

# Design, Engineering and Knowledge Management

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## Abstract:

This paper provides an overview of a survey conducted to capture several aspects related to knowledge management and processes. The relationships between knowledge workers and their use information and knowledge are explored. This is particularly important for workers involved in invention and innovation, such as advanced product engineering.

The result of the way knowledge is used is highlighted in the STARS Knowledge cycle and layered knowledge model.

**Keywords:** Knowledge, Knowledge Management, Knowledge Life Cycle, STARS methodology

## 1. INTRODUCTION

Since the 1970s there has been a steady focus on improving quality in products through systematic means such as quality systems, Total Quality Management [1], Kaizen [2] and Six Sigma [3]. ISO standards such as ISO9000 series [4] and lately ISO15504 [5] have focussed on processes and their impact on quality. Many enterprises adopted ISO based quality systems in Europe, Australia, Asia and the Americas. In many enterprises, processes became "king" and people were trained to comply with documented standard processes. The quality system became the organisation's source of information on performing work.

In the late 1980s and throughout the 1990s, media commentators coined the term "Information society" [6]. This term expressed the explosion in readily available information including 24 hours news channels and the Internet, more specifically the World Wide Web. One of the apparent contradictions as information became more readily available was the awareness within many enterprises and most individuals that their own level of knowledge was less than desirable, simply expressed "we don't know enough", when confronted by increasing complexity in innovation and design. Gradually, people's awareness has moved from a focus on access to and gathering of information to the use of it.

## 2. DESIGN AND KNOWLEDGE MANAGEMENT

In the past decade, organisations have realised that not all knowledge can be captured in quality systems. Organisations have begun to recognise the role of knowledge workers as crucial to organisation competitiveness. Nowhere is this more critical than in the fields of invention and innovation. Design by its very nature is firmly centred in invention and innovation.

Enterprises have come partly around the circle in terms of recognising the importance of the individual in design work. The role of chief designer (or chief scientist or technologist for research and software) has become more prominent in the past decade. Technology and processes supplement the individual's design capability and creativity (so designers are not quite emulating their pre 20th century counterparts as master artisans).

The term "Knowledge Society" has arisen to focus on the importance of knowledge and has replaced the term "Information society" that was prevalent in the 1990s. The challenge of

the knowledge society is to make best use of personal knowledge and organisational knowledge.

As more organisations move towards an innovation paradigm from a continuous improvement paradigm, the application and relevance of process-focussed approaches has come under increasing scrutiny and debate. At one end of the debate, some pundits believe that good processes can produce consistent high quality results without relying extensively upon individual skill of the person(s) involved, at the other end of the debate some pundits believe that individual skill and experience is paramount and standard processes are disadvantageous or even hinder positive innovation outcomes.

To determine the importance of knowledge workers and the role of processes, the author ran a survey over 3 weeks during September at KnowledgeBoard<sup>1</sup>, a respected and independent knowledge community web based community. KnowledgeBoard is partially sponsored by the European Commission to set up a knowledge society community portal [7]. Subsequent surveys at conferences and online at the author's web site have increased the overall usefulness and reach of the responses.

### **3. THE SURVEY**

The response data was cleaned, this consisted of:

- Ensuring that only attributable responses were used (respondents who voluntarily provided email addresses). Each person was emailed to check for a valid email address and to agree to his or her input.
- All responses without email addresses or invalid email addresses were eliminated.
- Checking and eliminating double responses (2 people were asked to select their preferred response between similar but not the same responses).
- Obviously false data patterns (e.g. all 1 response answer or an escalating pattern response) were eliminated.

After data cleaning, there were 170 valid responses. These responses represent over 140 different organisations. The questions mostly used a five-point ordinal scale, except for 2 questions that used a six-point scale.

While the data used for analysis represents attributable data from the respondents, the usual caveats for this type of survey apply. Firstly, the data sample size, while significant, is still a small data set that may be entirely representative of the communities covered. Secondly, as response was voluntary, the data may be biased towards organisations and people who may show more interest in the surveyed areas than normal. This may skew the results (more or less favourable), although data analysis has not indicated any particular bias.

Thirdly, many of the questions elicit people's opinions rather than independently verifiable facts. This is typical of knowledge management surveys, but needs to be understood when considering the results.

Finally the author may have unintentionally introduced some bias into the questions asked and the response categories. Data analysis does not indicate any such bias but this does not mean it can be eliminated as a consideration. The survey is still open to your input [8].

Please visit: Stars culture survey. If you complete the survey, the author will forward the full survey report.

#### **3.1 The survey questions**

The survey consisted of 25 questions included some questions that attempted to cross correlate the same issue while not totally redundant. There were knowledge management, process, and cultural dimension questions (e.g. organisational hierarchy, decision making, gaining management support). The more relevant questions are listed here.

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<sup>1</sup> Thanks to Ed Mitchell of KnowledgeBoard for setting up the survey web pages.

