 10 incidents/near misses (of all types) were occurring per month, particularly during months of November and December where 30 incidents/near misses befell due to several issues such as fatigue and stress. In fact, it was propagated that the likelihood of a person being injured while attending to rework was nine times greater when compared to normal work activities (Cumming, 2014). This was of a great concern to the alliance as it was contradictory to their underlying value system that had been developed at the onset of the project. Responsively recognizing the problem at hand, the Alliance Leadership and Alliance Management Team, collectively with the Non-Owner Participants, embarked on a targeted safety and rework improvement program to alleviate significant SQE issues that had been consistently emerging.

Table 5
Breakdown of lessons according to project phases.

Project phases	Number of lessons
All phases	9 (1%)
Concept design	50 (5%)
Commissioning	46(4%)
Construction	372 (35%)
Defects period	5 (0.5%)
Detailed design	266 (25%)
Functional design	132 (12%)
Procurement	28 (3%)
Stakeholder and approvals	28 (3%)
Uncategorised	127 (125)
Total	1063 (100%)

5. Research findings

5.1 Implementing change: re-defining alliance values

The Alliance Leadership and Alliance Management Team recognized that the culture of the alliance needed to change and a learning climate needed to be created to combat the rework and safety issues that were repeatedly occurring in their projects. The alliance had no clear strategy in place to address rework: it had been simply not recognized. In fact, when rework did occur, the Alliance Manager observed that that the mindset of people changed drastically and they became demoralized.

At the time when rework was identified as an opportunity for improved performance (e.g., cost, time and team satisfaction), the Alliance Leadership and Alliance Management Team observed that their initial KRAs (each had three to four different KPIs) were not aligned to alliance values and the nature of work that was required. A total of 21 KPIs had been developed to measure performance, which the alliance team found difficult to understand and implement. As a result, the original 21 KPIs were reduced to eight, which the alliance team was able to comprehend and consider tangible. The revised KPIs for each KRA were:

1. Delivery (40%) with earned value with a weighting of 40% and schedule 60%
2. Functionality (15%) with a weighting of 100%
3. Regional benefit (15%) with a weighting of 50% for subcontractor performance and legacy panels 50%
4. People and well-being with a weighting of 33% for value add and 67% for OP transition
5. SQE Risk Management (15%) with a weighting of 100% for Positive Performance Indicator Frequency Rate.

Values were re-defined and aligned to the performance objectives that were established, for example, safety was aligned to 'no harm' (i.e. the creation of mindset damage and rework can be prevented), and delivery to excellence. To improve the alliance's absorptive capacity awareness and accountability became central features of its ability to acquire and transfer knowledge. To be able to learn and instigate process improvement it was essential individuals were able to confidently answer three questions: (1) What am I accountable for? (2) What are the key risks and controls? (3) How do I know the controls are in place and effective?

A number of initiatives were established to build the capacity of the alliance under each of the questions. For example, under question one, paper-based manuals were replaced with a customized series of web-based process flowcharts to improve process clarity. In addition, to enhance individual accountability a ‘Code of Conduct’ was established through team consultation. All individuals working within the alliance were required to commit to its vision of ‘no harm’, which is described in further detail below. In addressing question two, behavioural based inductions, SQE leadership training, key risk area training and team based planning were initiated. Under question three, a series of checkpoints and surveillance regime were put in place to ensure effective controls had been allocated. For example, throughout the design and tendering phases, sign-off from SQE, operations and construction teams was required to ensure they were satisfied with the design and proposed delivery method. Moreover, prior to construction, a kick-off planning meeting would be held for each project to review their strategic risks. During construction, commission and handover a series of inspections, audits, and reviews, all essential processes for knowledge acquisition and enhancing the knowledge base, were regularly undertaken to ensure compliance and process improvement. Information from these inspections and audits were collated in real-time via an iPad/web-based system providing immediate trends for monitoring at the program and project level and, where required, issuing and tracking of corrective/preventative measures. An example of a trend identified and addressed by the alliance through this process is the number of injuries incurred and rework events, which are represented in Fig. 2. The information is extracted directly from the alliance Compliance Software Solution that automated all steps in the compliance management process, tracking responsibilities and due dates for legal and non-legal obligations.

5.2 Learning climate

The focus on creating an awareness and accountability provided clarity about what people had to do to ensure the ‘no harm’ mindset that was created translated into experiential learning. In addition, people were engaged and became part of the solution in conjunction with a genuine intent to understand people’s challenges and allowed roles to be framed within the context of climate.

An explicit feature in creating the new climate was ‘learning’ through interaction and participation between the alliance and its contractors. Particular emphasis was placed on feedback and knowledge acquisition derived from work processes, information, reflection and discussion between alliance members and its contractors; a distinct shift away from single-loop to double-loop learning occurred. A detailed description of ‘how’ the alliance was able to undertake this process can be found in Love et al. (2015a).

