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Investigating Innovation Practices in Design: Creative Problem Solving and Knowledge Management

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Abstract
This paper describes a case study investigating two key aspects of innovation practice in an engineering company: creative problem solving (CPS) and knowledge management (KM). CPS methods offer benefit to organisations in developing novel solutions and improving operations. This research identified the key factors in applying CPS methods from the literature, and compared the creative practices of one engineering organisation with three creative organisations. KM practices can support the sharing and reuse of innovative practices and creative outcomes. A central conflict in adopting KM is codification vs. personalisation. This issue is discussed with reference to a KM framework proposal.

Keywords:
Innovation, Creativity, Creative Problem Solving, Innovation Team, Knowledge Management

1 INTRODUCTION

This research set out to investigate two critical areas within the scope of an innovation team in a large engineering company (hereafter referred to as EngCo). The innovation team are a central resource charged with the promotion of innovation and creativity across the business. They operate a variety of activities and programs, which are designed to foster and improve innovation, including innovation awards, an ideas scheme, and innovation booster sessions.

In order to stimulate creativity and innovation, EngCo assign teams of employees to take part in creative and technical thinking meetings to support and promote creative practices. Innovation booster sessions are one such example. They are essentially creative problem solving (CPS) workshops led by a trained facilitator. The sessions are generally initiated by a problem owner who suggests the topic and identifies suitable attendees. The innovation office staff arrange the workshop location, as well as assigning a facilitator and additional employees to take part. Once the workshop is complete, the problem owner creates a report describing the outcome of the session. The innovation office collates these reports with the intention of sharing them across the company.

This project was focused in particular on the CPS workshops, from two perspectives. The first perspective relates to the CPS tools applied in the workshop: which tools should be used in a given scenario, and what are the best practices in applying those tools? The second perspective relates to the knowledge management (KM) activities carried out by the innovation office: how best to share the outcome of the innovation workshops?

The academic literature in the creative problem solving domain is somewhat limited: there is a large amount of literature describing creative problem solving methods but very little describing how to link a given problem type with a particular problem solving method. In the knowledge management domain, various generic solutions have been proposed to deal with knowledge management for innovation. The term innovation is variously used to describe both 'creativity' and 'new product development'. As such, there is limited provision for knowledge management for 'creativity'.

First, this paper will describe the methodology applied in the research, followed by a description of the underlying concepts from the literature. Following that, a description of the case study findings is presented. This includes a discussion on how CPS can be applied in an engineering design scenario, and a proposal for a KM framework to support an innovation team.

2 RESEARCH METHODOLOGY

This project set out to identify the important factors in applying CPS in an engineering company, and the KM methodology associated with that activity. The approach to the research involved three key stages: a literature analysis, a case study with EngCo, and two comparative studies with other organisations (one KM and one CPS).

The case study took place separately in these two distinct areas, with one researcher focusing on each. A series of semi-structured interviews was carried out (15 in each area) and notes were taken in each interview. A summary of the notes from each interview was validated by the appropriate participant. For both areas, an analysis of these summary documents was carried out to identify the important themes.

In identifying CPS practices, a comparative study was carried out with three creative organisations. The objective was to compare creative company practices with engineering company practices, therefore their responses will be considered as a group, and collectively they will be referred to as CreativeCo.

A comparative study to identify the relationship between KM and innovation in other product development organisations also took place. Their responses will be considered as a group, and collectively they will be referred to as ProdCo.

3 LITERATURE FINDINGS

3.1 Creativity and creative problem solving

Creativity is an essential part of design. This applies to all types of design, including but not limited to: industrial design, aesthetic design, creative design, fashion design, system design, mechanical design, and engineering design. Creative problem solving is a process which individuals go through as a way of developing a solution to a specified problem. Creative problem solving (CPS)

methods are widely recognised to offer benefit to organisations in developing novel solutions. This is of critical importance in a design context, contributing towards innovation and competitive advantage.