- How important are knowledge workers to the success of the organisation?
- How important are process specialists to the success of the organisation?
- To what extent are employees informed about overall business objectives and processes, running projects and their results?
- How easily accessible is this information?
- To what extent are employees informed about innovation and improvement?
- How easily accessible is this information?
- Are there any forms of informal communication (peer to peer communication)?
- Is innovative behaviour promoted/supported/rewarded?
- Is risk of failure recognised and tolerated as part of innovative behaviour
- Does the organisation look outside for new knowledge, improvements or innovations to learn and use?
- Do processes within your organisation work for or against innovation?
- How easy is it to gain resources, support and privileges from management for improvement or innovative activities?
- How would you describe your organisation?

### 3.2 The analysis

The analysis presented here does not provide the complete analysis intended of the data, but highlights some general results and also some comparative results (between questions). Where appropriate, confidence tests were applied to the analysed data, to support the conclusions. This is not presented in this report. The organisational business covered a wide area of endeavour as shown in the following figure.

The main business areas were education, Information Technology and software development, aerospace, automotive, banking, manufacturing and public administration.

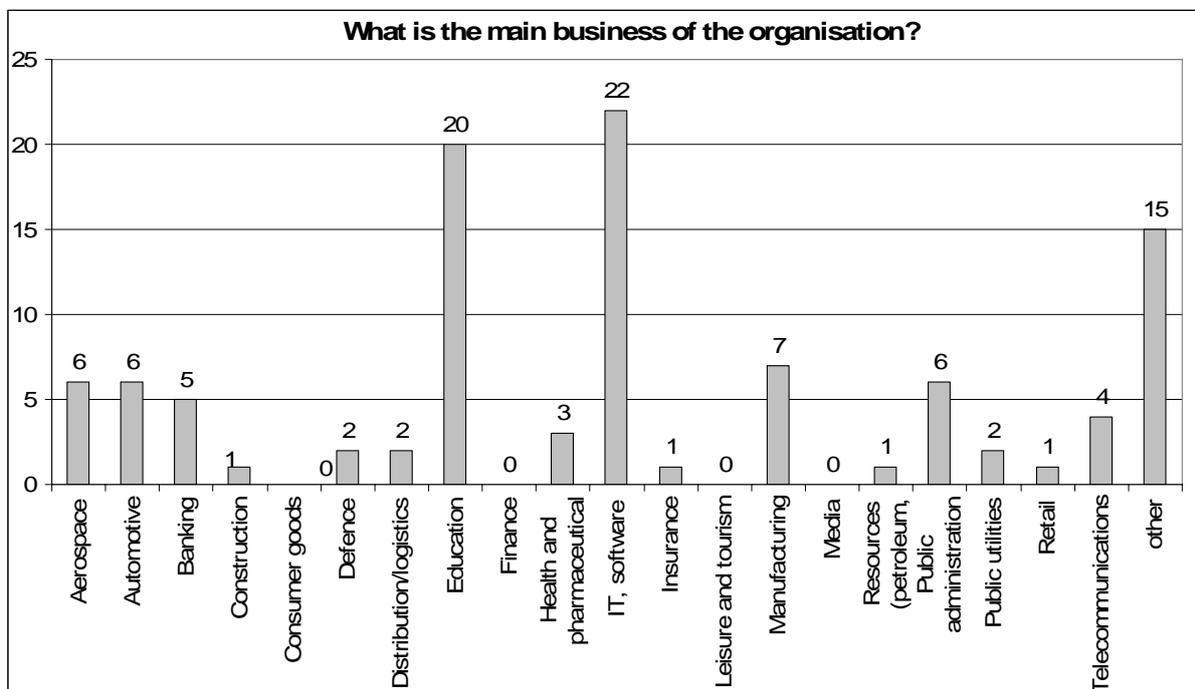


Figure 1: Business area

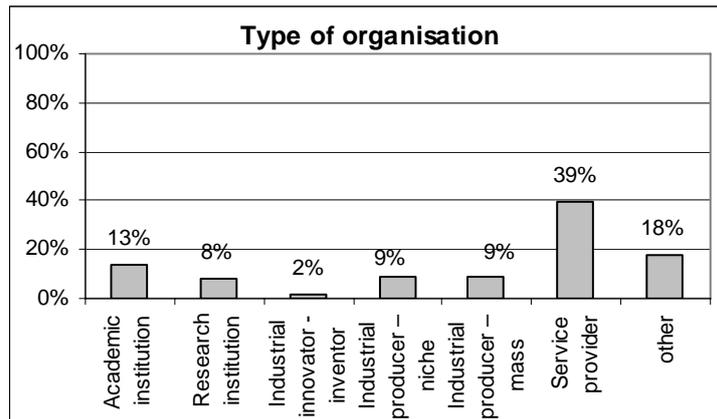


Figure 2: Organisation type

Respondents were also asked to categorise their organisation. The largest groups were service providers. The respondents also covered a wide variety of roles and positions.