The Alliance Leadership and Alliance Management Team actively promoted the principles embedded with an alliance such as trust, honesty and cooperation to engender an error management culture (i.e. an organizational culture that supports effective and productive error handling). The same level of promotion to safety was also afforded to rework. The development of this culture was a major challenge for the Alliance Leadership and Alliance Management Team, which required changing existing behavioral norms and values that had already been established within the alliance. To enable an error management culture, the adopted model for change focused on changing behaviors, its climate, providing motivation and re-examining the way performance was being measured. Not only did the Alliance Leadership and Alliance Management Team provide awareness to the Non-Owner Participants of the opportunities that would be afforded of a cultural change, but they also actively engaged their contractors. To achieve this aim, the Alliance Leadership and Alliance Management Team recognized that they needed to demonstrate their commitment to change by providing additional resources to contain and prevent rework.

Another issue considered was the institutional politics that existed within the Non-Owner Participants’ organizations. For example, within the contractor’s organization, the issuing of NCRs was deemed to reflect poorly on their ability to manage a program of works and therefore NCRs tended to be avoided. Yet, the issuing of NCRs provides a valuable learning opportunity and demonstrates that a detection system is in place, which is a pivotal aspect of rework prevention. An over reliance on rework prevention may reduce their detection. When people are convinced that rework prevention is successful, a form of *hubris* may manifest, which can lead to a decrease in its anticipation, rendering it difficult to detect (Love et al., 2016). It was acknowledged by the SQE Manager, however, that a duality was associated with rework. On one hand, it had negative consequences on safety, productivity, cost and schedule performance, but on the other, it provided learning opportunities for other projects that were to be undertaken as part of the program of works.

5.3 Learning from lessons learned

Learning formed the nucleus of the alliance’s new culture, which was championed by the Design Manager. The journey to reduce incidents and rework required the alliance to develop systems that could dynamically capture in real-time, issues that contributed to them, as well as other events, so the project team and contractors were aware of issues that may arise in other projects to be constructed. To support continuous improvement, a lesson learned system was developed and integrated into the alliance’s Compliance Management System, which was implemented as part of the change initiative that was embarked upon. The developed lessons learned initiative provided a systematic process of collecting, disseminating and institutionalizing lessons learned from projects and was incorporated into the process architecture of the alliance.

The lessons learned process developed by the alliance is presented in Fig. 3. Lessons learned were acquired from a variety

Fig. 2. On-line trend analysis from field-based monitoring.

of sources such as functionality assessments, and compliance reports, and informal observations and experiences of individuals that had been ‘explicitly’ documented. Standing ‘lessons learned’ agenda items on project meeting templates also provided a platform to capture ideas while they were still fresh in the team's mind. It was recognized that having the project closeout meeting as the only formal place to capture lessons learned was not optimal since it would often be months or years since relevant learning events had occurred, and key project staff might have moved on to other projects. The lessons learned register, a macro driven