There are three key issues relating to the application of CPS methods that this research set out to discover. Firstly, there are a large number of CPS methods available. It is not clear which of these methods should be applied in a given context. Second, best practices in applying CPS methods should be identified. Third, important factors in the application of CPS methods need to be identified in order that they can be effectively addressed: personal qualities, skills, culture, location, and so on. It should be noted at this stage that there were no quantitative indicators identified in the literature regarding the suitability of any given CPS method to a particular situation. Best practices are also extremely sparse; the few references identified were from practitioner sources and not academic journals. Having developed an understanding of the background of CPS, of the three issues only one is properly addressed by this paper: important factors in the application of CPS methods. This is due to the limitations of the current literature, which is in part due to the unexpected complexity of the subject, but also relates to a lack of empirical studies to assess the effectiveness of CPS methods. The study into factors supporting creativity and CPS has been supported by an analysis of the literature and a case study.

3.2 Creativity in the UK manufacturing sector

In 2005 the UK government published The Cox Review, a report identifying a need for enhancing creativity in the manufacturing sector. Creativity is, according to the report, not simply a way to develop novel products and services but also a proven method to enhance productivity; however it is not always recognised as such. Definitions of creativity, innovation and design will be adopted according to the Cox review:

"'Creativity' is the generation of new ideas – either new ways of looking at existing problems, or of seeing new opportunities, perhaps by exploiting emerging technologies or changes in markets.

'Innovation' is the successful exploitation of new ideas. It is the process that carries them through to new products, new services, new ways of running the business or even new ways of doing business.

'Design' is what links creativity and innovation. It shapes ideas to become practical and attractive propositions for users or customers. Design may be described as creativity deployed to a specific end." [1]

3.3 Creative Problem Solving

Structured problems which are well defined can be approached with direct and systematic methods. Creative problem solving is particularly suited to problems that are ill structured or difficult to define.

According to Stouffer et al [2], the creative problem solving process consists of four key stages. First, a notion or need (sensing, problem definition, and orientation); second, an investigation of that notion or need (testing, preparation, incubation, analysis, and ideation); third, an articulation of a new idea or solution (modifying, illumination, and synthesis); and fourth a validation process of that idea or solution (communicating, verification, and evaluation) resulting in an idea, theory, process, or physical product.

Mauzy & Harriman were able to identify four critical qualities that underpin creative thinking: motivation, curiosity and fear, the breaking and making of connections, and evaluation [3].

3.4 Creativity in academic literature

Definitions of creativity in the literature are numerous and varied. Rhodes performed an analysis of over 40, with the intention of creating a single unified definition. Instead, the analysis led to the proposal that there are four strands of creativity: Person, Product, Process and Press (Environment). "Each strand has unique identity academically, but only in unity do the four strands operate functionally" [4]. This reflects both the multi dimensional nature of creativity and the difficulty in creating a universal definition.

More recently, researchers have examined the relationship between creativity and cognitive styles. Kirton identified two types of creative style through observing managers in a company. The first group, called 'adaptive', was characterised by their ability to initiate changes which helped in improving the organisation, and their inability to see opportunities outside the organisation. The second group, called 'innovative', were characterised by their frequent ideas for radical change and low acceptance rate of those ideas. Kirton's later hypothesis suggested that rather than a discrete typology there is a continuum between the two styles. This can be described as the "adaptor-innovator" continuum [5]. Essentially 'adaptors' are individuals who work and think in a precise and methodical way, and 'innovators' are individuals who work and think in an undisciplined, 'different' way.

Understanding how individuals, or cognitive styles, relate to creativity is one important component of identifying appropriate CPS methods.

3.5 Organisational Environment

An organisation's culture is determined by the basic values, assumptions and beliefs that are shared, at the deepest level, by the organisation's members. The culture manifests in the actions of those members [6, 7, 8].

Isaksen and Lauer identified ten factors which contribute to creativity in a collaborative environment, and nine dimensions which promote creativity and creative problem solving [9]. These are shown in table 1.