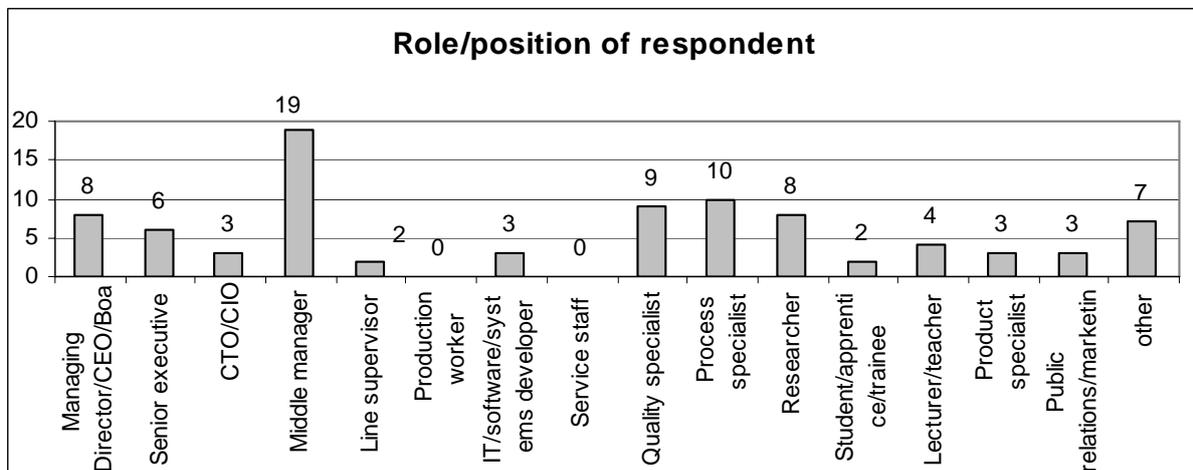


Figure 3: Respondent's role

### 3.3 The results and some comments

The importance of people to the organisation.

**Q1. Importance of knowledge workers:**

- No respondents believed that knowledge workers were not needed or were of low importance to organisational success. 95% of respondents state that people able to apply knowledge for improvement or innovation are important or extremely important to success. 62% stated that knowledge workers are extremely important to create new ideas, improvement and innovation as a basis for success.
- This confirms that the survey target audience is the one expected. It also (unsurprisingly) reflects the KnowledgeBoard community.

**Q2. Importance of process specialists:**

- 9% of responses indicated that process specialist were of low or very low importance. 77% of responses indicated that process specialists were important, to both create and tailor processes, as well as to improve and optimise the organisation. 37% of these responses saw process specialists as extremely important to processes that aid innovation, improvement and optimisation.

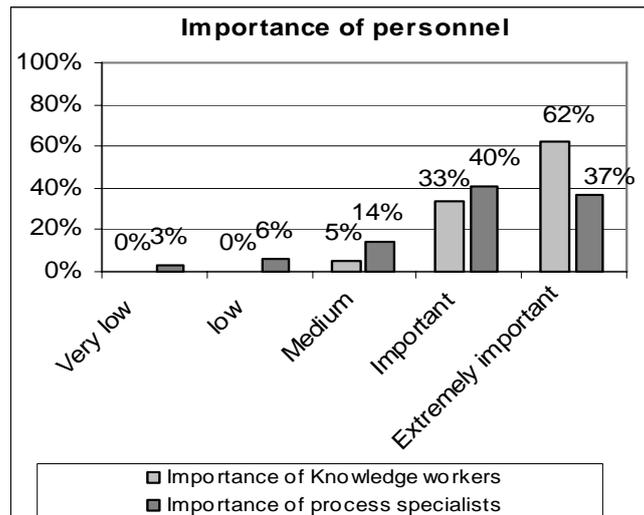


Figure 4: Importance of Knowledge and process workers

Using individual comparison of each respondent's data to compare the relative importance of knowledge workers and processes specialists is shown in the following graph.

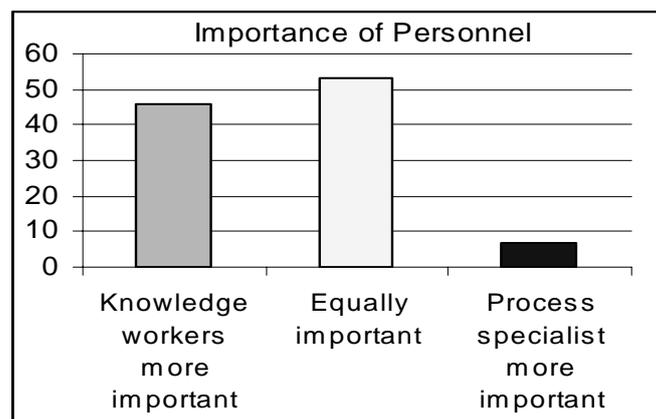


Figure 5. Relative importance of knowledge versus process workers.