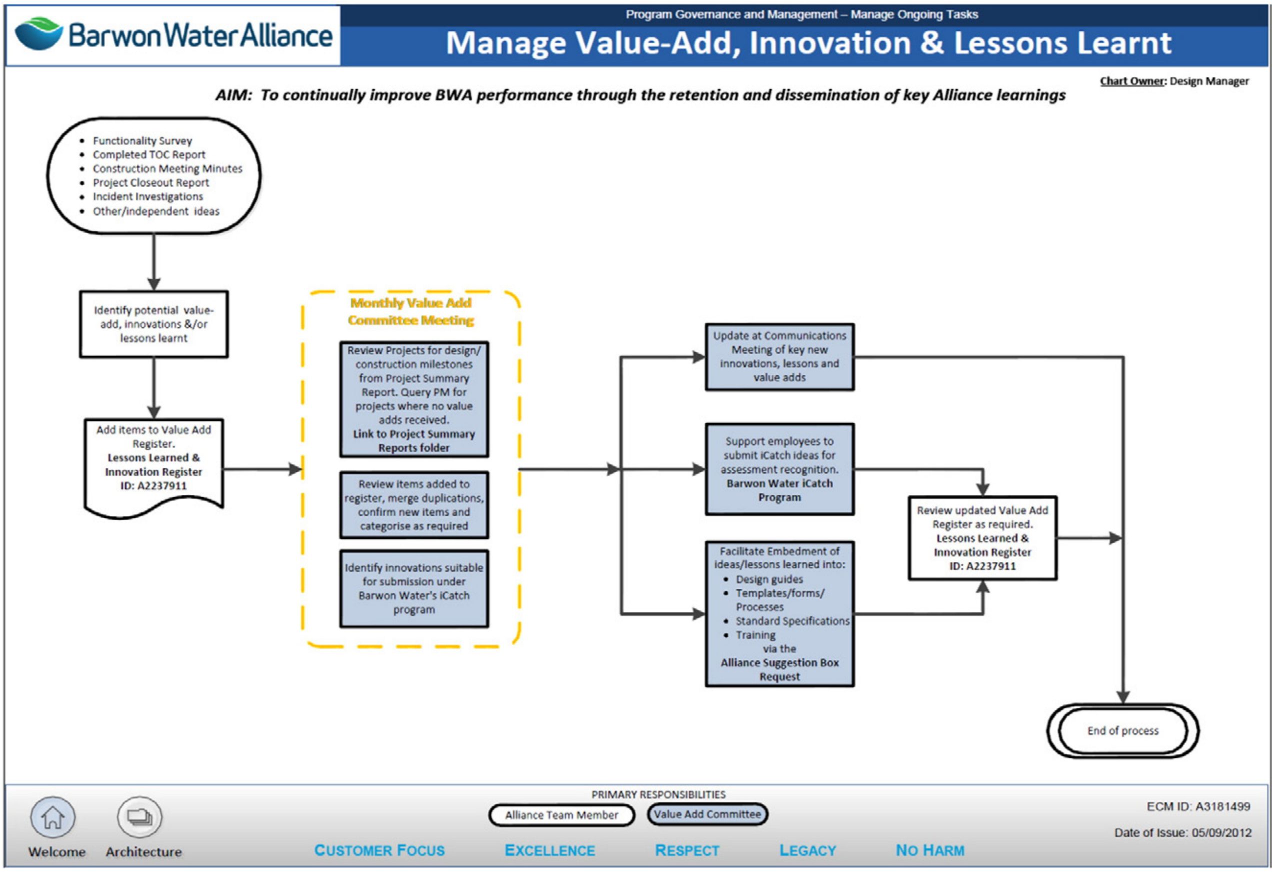

Fig. 3. Lessons learned system workflow.

spreadsheet presented in Fig. 4, was accessible to all project team members and all were encouraged to participate in the initiative. The register also acted as a 'value-added' and innovations register, where the costs or savings from implementing actions were documented. The alliance recognized that there was often crossover between a lessons learned, an innovation and a 'value add' provided by the project, all of which had KPI drivers to ensure they were captured. The process of entering such data needed to be seen as simple and efficient by employees, with no need for duplication of data across different registers. The efficiency of learning from lessons, that is acquisition and assimilation of knowledge, affects the project's ability to transform and exploit new knowledge.

The transparency of the lessons learned system provided the project team members with the confidence to explore and challenge existing knowledge (e.g., specifications and work methods) and propagate innovative ideas through the Owner Participant's Innovations Catchment (iCatch) Program. Project team members were encouraged and rewarded to input lessons they had encountered in their daily work into the lessons learned register and iCatch program.

When a project was completed, three key lessons were identified, summarized and distributed to all alliance team members and contractors and subsequently discussed during project closeout workshops. An example of the lessons learned that were distributed can be seen in Fig. 5. Rather than distributing a simple list of issues to consider it was perceived that a visual of the project would provide people with context to reinforce learning. In addition, a full list of lessons learned in the register for that project was also issued to project team members and nominated Lessons Learned champions (from each alliance department) to review and identify specific actions to improve and prevent reoccurrence of the issue. A period of 48 h was given for the review and for actions to be entered into the register. The register prompted for controls to be put into place through updates to systems such as design guides, standard specifications, standard drawings, inspection/audit checklists, process flow chart/forms, toolbox topics, construction guides, training guides, or simply as a discussion topic for a following meeting.

In each case, a person was nominated to be responsible for the action and a due date provided. Earlier attempts at establishing a lessons learned implementation process were unsuccessful for a variety of reasons, which included:

- A register alone to capture ideas was insufficient. Even though employees were prompted to review the 'Lessons Learned Register' at key points of the project delivery process to check for relevant issues, this rarely occurred; and
- The register originally had a simple field for follow-up action, however it was found that these actions were never completed, as there was no simple/automated method of informing the responsible person of their action from a spreadsheet, nor