Dimensions which promote creativity	**Factors which contribute to creativity**
Risk-Taking	Trust
Trust and Openness	Team spirit
Idea Support	Unified commitment
Freedom	Principled leadership
Challenge and Involvement	An elevating goal
Debate	Participation in decision-making
Conflict	An aptitude to adjust roles and behaviours to accommodate new emergent values
Playfulness and humour	A results-driven structure
Idea time	Standards of excellence
	External support and recognition

Table 1: factors supporting creativity [9]

Organisational culture is frequently cited as an important factor in applying CPS, however there are no qualitative models offering an insight into how changes to certain aspects of culture influence the adoption or effectiveness

of CPS. In part, this is limited by the nature of culture: whilst the organisation has some influence, it is by no means under their direct control. Given a lack of measurement frameworks for organisational culture, it is difficult to identify the 'most important' factors.

3.6 Individual Qualities

Individual qualities relevant to creativity are increasingly prevalent in the literature. The relationship between creativity and cognitive styles, creativity skills, and the ability to learn creative methods are some examples of how creativity is related to the individual in the literature.

Amabile suggested that there are three key components that support creative production or the creative outcome from an individual's perspective: domain-relevant skills, creativity-relevant processes, and task motivation. Domain-relevant skills refer to the knowledge each individual has and the expertise in the area. Creative-relevant processes refer to the cognitive styles and creativity strategies that each individual adopts. Task motivation is closely related to the successful development of a creative outcome, in particular intrinsic motivation [10]. In fact, motivation is widely recognised as a critical component of creativity [11].

3.7 Creative Problem Solving Tools

There is a lack of academic material on how to identify appropriate CPS tools. In part, this is due to the wide range of CPS tools available. It is also due to the twin influence of individual qualities and organisational environment. A further complicating factor is the range of problems CPS tools can be applied to. This research sought to identify CPS tools which can be used specifically in an engineering context. The analysis of the literature identified three sources citing the application of CPS tools in an engineering context. Note that there was no indication of selection rationale or effectiveness; these issues are not addressed in general in the CPS literature. The three sources citing CPS tools applied in an engineering perspective are shown in table 2 along with the tools applied in each case.

	Brain Storming	Synectics	Check Lists	Reversal	Attribute Lists	Forced Relationship	Value Engineering	Brain Writing
Hall (1996)	X	X		X				
Singer & Adkins (1984)	X	X	X		X	X	X	
Thompson & Lordan (1999)	X	X	X					X

Table 2: CPS tools used in engineering

3.8 Knowledge management

Organisational knowledge provides a platform for innovation and allows individuals across the organisation to share and apply creative ideas. Innovation is very closely linked with knowledge management [12]. The definition of knowledge management adopted in this research is: "…knowledge management is the set of proactive activities to support an organization in creating, assimilating, disseminating, and applying its knowledge'" [13].

Nonaka & Takeuchi argue that organisational knowledge and learning are vital in the innovation process, as innovation is predominantly a process of knowledge creation which relies heavily on the availability and readiness of knowledge [14]. A small number of knowledge management for innovation frameworks have been developed, including the integrated management framework for knowledge management and innovation [15] and the 'know-net' framework [16].

It is essential that an organisation manages both tacit and explicit knowledge to ensure their organisational knowledge is effectively applied. Goh [15] explains how the socialization phase (direct personal communication) of their SECI model enables individuals to share their experiences, ideas and knowledge. Li & Gao [17] highlight that knowledge could not be 'managed' and had to be 'led' through creating and managing the 'Ba' (a shared context in which knowledge is shared, created and utilised). Haldin-Herrgard [18] highlights that methods such as, "direct interaction, networking and action learning that include face-to-face social interaction and practical experiences" are key to sharing tacit knowledge. Bröchner et al [19] also found that face-to-face meetings were an effective knowledge transfer mechanism.

Hansen et al [20] studied knowledge practices at management consulting firms, health care providers and computer manufacturers. They found that in companies that provided, 'standardized products' knowledge was codified and stored in databases, allowing the data to be accessed at any time. They called this the 'codification strategy.' Within companies that provided 'highly customized solutions to unique problems', knowledge was shared between 'person-to-person contacts' and computers were only used to help people to communicate knowledge, not to store it. They called this the 'personalization strategy.' Hansen et al argue that one strategy or the other will dominate. This goes against many views which reinforce that both IT infrastructure, allowing codification, and an open knowledge sharing culture, allowing personalisation, must be in place for effective knowledge management [12].