**Q4.** To what extent are employees informed about overall business objectives and processes, projects and results?

**Q5.** How easily accessible is this information?

**Q6.** To what extent are employees informed about innovation and improvement?

**Q7.** How easily accessible is this information?

For overall business information:

- 62% of responses indicate that information about overall business objectives, processes and projects is disseminated, but little or no feedback is sought (one-way information dissemination). Within organisations that practice this one-way dissemination, approximately half provide both overall organisation information, as well as own/related projects, the other half only provide very limited information outside their own area/project.
- 31% of responses indicate an active information dissemination and collection approach covering overall business objectives, processes and projects.
- 21% of responses indicated a need to actively search for information, as little was made available.
- 79% of responses found overall organisation information to be available without requiring special activity for the receiver.

- However only 6% had both push (dissemination) and pull (knowledge management systems) access. It appears that KM systems are still not widely popular and/or available (although the survey did not investigate the reasons why).

For improvement and innovation information:

- 85% of respondents indicated that they were either moderately informed (32%), relatively well informed (36%) to very well informed (17%) about innovation and improvement.
- 27% of respondents needed to actively pursue innovation and improvement information.
- 70% of respondents indicated that innovation and improvement information was regularly provided or available.
- A small percentage of responses (5%) indicated that active push and pull (KM system) mechanisms rarely exist.

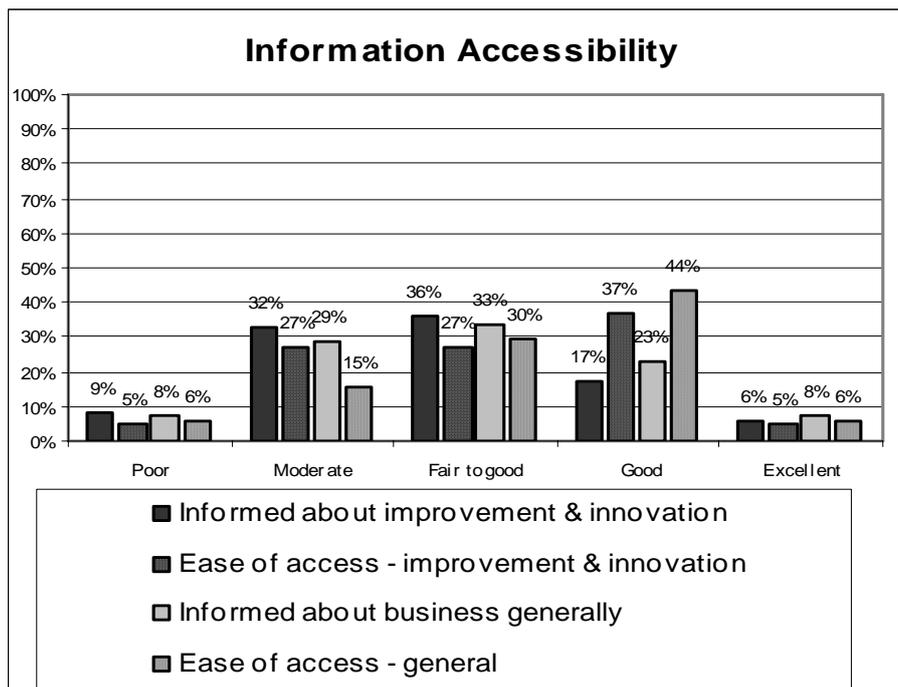


Figure 6: Information accessibility

The low percentage of both push and pull information is related to the use of Knowledge Management systems. The low result for both push and pull information mechanisms is somewhat surprising, given the acknowledged desire to improve knowledge management; the author conjectures that this indicates the entire domain is still at a low level of maturity in understanding what is needed for pull-based KM.

**Q8.** Are there any forms of informal communication (peer to peer communication)? 83% of respondents indicated that informal peer-to-peer communication was considered important and/or encouraged by management. A significant percentage (47% of total) of responses indicated that management formally recognised and supported it.