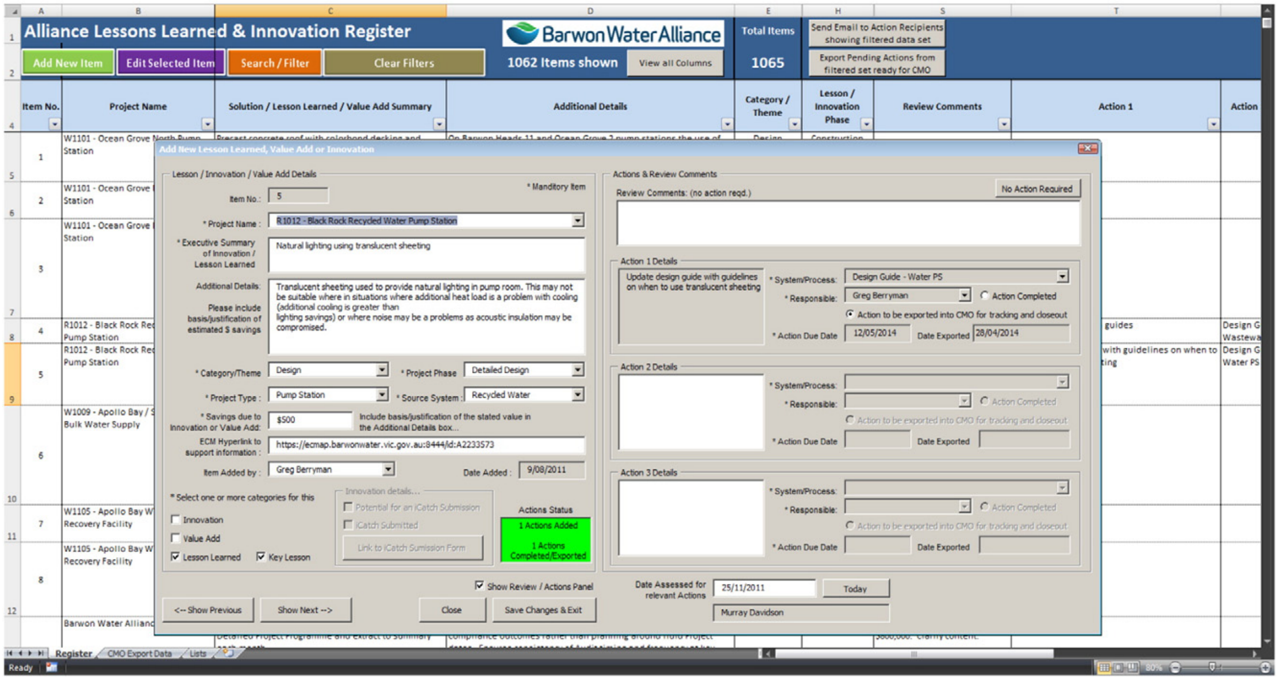

Fig. 4. The lessons learned and innovation register.

reminders of outstanding actions. The manual re-entry of action data was a time consuming administrative task and so the system failed. In addition, employees were not held accountable for any actions entered into the 'Lessons Learned Register', and so other tasks took priority.

The real shift in closing the lessons learned loop occurred when an automated method of merging the actions from the 'Lessons Learned Register' with the central action tracking register in the Compliance Management System, from which all employees received regular reminders of outstanding actions.

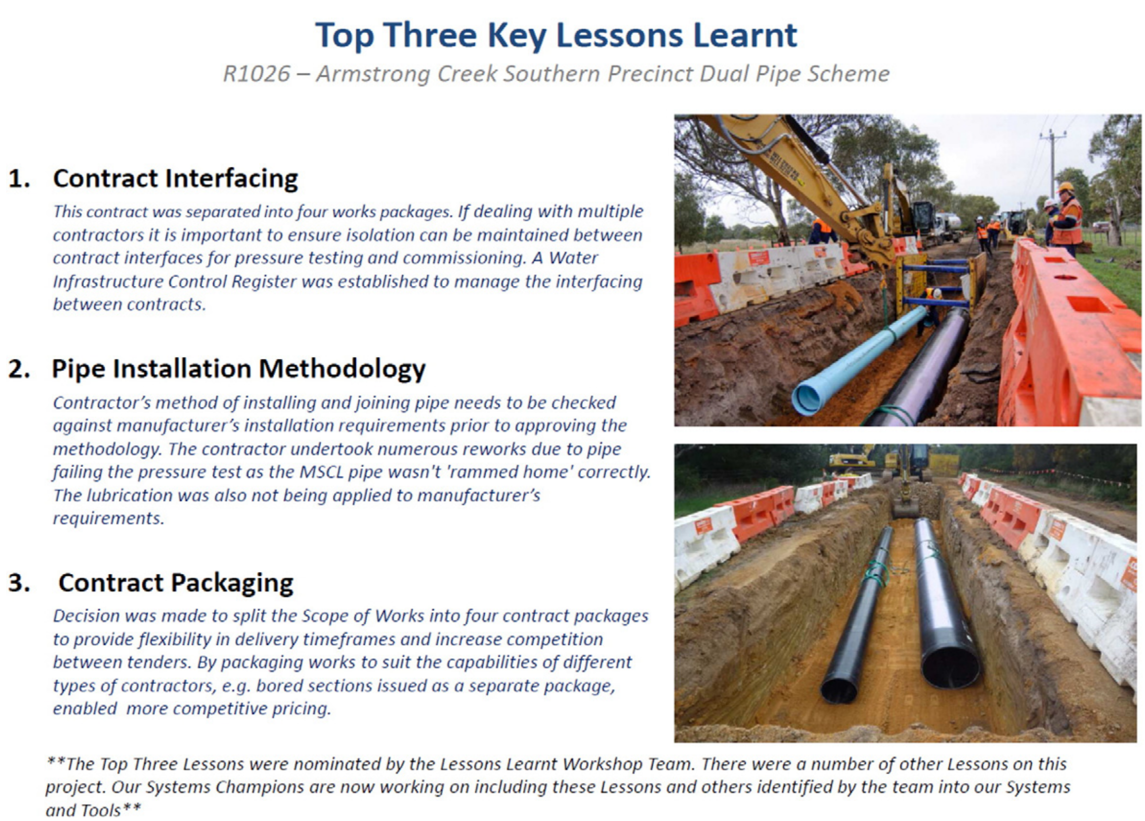

Fig. 5. Example of top three lessons learned for a pipeline project.