Koners and Goffin [21] highlight the importance of post-project reviews (PPRs) as a knowledge creation and sharing activity. They highlight that most researchers focus on documenting knowledge and sharing and fail to realise that there is more to learning than documentation. They carried out research on five companies from different sectors to assess how R&D companies carry out post-project reviews and whether they 'promote the creation and transfer of tacit knowledge'. They highlight that people, time, location, duration and preparation are vital. Since a PPR is a meeting, made up of people coming together for a certain purpose, a comparison is drawn between a PPR and an 'innovation booster' and a PPR and a 'booster review'. These activities will be discussed in the case study section.

The framework developed in this research aims to illustrate how to use knowledge management activities for an innovation team for example, through utilising knowledge management tools [12], organised post-project reviews [21] and enabling effective tacit knowledge transfer [18].

4 CREATIVITY CASE STUDY

The CPS objective was to identify a CPS toolkit. This objective was not supported by the academic literature, so the focus of the project changed to identifying potential CPS methods and critical factors in their application. The 15 interviews with the EngCo employees focused on creative problem solving methods. Questions include: what CPS techniques are you aware of; which

ones do you apply; how is CPS promoted; and what qualities do you think an individual needs to be creative. In addition to the company interviews, three respondents from three creative companies (referred to collectively ad CreativeCo) were also interviewed using the same semi-structured template for a comparative study.

Content analysis was carried out to indicate the frequency of responses. Whilst it is recognised that the small sample sizes do not reflect broadly applicable trends, it is a useful mechanism for comparison. A summary of the analysis showing the most common responses are shown in table 3 for EngCo, and table 4 for CreativeCo.

Questions	**Key Themes: EngCo**	**Frequency**
How long have you been in the company?	Over 25 years	40%
What type of problems do you encounter at work?	Time Issues Communication Problems	47% 40%
What qualities do you think an individual needs to be creative?	Open minded to other peoples ideas Willing to take risks Not afraid to ask questions	66% 47% 40%
Would you call your organisation one that takes risks?	Calculated Risks Needs to take more risks	47% 33%
[how] Does your organisation promote Creativity and CPS?	Innovation Awards Innovation Workshop Facilitator Training Idea Scheme	73% 60% 60% 27%
What CPS tools are you aware of?	Mind Maps Brain Storming Not Aware	47% 6% 33%
Which ones do you apply on your role?	Brain Storming and Mind Maps None	66% 33%
Do you think job roles affect attitudes towards creativity?	Yes No	13% 87%
Is knowledge managed well within the organisation?	Knowledge managed poorly, not shared enough	93%
How could Creativity and CPS be improved throughout the organisation?	More awareness of CPS	60%

Table 3: content analysis of company interviews EngCo (15 respondents)

Questions	**Key Themes: CreativeCo**	**Frequency**
How long have you been in the company?	3 years +	100%
What type of problems do you encounter at work?	Communication Issues	100%
What qualities do you think an individual needs to be creative?	Open minded free thinkers	66%
Would you call your organisation one that takes risks?	Yes	100%
[how] Does your organisation promote Creativity and CPS?	Training in creativity	66%
What CPS tools are you aware of?	Brain storming and Brain Writing	66%
Which ones do you apply on your role?	Brain storming and Brain Writing	66%
Do you think job roles affect attitudes towards creativity?	Yes	100%
Is knowledge managed well within the organisation?	Client Meetings, Intranet	100%
How could Creativity and CPS be improved throughout the organisation?	Research into creativity Branding creativity	33% 33%

Table 4: content analysis of company interviews CreativeCo (3 respondents)

4.1 Discussion and comparison of CPS findings

The results from the interview data analysis identified that a high proportion of respondents in the engineering company had worked in the company for over 25 years: 40%. The respondents from the creative companies had all been there at least 3 years.

Common problems encountered at work included communication issues in both company types, in addition to time pressures in EngCo. Additional issues mentioned in EngCo which relate to the complexity of the products and organisation include: understanding the project, and following numerous complex processes and procedures. CreativeCo identified their main problems in terms of communicating their work. They often work as a contracted creative specialist, so problems include getting the right information from the client, and (a common issue) communicating with the various partners on the project. This issue of communicating between disciplines is not restricted to creative domains: there are often conflicts brought about by a lack of understanding where people from different disciplines work together.