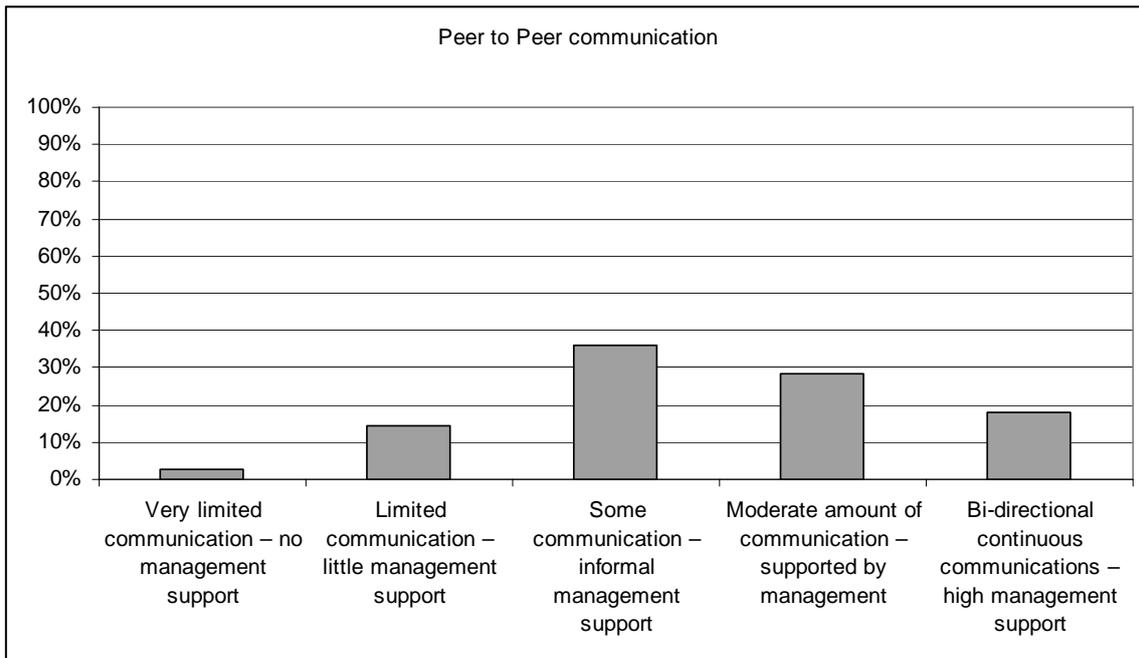


Figure 7: Peer to Peer communication usage and importance

This percentage is similar to that in Q6 about how well employees are informed about innovation and improvements. It could therefore be supposed that informal peer-to-peer communications are still a major information resource for knowledge.

### 3.4 Innovation questions

In the survey, there were several questions about innovation and related organisation cultural dimensions.

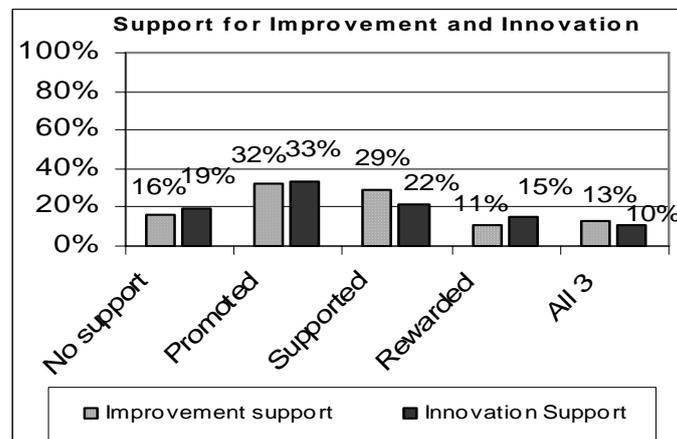


Figure 8: Support for improvement and innovation

The figure illustrates that overall there was a similar level of support for innovation and improvement.

There was also a question about whether enterprises sought external or internal innovations. External search occurred in over 50% of enterprises.

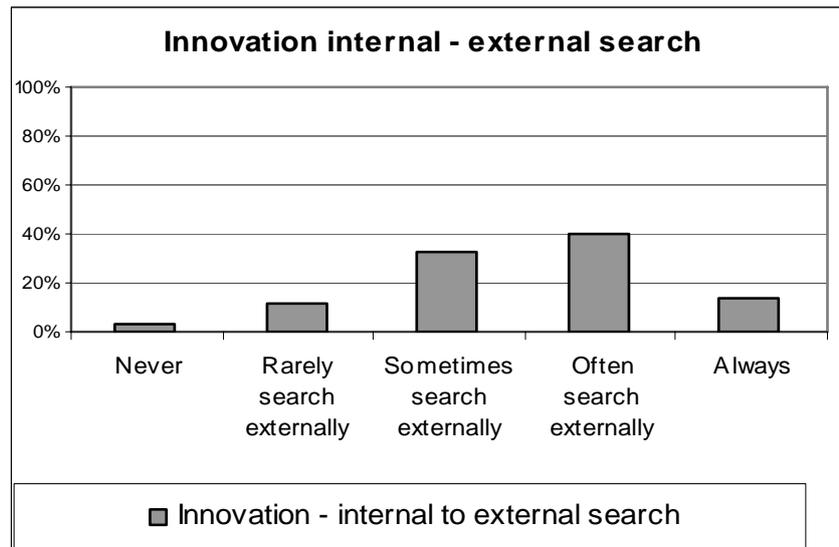


Figure 9: Use of internal versus search for external innovation

Related questions looked at how centralised or dispersed the innovation actions were, and this was compared to organisation hierarchy.