From these highly visible action lists, management drove actions and shifted their subordinate's priorities based on due dates and fear of a red 'Overdue' status. The importance of management support for employees to capture and implement lessons learned should not be underestimated. Employees were encouraged and permitted to make time to implement the procedural/technical changes resulting from the lessons learned outcome actions, or again, the loop would not be closed and the system fail.

Ideally, if lessons learned could have been entered directly entered into the Owner Participant's central application or system for managing actions/tasks, then the complex middle step of action data transfer between systems could have been eliminated and the process streamlined. A further key factor was the allocation of employee(s) as 'champions' for the process, who were responsible for organizing project closeout/lessons learned meetings and carrying out associated administrative tasks. Personal lessons learned related KPIs for these champions, staff and managers were also strong drivers and motivators to keep the processes moving.

Regular face-to-face meetings/workshops were also undertaken to disseminate experiences and reflect on issues that had been incurred. An example of minutes developed from a project and issues discussed in the workshop are presented in Fig. 6. Consequently, tacit-to-tacit knowledge was shared, which formed the building blocks for creating a contextual backdrop for the lessons that had been acquired throughout a project. Through this process of socialization, tacit knowledge became explicit, as individuals were able to explain knowledge and know-how.

The alignment of the Compliance Management System with the lessons learned system provided the alliance with the ability to 'close the feedback loop', which gave them the impetus to embrace learning. Mover, it facilitated the sharing of responsibility for maintaining the process of 'getting', 'giving' and 'learning' to be undertaken in a proactive rather than a passive manner. Thus, learning within the alliance was embedded in a reciprocity process that emphasized mutual and equal balance between knowledge acquisition and sharing. Evidence of this could be seen in the 'Lessons Learned Register' identified in Fig. 4, where a rework issue was identified and an email was distributed to people informing of what had transpired, which then enabled them to take an appropriate action. Throughout the duration of the alliance, a total of 1063 lessons were derived from 88 of the 129 projects, with the most originating from design (n = 364) and construction (n = 230). Fig. 7 provides a categorization of the lessons learned. The main project types with the highest number of lessons learned were: water pipelines (21%), sewer pump station (19%), sewer pipelines (11%) and water storage (10%). Noteworthy, 60% lessons learned resulted in actions being undertaken and changes being incorporated into design guides, protocols and systems, specifications and standards.

The need to address rework and safety were the drivers for initiating change within the alliance so that learning become a function of daily working. A detailed analysis of the lessons learned derived from the register for rework was used to construct a causal map of the issues contributing to its occurrence in design and construction (Fig. 8). It can be seen that constructability issues on site, geological conditions, and the interface between design and construction were contributors to rework. The Alliance Management Team observed, for example, that their design engineers were divorced from what actually transpired on-site. There were several incidences where what was being designed were difficult to construct or not understood by the construction team and this impasse later caused rework. In addition, lessons learned during construction were not being fed back into the technical specifications to align the design intent with the preferred construction methods or materials.

Thus, engineers were required to complete 'design intent' site visits from the commencement of construction and engage with the construction team to confirm an understanding of the design and the specification that was in place. In addition, constructability reviews in the design phase were enhanced through the designer and construction team attending site visits at the 30% stage of the detailed design development to discuss a range of design topics such as the extent of bulk excavations required, existing services, and site access. This process improved constructability and any unresolved design issues (e.g., exclusions) were clearly articulated to the contractor. A site leadership induction programme for contractors was also

- **Alliance toolbox talks –** Continue to be well received. Over 85 topics delivered to date. Encouraged Contractors to provide input to topics and suggestions.
- **Web portal –** a feature agenda item for this forum. Refer details below.
- **PPIFR** - Positive Performance Indicator Frequency Rate (PPIFR) continues to be used a measure of overall SQE improvement. Trending upwards from around 40% a year ago to now approaching 75%. Noted also that the rise in PPIFR has coincided with a marked reduction in lag indicators TRIFR and LTIFR (0.0).
- **SQE inspections/audits** - Over 650 individual surveillance/ monitoring activities since previous forum. Key risk areas continue to be environmental management, excavation/trenching, and work at heights. Confined spaces has been the risk area of most notable increase with regards non-compliance.
- **SQE Awards –** The Alliance continues to reward the best Start Card and/or Hazob card every few months. Noted that the quality of reporting has improved and the effort and focus given towards the Start Card process has not gone unnoticed by Alliance management.