Key qualities thought to support creativity include (from both) open mindedness and (from EngCo) a willingness to take risks. This risk factor is an interesting quality of creativity, particularly since it was not mentioned as a factor by the CreativeCo respondents. However, the creative companies all professed to be in risk taking organisations, whereas 47% of EngCo respondents identified that it takes ‘calculated risks’, and 33%

suggested they need to take more risks. Risk is identified by Isaksen and Lauer (2002) as a dimension which promotes creativity. This is supported by the case study findings. There is some conflict regarding the view of risk in small and large organisations: in a smaller organisation, every activity is inherently more risky since relatively small expenditures represent a much larger proportion of the company revenue than in larger companies. Similarly, inherent risk in a single project is larger if the total number of projects is small. Even with the variance in company size and therefore 'relative risk', risk remains an important factor in creativity and should be recognised as such.

There were a variety of methods in place in EngCo to promote creativity, including innovation awards, an idea scheme, innovation workshops and workshop facilitator training. Two of the three CreativeCo respondents delivered creativity training. EngCo did not formally train people in creative methods.

Regarding awareness and use of CPS tools, 66% of EngCo respondents applied brainstorming and mind maps, and the same proportion in CreativeCo applied brainstorming and brain writing. The key difference is that 33% of EngCo respondents are not aware of and do not apply any CPS techniques, whereas all of the CreativeCo respondents were aware of, and used, various CPS techniques.

All CreativeCo respondents believed that job roles affected attitudes towards creativity. One respondent in CreativeCo suggested that "individuals will only fulfil the requirements that their job roles state". The question was included in order to identify whether job roles restrict individual flexibility to operate in new areas, and in doing so restrict the potential for creativity. Our survey does not provide a full answer to this question, but does prompt a further investigation into the potential adverse relationship between job roles and creativity. Another response from CreativeCo was "creativity could be stifled depending upon which specific role you were playing". The majority of EngCo responses indicated that there was not such a relationship; some also indicated that creativity is a personal issue. Of the 13% who suggested that job roles were related, one suggested that they were "over-worked with little time to spend on problem solving or thinking of new or creative ways of tackling problems".

This view of job roles is one of three key differences between the two sectors, as identified through our case study. The third relates to knowledge management. CreativeCo responses all indicated that they try to share as much knowledge as possible with employees and clients through mechanisms such as meetings, intranet and forums. 93% of EngCo respondents suggested that knowledge was not managed well, including comments such as "Knowledge management does not seem to be visible"; "Knowledge management is applied poorly"; "there needs to be more interaction between people" and "people are too busy to share knowledge". Whilst this could indicate that EngCo is less effective in its KM practices than CreativeCo, it may also indicate a difference in understanding of what constitutes KM. Organisational structure and culture were cited as strong influencing factors in knowledge management.

In terms of improving creativity, the largest response from EngCo was awareness. This is supported by the finding that 33% of respondents were not aware of CPS techniques. CreativeCo identified continued encouragement, research, and branding. Branding is closely related to awareness. This indicates that organisations need to adopt and promote creativity and CPS if it is to be effective. It needs to be an actively encouraged and supported part of the culture.

5 KM CASE STUDY

A series of interviews were carried out during the KM case study. These were carried out with 15 EngCo employees and 7 ProdCo employees. Topics covered during the interviews were: background of the project; employee background: roles & duties; "How is KM applied in your role (systems, methods)?"; and "Is there a link between KM and innovation?". Additional questions were asked of the ProdCo respondents, including 'how would you rate the innovation / KM in your company", "what are the barriers to innovation", and "how closely linked are innovation and KM?"

5.1 EngCo KM findings

The innovation booster sessions are considered within this case study as the main activities of the innovation office. An innovation booster session is defined by the employees of EngCo as:

- A kind of workshop… using creative problem solving techniques *(Head of Innovation).*
- A method of exploring a problem or investigating a specific topic with the assistance of colleagues from varying backgrounds *(Principal Engineer).*

As identified in the case study, important activities include planning and logistics, facilitation, output, and follow-up. Within the scope of these activities, there are several KM tools currently in use, including company intranet, internal wiki, Windows SharePoint Services (WSS), and various shared drives.