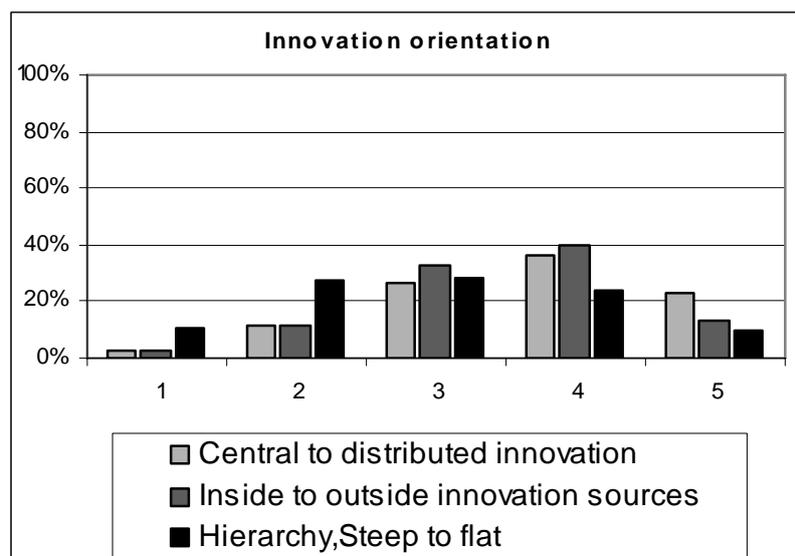


Figure 10: Source of innovation, centralisation and hierarchy

Another key question was Q.18, the effect of standard processes upon innovation.

- 39% of respondents indicated that standard processes have a negative effect upon innovation, mostly slowing down rather than preventing innovation. On the other hand,
- 27% of respondents indicated their organisations have processes to support innovation.
- 1/4 (24%) of respondents stated that standard processes have neither a negative or positive effect on innovation.

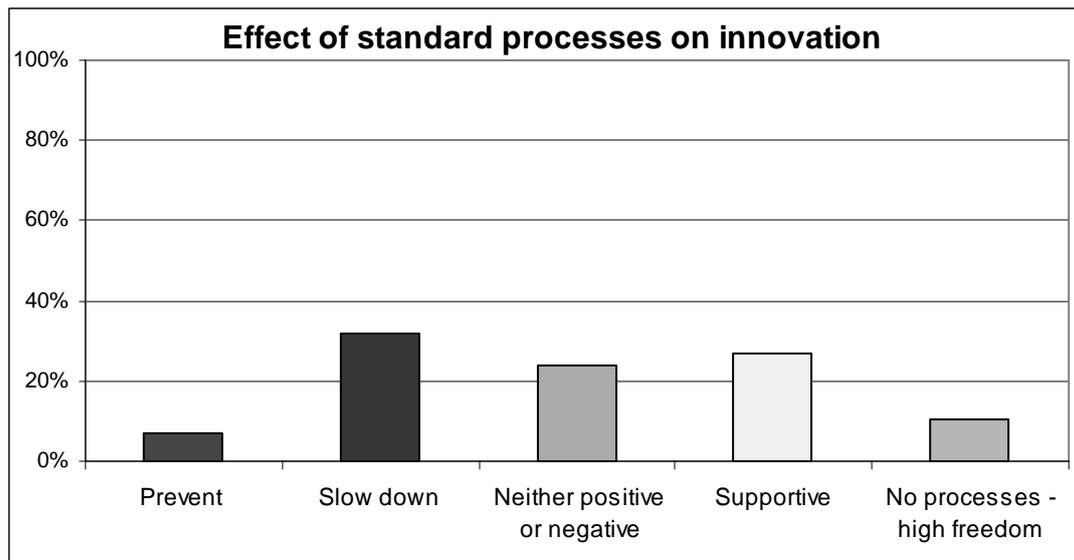


Figure 11: Effect of standard processes on innovation.

The respondents indicated that a greater percentage (39%) believe standard processes adversely affect innovation than support it (27%). Note that the amount that processes slow down innovation (32% group) was not surveyed.

However if one concludes that greater innovation is a trend, then care must be taken that process-focussed organisations do not unnecessarily adversely affect innovation. On the other hand the process support to innovation shows that this can be adequately resolved if care is taken to handle innovation issues correctly.

### 3.5 Survey summary

The survey shows that knowledge workers are highly important, that there is an increasing trend towards innovation, knowledge is sought after but poorly handled within existing knowledge management systems, and hence informal communication (peer to peer) is still important for gaining knowledge.

## 4. HANDLING KNOWLEDGE - THE STARS APPROACH

Based upon survey feedback and discussion within the KnowledgeBoard community, the author has looked at how knowledge is gained and used. The resultant model applies to any knowledge intensive industry, especially in enterprises that innovate and invent. These types of enterprise constantly need to advance their state of the art by intelligently using existing knowledge to create new knowledge. This does not apply to the same extent in fields such as education where syllabi may be unchanged for long periods. Advanced design implies a need to use knowledge in order to create advanced products. This applies in software and hardware design and development firms.