  BWA submissions for industry awards in recent months has resulted in winning the CCF Victoria Earth Award, a High Commendation in the Alliancing Association of Australasia Excellence Awards, and a Certificate of Merit in the National Safety Council of Australia National Safety Awards of Excellence.
- **AMS –** update provided on the outcomes of the AMS working group that formed at the last forum and worked

Fig. 6. Extract of minutes from a workshop forum.

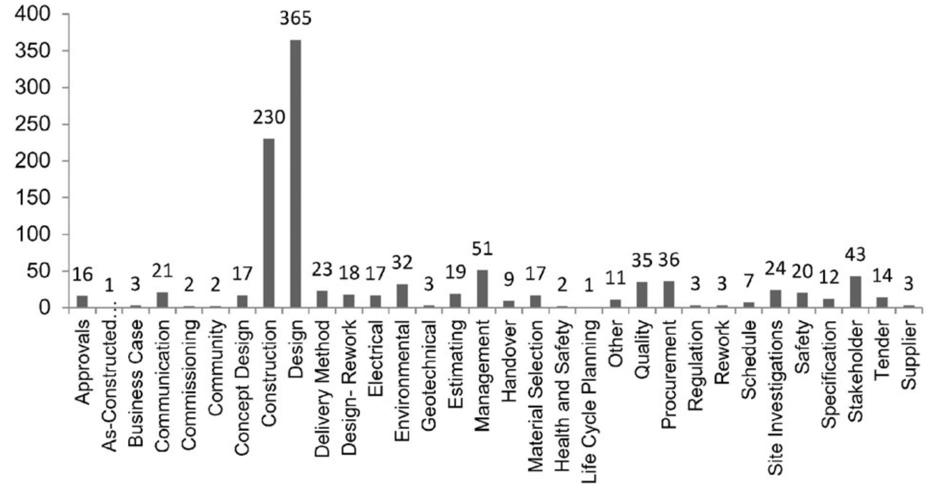

Fig. 7. Categorization of lessons learned.

established as part of a strategy to provide them with the skills and capability to improve the productivity and performance of the projects that they had been contracted to deliver.

5.4 Learning in action

Examples of the double-loop learning that occurred in the alliance relating to safety and quality (e.g. rework) are presented below. In the examples, processes were developed or significantly changed to accommodate the issues to ensure that they would not be repeated.

5.4.1 Safety

Lessons learned from safety incidents (e.g., accidents and near misses) were reflected and enacted through revisions to design, standard procedures and construction methods. For example, an incident occurred when personnel were required to cut a High Density Polyethylene (HDPE) liner for a pump