Knowledge sharing is not formally recognised, and there are no rewards schemes in place. The knowledge management tools currently in place are not updated regularly, and in some cases are country specific. Not all information can be accessed outside of the innovation office.

Capturing and documentation of information during the booster, formal report writing after the booster, dissemination and sharing of the results, feedback and follow up sessions all take place, but inconsistently.

There are no formal processes in place for measuring the success of the boosters for any of the critical elements (planning, facilitators, output, and follow-up).

The most beneficial output appears to be in an intangible form rather than in the form of reports. During the booster, conversations, interaction with other participants, understanding different perspectives, and personal learning all take place.

5.2 ProdCo KM findings

Respondents stressed that innovation was critical to them but barriers such as bureaucracy and individual thinking can hinder innovation. Three of the seven respondents rated their innovation as 'Good'.

Regarding knowledge management, the respondents explained that knowledge sharing is vital, and that it is enabled by IT infrastructure, social networking and meetings. They emphasised that rewards for sharing knowledge should be in place as well as a knowledge sharing culture. Knowledge management was defined differently by all the organisations. Four of the seven respondents rated their KM as 'Good'.

The respondents identified a definite link between knowledge management and innovation, suggesting that organisations should ensure knowledge management supports innovative practices. Four of the seven respondents highlighted that knowledge management and innovation are 'Extremely related'. One respondent highlighted that their knowledge management and innovation are not related in their organisation, stating

'We show very little attempt to innovate and have no clear knowledge management structures'.

Workshops were used within ProdCo to promote innovative and technical thinking.

Respondents reported various different barriers to innovation, including excessive bureaucracy, poor IT infrastructure, insufficient resources, and not having a formal procedure for submitting ideas.

Six of the seven respondents reported innovation teams in their organisations. One described 'working groups' which are formed on a 'need to have basis' as 'the main vehicle for sharing knowledge.' Innovation teams were different in all the organisations with some being R&D related and others dedicating an entire 'Advanced Technical Centre' to an innovation team: all of the innovation teams were unique in their activities and structure.

5.3 Discussion of KM findings

ProdCo respondents reported a variety of mechanisms for managing innovation. Workshops are a key method. KM was reported to be very closely related to innovation; a supporting function without which innovation would be less effective.

They key to the success of the innovation boosters, and ultimately the innovative practices they promote, is to ensure that their planning, follow-ups and the actual meeting itself are effectively managed, measured and monitored. Within EngCo there are potential improvements to every stage.

6 PROPOSED KM FRAMEWORK

Figure 1 shows the proposed KM framework. The framework is presented as 'KM for an innovation team', meaning that It should be applicable to any innovation team, rather than just EngCo. In order to show the changes made to the current process, changed or additional tasks or information sources are shown with red borders.

6.1 Promotion and Continuous Improvement Stage

The innovation team should promote their activities and make the outcomes available across the organisation. The two tasks in figure 1 are linked to WSS and intranet; however any accessible platform could be used.

The *company investigation* found that the intranet was not utilised or updated and that the different innovation managers used separate country specific network drives rather than WSS where information could be shared internationally.

The *industry study* found that knowledge management though effective tools were vital for knowledge sharing and communication across the organisation.

6.2 Contact Stage

The contact stage should be led by problem owners, as in the current situation, and also by facilitators. The investigation showed that the limited visibility of the innovation office prevented innovation sessions from being initiated.

6.3 Planning Stage:

There are a variety of mechanisms being applied during the planning stage. Initially, the problem is assessed for suitability. An internal wiki could be applied to this stage, to search and consult on the problem in order to understand it and to assess its suitability for a booster session. If the problem is suitable for a booster the problem owner is provided with a 'booster pack' containing instructions, support documents and feedback forms. The documentation is not currently formally defined. Venue is arranged. In assembling the team, the innovation team should consult the yellow pages to identify appropriate personnel based on the venue, problem type and existing participants. Further work is required to support the matching of personnel with problem type. Currently, the innovation team have access to a small selection of personnel.