The STARS Knowledge cycle shows how we convert data into information, and then into knowledge and intelligence, apply it to gain competence, and integrate it into expertise and mastery.

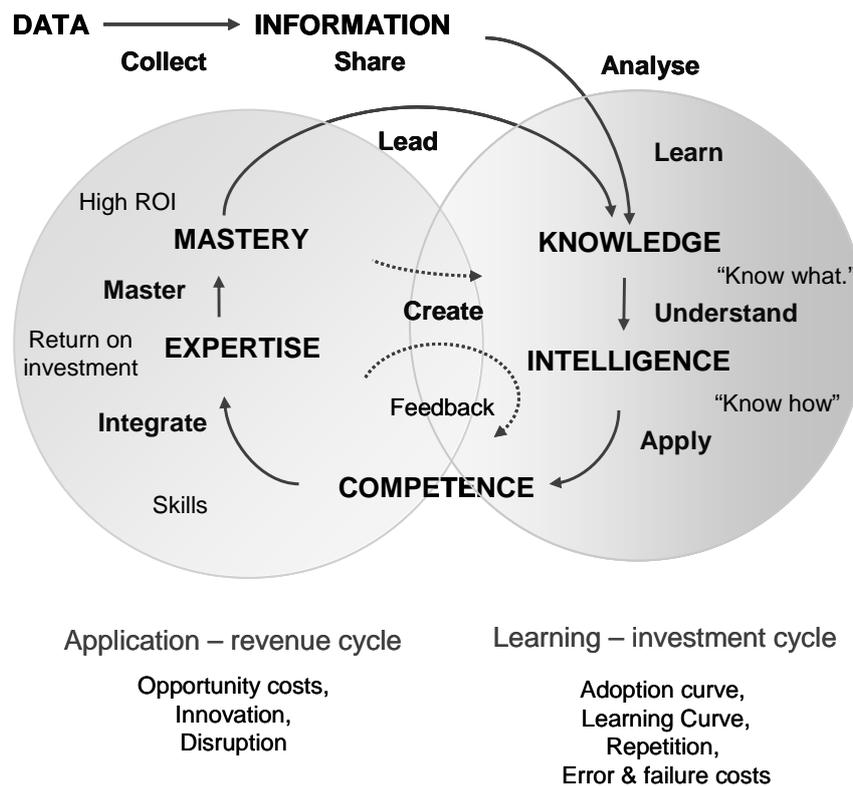


Figure 12: STARS Knowledge Life Cycle

At each point in the cycle, we take actions:

- We collect DATA
- We share INFORMATION (sharing turns data into information)
- We analyze and learn information to convert it into KNOWLEDGE.
- When we understand our knowledge and how to potentially apply it, we gain INTELLIGENCE.
- When we apply our intelligence, we gain COMPETENCE (we are able to use it).
- When we integrate our applied competence with other competencies, we develop EXPERTISE.
- When we master our expertise, we assume MASTERY of our knowledge and that enables us to lead others and leads to new knowledge.
- The interaction between learning and applying our knowledge allows us to create new knowledge.

You probably have noticed that the words in capitals are all nouns – they are states in the knowledge cycle and represent a positive progression towards Mastery. The actions are all verbs; they represent the actions taken to achieve the next state. Only the most important states and verbs are shown.

The STARS Knowledge cycle represents our learning cycle. The cycle shows a generic feedback link from Intelligence, Competence, and Expertise to Knowledge. They literally feed back what we learn into increasing our knowledge. When we "apply" our Intelligence to become Competent, we are learning by doing (experiential learning). The feedback from Competence to Knowledge is quite simply experience! Experience is a great teacher; learning by making mistakes is a strong learning technique. It is often considered the best way to learn, but I like the quote that says: "Experience makes you sit the test before it teaches you the lesson!"

The disadvantage of learning from experience is that it can be costly in many ways; in time, in personal confidence, in money, and in achieving success. Some experiential learning is always good, but it should not be the only technique. Experiential learning can be

especially costly in advanced design work. If our knowledge and intelligence are combined with some expertise or mastery from others, we can learn from them without making costly mistakes.

#### 4.1 Knowledge use

Another important aspect is the use of knowledge. People use knowledge in different ways; an expert designer obviously relies upon his or her innate, existing knowledge far more than a novice or beginner in the same field can. Any knowledge enhancement approach therefore must handle the varying needs of users. STARS uses a layered model to represent the way that knowledge is really used by people. For an expert or master designer, it is often enough to just be reminded to do a detailed design task. A new or inexperienced designer benefits from advice that is more detailed, together with instructions and activities that should be followed.