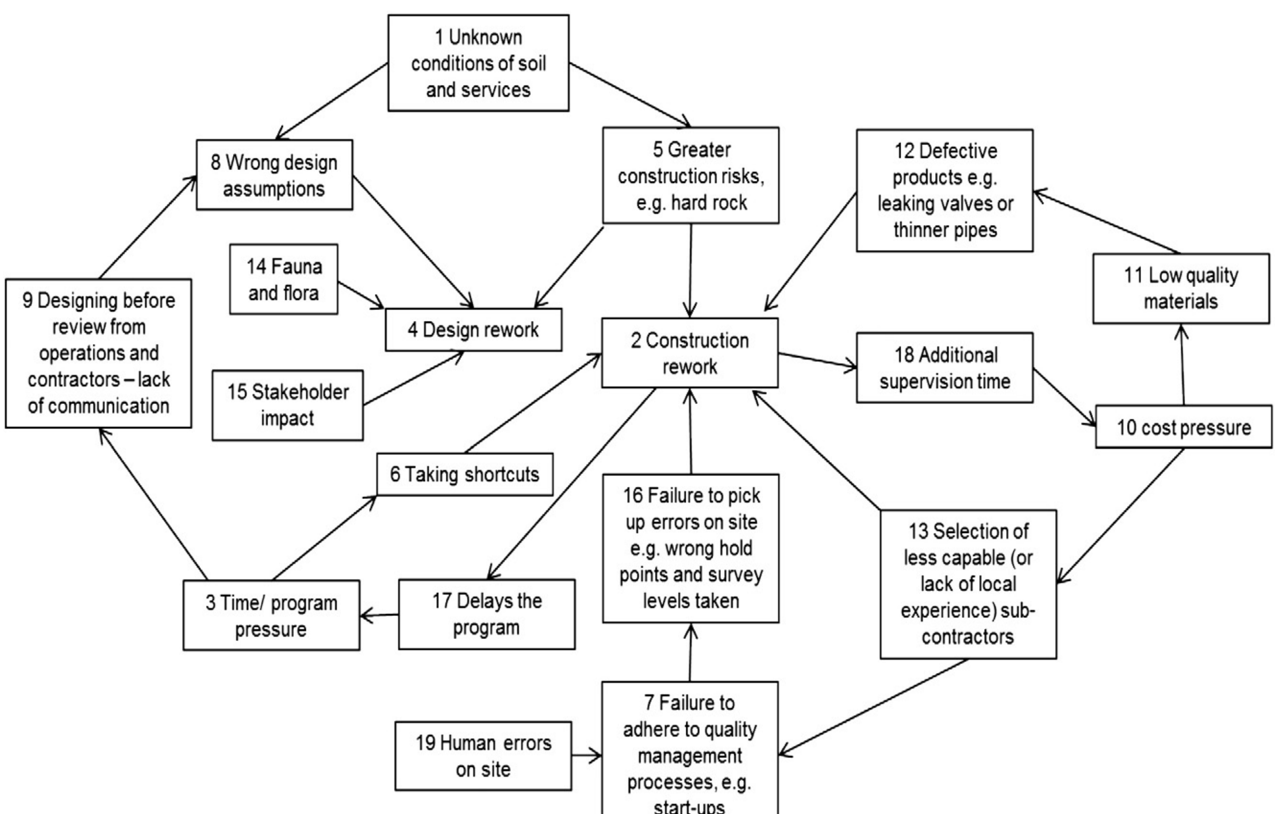

Fig. 8. Causal map for design and construction rework derived from lessons learned.

station wet well that was 3 m in height but the formwork had only been constructed to 2.4 m. The HDPE liner protects the concrete well from corrosive gases. After a detailed investigation, it was proposed that designers need to consider alternatives to reduce height safety risks, that is, evaluate the HDPE liner against other epoxy coatings and/or use of forced air ventilation/extraction from the pump station voids to eliminate volatile gases. In another example, a 12 m × 2.4 m diameter pipe rolled off the side of the truck narrowly missing the transport driver. The pipe had been placed on the back of the truck without being chocked, and rolled off when the tie-down straps were removed. However, this incident was not due to a negligent act, but the standard procedures did not require storage pipes in transit to be chocked. As result of this incident all large diameter pipes on the back of trucks were chocked.

5.4.2 *Quality*

Learning from an error and subsequent rework that occurred in projects was considered to be positive experience within the alliance. In tackling this problem through the change management initiative, processes and procedures became more efficient and effective, particularly those relating to the SQE risk management. For example, the revised process for SQE risk management at project initiation involved the use of standard Project Risk Assessments to develop the risk profile for each project type (Cumming, 2014). Risks that could not be mitigated through the Project Risk Assessments were then transferred to the Workplace Risk Assessment. For activities identified as high or medium risks in the Workplace Risk Assessment, an Activity Method Statement was developed to ensure the appropriate construction methodology was implemented to reduce risks on-site. The stage of the process was the development of a Safe Work Method Statement where the methodology was broken down into logical steps and tasks for site staff. Finally, a ‘Start Card’ was required to be completed by individual site staff as a final check before commencing and conducting work so as to ensure all risks were identified and controlled.

On the ‘Start Card’ it was made explicit that “No Harm, is a belief that harm, damage or rework can be prevented”, if anyone did not adhere to the specific requirements they were given a warning. However, if an individual was found to have blatantly committed an action identified on the ‘Start Card’ they would be immediately removed from site. It had been observed by site managers and widely discussed in the workshops that many safety incidents were arising when rework was being undertaken. Emphasis was ‘openly’ placed on rework prevention. Moreover, the ‘Start Card’ explicitly stated that if NCRs were not reported then individuals could be dismissed.

From the lessons learned, it was revealed that the most common rework that occurred in pipeline construction was attributable to failure to comply with hydrostatic pressure testing. In this instance the pipeline was pressurized up to 25% over the normal operating pressure and held in this state for a number of hours. However, failing the pressure test was often accepted to be the norm. A pipeline typically consists of an array of flanges and bolts and when a pressure test fails the propensity for a rupture increases. To identify a leak, sections of the pipeline need to be re-excavated and checked, then backfilled and pressure tested again. There were several instances where it took a couple of months to identify the location of leaks, and it was not uncommon to uncover sections of the pipeline four or five times at significant cost. It was identified through the monthly meetings and lessons learned system that values were a major contributing factor to the pipelines failing the pressure tests.

In one particular case, a recycled water pipeline had 100 valves with 25 of them being revealed to be defective. The valves had a brass nut that cracked under extra pressure. Consequently, the contractor had to rectify the defect, which involved excavating the earth to uncover the pipework and replacing the valves. Furthermore, five of the valves were situated in a roundabout, and therefore it had to be demolished and re-constructed, with the contractor having to install temporary road and traffic management throughout the rectification period. The original order for the 100 valves was AU$240,000 and the estimated cost of rework AU$200,000. The lesson learned was incorporated into Safe Work Method Statement, which resulted in an action that led to testing of the valves above ground on-site or in-situ. After a year into the lessons learned program, it was observed that the number of NCRs and safety incidents had significantly reduced and approximately AU$24 million was saved from innovations that had been suggested by project team members.