The industry study found that one organisation 'would be more efficient in our execution of innovation if we had stronger global links and (IT) systems'. This highlights that other organisations also have IT issues relating to KM and global contacts.

6.4 Booster Session Stage:

This activity is presented as the central part of the innovation activity, since it performs two key functions. First, the application of CPS has a direct impact in terms of improving the outcome of the problem (often a product innovation). Second, the meeting itself is a key KM activity. We have described that methods such as direct interaction and networking that include face-to-face social interaction and practical experiences are key to sharing tacit knowledge: such meetings are regarded as the most effective knowledge transfer mechanism.

The booster session includes a series of CPS activities. Various CPS tools suitable for an engineering environment have been described in section 3.7. The booster pack should include details of these tools, including best practices and rules of engagement.

The industry study found that the purpose of these workshops was to 'promote creative thinking' and 'break down barriers between people and groups'.

The 'Advertise Booster' activity has been added to indicate that the booster should be advertised as not only a session which may provide results to a problem but also as a knowledge sharing activity which will promote idea and experience exchanges between participants from varying backgrounds. Additionally, since these are key outcomes of the booster, the company should seek to periodically measure them. The mechanism to support measurement of knowledge sharing is identified as further work.

6.5 Outputs: Follow-Up and Review Stage

Feedback is a critical part of this stage. A feedback activity should take place within the session itself, in order to identify the experiences of the participants regarding the venue, facilitator, CPS tools and quality of the outcome (i.e. the solution to the problem).

The problem owner report should also be created at this stage. A template for the report is provided with the supporting documentation (the booster pack). The report is used in two ways: to share the result, and to promote the innovation activities. This should be completed, shared and made widely available.

Participant feedback should be sought after a suitable period (thought to be 3-6 months) to investigate the outcome of the meeting itself for all participants: did practice change as a result of the booster session? This activity could take place with randomly selected participants, using a simple online questionnaire format to minimise the administration requirement. As a key activity supported by the innovation office, an attempt should be made to measure the value of the intangible outcome of this activity: knowledge sharing.

Facilitators should meet periodically to share experiences and best practices.

The company investigation found that reports are not always created, and are rarely shared. The industry study found that it is important to have a great depth of common knowledge between people which will lead to innovation and to enable them to share this knowledge.

7 VALIDATION

The knowledge management framework was validated using a structured interview with the lead industry participant from EngCo. It was considered that implementing the framework would provide value to the innovation team and the NPI process.

8 SUMMARY

It was suggested in this paper that the creative problem solving workshop, or innovation booster, is itself a key knowledge management mechanism, promoting knowledge sharing through face to face communication. Two aspects of that workshop were investigated through an industry case study and comparative studies with external organisations. First, appropriate CPS methods to apply during the session were investigated. Second, the knowledge management methodology and tools were investigated and a proposal made for KM to support innovation.

Creativity has been identified as a critical element of design and of productivity improvement in manufacturing and engineering companies. Our comparison study identified that *creative organisations* routinely apply creative methods. Our experience with a large *engineering* company supports the findings of the Cox review: creativity practice is limited, and needs to be more widely adopted.

There are a variety of important factors regarding the successful application of CPS identified in the literature. Our case study findings indicate that creative companies are better at applying creative problem solving than the engineering company we studied. Whilst this is not an unexpected finding, some of the contributing factors are interesting. For instance, the creative companies deliver specific creativity training, whereas EngCo focuses not at the individual level, but instead trains people to facilitate CPS events. A proportion of the EngCo employees were not aware of CPS methods, and therefore had not applied them. This is closely related to the issue of communicating creativity and CPS methods.

In a highly planned and structured organisation in which time is booked against specific projects, free time will always be limited. In a time limited organisation, intuitively there are two ways which could improve the use of CPS methods. Either build CPS into the structure, making it a part of the project delivery plan and accounting for the time required, or promote CPS and deliver individual training in order that it is so ingrained into the work practices of every individual that it is naturally a part of their activities.