Therefore, the level of detail of knowledge a person needs depends upon the extent to which he or she has progressed around the knowledge cycle. As you progress towards expertise and mastery, a person's need for externally available detailed knowledge is reduced. So, STARS categorizes knowledge in layers. The top layer is called a Theme. It describes a holistic view of an important thematic subject.

- Each theme has 5 stages. Each stage can be used together with or independently of the others in a theme, or used with stages from other themes. In this sense, the stages create a toolbox of options that a user selects as needed.
- Each stage has a number of suggestions for how to do the work. The user can choose the most appropriate suggestions for the particular work.
- Each suggestion can have an underlying process. Finally the lowest layer provides resources.
- There are four (4) main layers in the model. These provide people with the choice of what level of detail they need to follow.

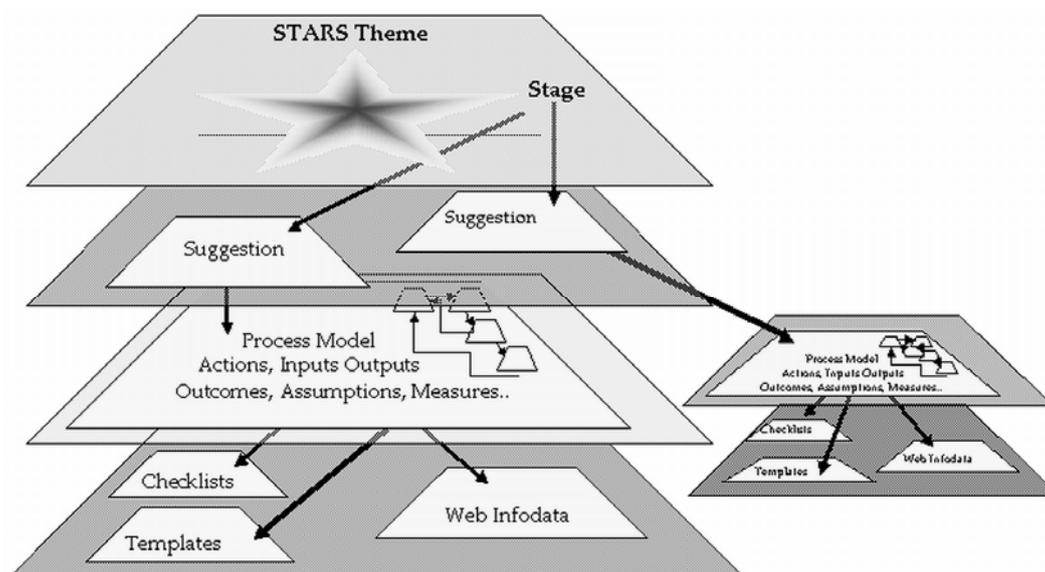


Figure 13. STARS Layered Knowledge model

- You can choose one or more STARS Themes.
- You can choose one or more STARS Stages.
- You can choose one or more STARS Suggestions for how to perform a Stage.
- You can choose to follow a STARS Process model to help you with the details.
- You can choose to use checklists, templates and various sources of data and information, for example from the World Wide Web (web infodata).

Experts (a person with expertise as shown in the Knowledge cycle) and Masters (a person with mastery of a domain in the Knowledge cycle) often only need the reminders provided by the first and second layers. Novices or people learning to do something new would look more often for information in third and fourth layers. The layers are not meant to be restrictive, a person can use information at any layer, and for example experts often look for a specific detail of information or data in the World Wide Web. So, a person is free to use data and information from any layer on its own.

There is an additional advantage when the data/information from the lowest layer is integrated into a way of working (into the process model). Then it becomes a tool for facilitating the knowledge and intelligence of people. The layering of data, information, knowledge (and intelligence) ensures that knowledge management tools are designed to help people.

The research is expanded upon in the author's book: Reach for the STARS. Leadership and management in the new millennium [9]. The book covers various knowledge and information heavy aspects, including:

- Creativity and innovation.
- Personal and team approaches.
- Customer and Product design approaches.
- Systems Thinking and culture themes.
- Innovation and Improvement themes.
- The knowledge cycle, learning cycle and knowledge enhancement aspects are covered.

## **5. CONCLUSIONS**

The survey results show the importance of people to the success of the organisation, especially knowledge workers. This is especially important when people are involved in innovation and invention, for example advanced product designers.

The survey stresses the need to consider people and knowledge in the enterprise approach. The understanding of the knowledge cycle helps to both classify various states of knowledge gathering and use and as a basis for modelling knowledge use. It helps to clarify the status of people in terms of their capability to exploit and create knowledge.

STARS provides a holistic and thematic approach to knowledge, suited to the needs of knowledge workers, especially people involved in innovation and invention, such as advanced product design. For further information, visit the author's web site: [www.lc-stars.com](http://www.lc-stars.com) and [http://starswebworx.lc-stars.com/stars\\_culture\\_survey1.htm](http://starswebworx.lc-stars.com/stars_culture_survey1.htm)

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