5. Discussion

To reduce rework and ensure the safety for individuals during construction, there is a need to measure and monitor their progress. When deviations in quality or incidents arise, then actions need to be taken in order to mitigate their future occurrence. In construction, however, there has been a proclivity to discount the negative influence of rework, as it is perceived to be associated with poor workmanship (or management) and a fear of being held accountable for the action (Love et al., 2015b).

The Alliance Management Team recognized there was a problem with rework, which had also adversely impacted safety. Accordingly Cumming (2014) and Love et al. (2015b) have indicated that a symbiotic relationship exists between quality and safety. Instead of engaging with the process of single-loop learning, which would invariably result in underlying problem(s) remaining within the alliance, the Alliance Management Team sought to identify and remedy the underlying causes that were contributing to rework through double-loop learning. The underlying causes of rework within the alliance, discussed in detail in Love et al. (2015a), pertained to its culture, organization, systems, and procedures that had been established at the onset of the program. The change management initiative that was instigated focused on creating a learning climate, whereby knowledge acquisition and transfer provided the impetus for process improvement to be undertaken. The design of new formal and informal initiatives provided the platform for lessons learned to form an integrated part of the alliance's fabric and enrich its absorptive capacity, which resulted in significant reductions in rework and improvements in safety. The alliance had embedded routines and systems which created improvements in accordance to the components of absorptive capacity, that is, from a process perspective (Zahra and George, 2002), and from a learning perspective (Lane et al., 2006). Table 6 summarizes the initiatives and processes in relation to the components of absorptive capacity.

To implement effective lessons learned, managers and decision-makers in construction, therefore, need to possess and espouse three essential ingredients within their projects: (1) a self-awareness to recognize what is often unconscious or habitual, (2) honesty and ability to admit mistakes and discuss with team members to discover and validate underlying causes, and (3) taking responsibility to act appropriately on what is learned. The formal lessons learned register coupled with the ability to speak freely and share experiences at the workshop forums, provided the basis for mutual understanding of high-risk events. Such open communication can facilitate the speedy detection of an error and the handling of the subsequent rework that may be required (Love et al., 2016). Moreover, the acceptance of rework can allow and encourage exploration, which in turn can foster learning and a deeper understanding of the event and conditions that lead to its occurrence. According to Love et al. (2015a), a high-error management culture can stimulate innovation, as people accept errors as a natural part of work and are confident they will not be blamed when errors arise. Furthermore, in such cultures people are likely to communicate more openly about errors and mistakes with their peers, which may encourage individuals to explore and experiment and therefore learn through experience.

This absorptive capacity of the alliance, however, could only be established by developing knowledge processing systems, which provided the basis for learning through experience to materialize. The tuning of the alliance's absorptive capacity required a mixture of new systems and processes, and coordination abilities with their contractors and subcontractors. Such an approach to innovation relies on coordination capabilities (e.g. loosely formalized procedures and informal knowledge networks) (Aribi and Dupouët, 2016). Rather than pursuing "a new to the world" innovation, the alliance adopted a "new-to-the-organization" approach, which was a less radical in nature (Aribi and Dupouët, 2016). A key ingredient contributing to the alliance's absorptive capacity, was the high degree of autonomy provided to project team, which enabled them to actively engage in the innovation process. As a result this enabled creativity, routine-breaking behaviours and the avoidance of existing routines to thwart the innovation process (e.g. O'Reilly and Tushman, 2004).

6. Conclusion

The case study presented this paper has provided an understanding of how the absorptive capacity of an alliance enabled it to combat rework and improve its safety. A key observation was that absorptive capacity relied on the establishment of knowledge processing systems which enabled it to learn and adapt its capabilities. Recognizing that rework had become a problem provided the alliance with the foresight to prevent its future occurrence by engaging in a change management initiative that required it to re-define its values as well enhance the accountability and awareness of project team members. In doing so, the alliance established a learning climate that was underpinned by robust systems and processes, which provided the mechanisms to maximize its absorptive capacity. By actively acquiring and transferring knowledge through formal and informal mediums the alliance was able to shift its mindset from single to double learning and therefore further fuel its absorptive capacity. The resultant experiential learning that was engendered lead to improved quality and safety performance being experienced. The alliance's experiences presented in this paper provide a learning opportunity for those organizations that are seeking to ameliorate the performance of the projects that they are charged with delivering.

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Table 6
Dimensions of absorptive capacity within the alliance.

Process components of absorptive capacity	Learning components of absorptive capacity	Initiatives/processes/systems
Acquisition	Exploratory learning	Data was collated in real-time via an iPad/web-based system, CMO compliance system during inspections and audits.
Assimilation		Development and implementation of web-based process flowcharts, behavioural based inductions.
Transformation	Transformative learning	Transformative learning through Implementing Change: Re-defining Alliance Values, and development of error management culture (i.e. an organizational culture that supports effective and productive error handling), as well as a conducive learning climate. Acceptance of rework as part of learning.
Exploitation	Exploitative learning	Utilize and exploit acquired knowledge in creating design innovations and efficient solutions to problems.

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