A knowledge management framework was developed to support an innovation team. The framework describes activities and inputs required for the four key steps: planning and logistics, facilitation, output, and follow-up. A flowchart and description of the KM framework is provided. The framework emphasises the importance of knowledge sharing tools to enable communication and updated information, the meeting as a knowledge sharing activity, and the potential to measure the tacit and explicit outcomes of a knowledge sharing activity.

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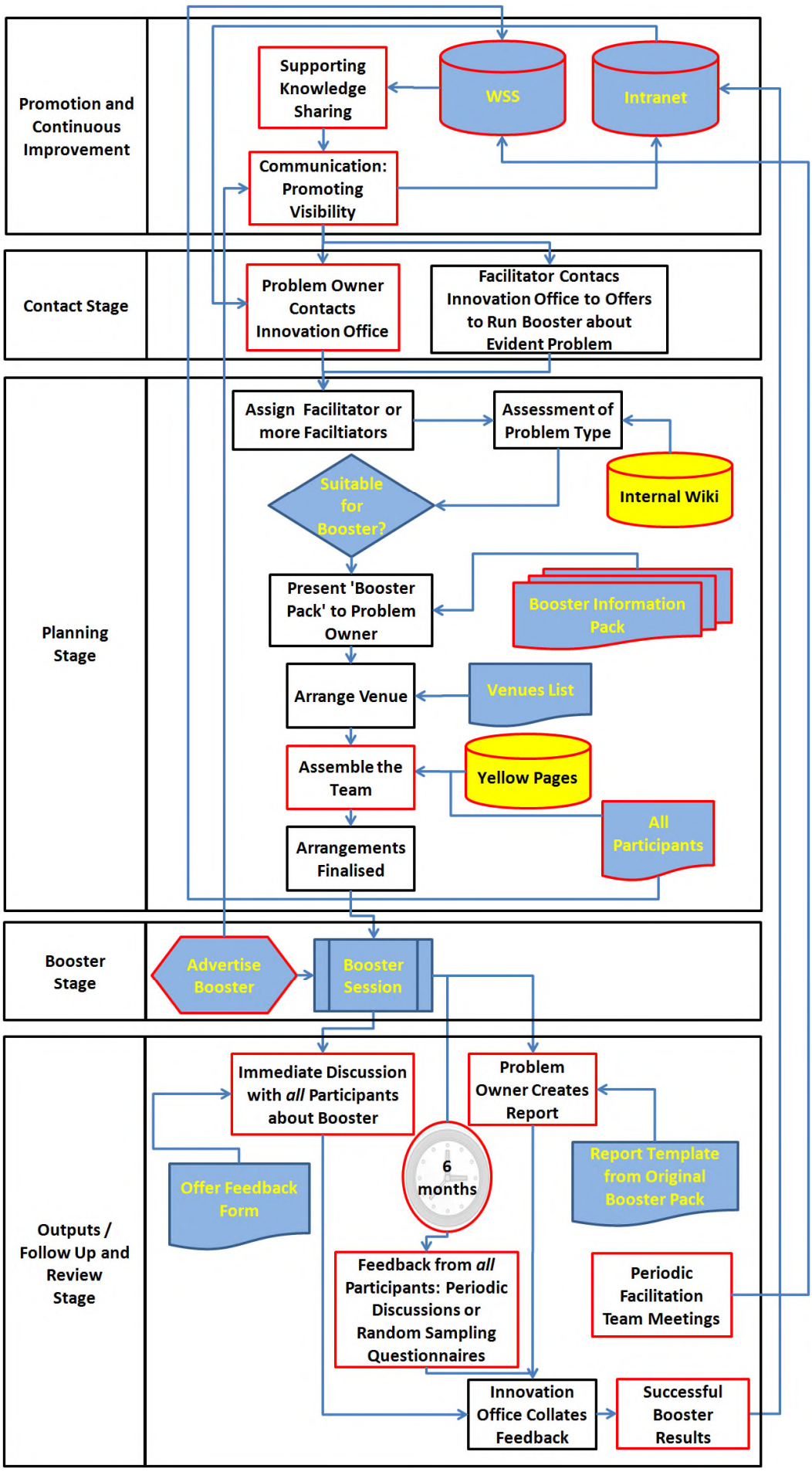

Figure 1: proposed KM framework