KNOWLEDGE MANAGEMENT IN NUCLEAR R&D INSTITUTES

R. Mukhtar
Pakistan Atomic Energy Commission, Pakistan

E-mail address of main author: rehanamukhtar@hotmail.com

Abstract The evolving field of Knowledge Management (KM) provides techniques that can be applied for an efficient management of a Research and Development (R&D) organization. KM ensures that right knowledge is applied at the right place and time and is about doing the right thing. Implementation of KM in R&D organizations will avoid unnecessary duplication of research. Management of Intellectual Capital can provide significant added value to the worth of an organization. Content Management for providing the right content to researchers at the right time is important. Sharing of knowledge should be encouraged. An organizational culture which facilitates open access to knowledge, supports professional development and encourages its researchers to keep abreast of new developments is conducive to increased innovation. This paper describes the KM techniques that can be beneficial to a R&D organization. Knowledge preservation which includes data preservation and capturing tacit knowledge of experts and succession planning for the sustainability of Nuclear Science and Technology is also discussed.

Nuclear Knowledge Management is of great importance to Pakistan because of its expanding nuclear program in the peaceful uses of atomic energy. The application of NKM techniques in a Nuclear R&D Institute of Pakistan has also been discussed.

1. Introduction

The varied applications of nuclear science and technology have made important contributions for the well being of mankind – in energy, food and health. Nuclear science and technology encompasses all basic sciences (mathematics, physics, chemistry, and biology), engineering, geology, hydrology, industrial research, environmental sciences, information technology, medicine and agriculture. Nuclear knowledge is continuously growing as a result of research being carried out throughout the world. Research and Development (R&D) is a process of utilizing available knowledge for the creation of new knowledge. The key strategic goal of a nuclear R&D organization is not only the creation of new knowledge with respect to its deployment into products processes and services but also creating state-of-the-art knowledge.

Nuclear Knowledge Management (NKM) is increasingly becoming important as a tool to provide technology transfer to a younger nuclear work force, provide a solid foundation for power and nonpower nuclear applications and advance the next generation of nuclear technology. For the advancement of nuclear science and technology, Knowledge Management (KM) needs to be implemented in R&D organizations. Application of KM techniques should lead to an efficient management of R&D activities. This paper describes the benefits that can be attained by the adoption of KM techniques in nuclear research institutes.

2. Knowledge Management and R&D

The evolving field of KM provides diverse tactical measures, methodologies and technologies which can be applied for the continuous improvement of an organization's performance. In the context of R&D, KM is defined as an integrated process to capture R&D knowledge hidden in various knowledge based activities and resources, transform it into usable knowledge and diffuse it throughout the R&D organization for future use [1]. According to Malhotra, KM ensures that right knowledge is applied at the right place and time and it is about doing the right thing instead of doing things right [2]. KM seeks synergistic combination of data and information processing capacity of information

technologies and the creative and innovative ability of human beings. Its application to R&D will avoid unnecessary duplication of research. It can help support both individual and organizational learning from past successes and failures while guiding future actions and changes. KM attempts to bring under one set of practices various strands of thought and practice relating to:

- Intellectual capital and knowledge worker in the knowledge economy
- Various enabling organizational practices such as Communities of Practice and Corporate Yellow Page directories for accessing personnel and expertise
- Various enabling technologies like knowledge bases and expert systems, help desks, corporate intranets and extranets, Content Management and Document Management

Knowledge is often classified as tacit or explicit [3,4]. Intellectual capital is an agglomeration of explicit and tacit knowledge, codified information and intrinsic know how. It is rooted in the experience and expertise of the individuals belonging to the organization. If managed properly it can provide significant added value to the worth of an organization [5]. Tacit knowledge is stored in people's minds, hard to formalize and difficult to communicate. Tacit learning is deeply embedded in the lifelong experience of employees [6]. Explicit knowledge can be externalized, codified, structured, stored in databases and is relatively easy to communicate. Some tacit components can be externalized and codified to create explicit knowledge; however insights, intuitions, etc., cannot be externalized and are difficult to share.

KM focuses on processes or methods to find, create, capture and share knowledge and on technology to store and make knowledge accessible. KM can help collect knowledge from multiple areas and integrate it with relevant knowledge from internal and external sources. The process involved can be divided into four steps: knowledge acquisition, knowledge organization, knowledge dissemination and knowledge application.

- Knowledge Acquisition: Identifying relevant knowledge for current and future needs and then finding ways and means to access or extract knowledge
- Knowledge Organization: Involves refining, organizing and storing the knowledge collected
- Knowledge Dissemination: This phase involves who gets what knowledge and how
- Knowledge Application: Involves applying knowledge for problem solving and learning

2.1. Content Management

For R&D to succeed knowledge should be collected from all sources both internal and external to an institute. This is a necessary condition for any R&D activity which requires its personnel to continuously enrich their knowledge and use it to develop new information and knowledge. R&D organizations need to invest in acquiring relevant knowledge and people engaged in research should be able to make use of a variety of knowledge sources which will enhance their ability to innovate. Content Management (CM) defined as the act of locating, selecting, acquiring, processing, managing and disseminating content [7], is important in this context. Often the right content is not found or found too late. CM deals with managing content in organizations and making the right knowledge available at the right time to users. Content can be power if it is readily accessible, organized, managed, analyzed and delivered to meet an organization's needs.

2.2. Knowledge Sharing

Research has shown that sharing of knowledge is essential for creating an innovative mindset. Many people are afraid that by sharing knowledge they will lose their importance. Organizations should try to overcome this concern by providing incentives to employees for sharing their knowledge. A major component of the implementation of KM is to change this culture and encourage knowledge sharing rather than hoarding. Ambrecht et al [8] have proposed that a R&D organization should build a supportive culture enabling knowledge flow, promote creativity, capture knowledge of experts, access tacit knowledge and accelerate R&D process. Koenig [9] has proposed that for KM to be successful management of an organization should:

- Facilitate rich and open communication of information and knowledge
- Foster egalitarian organizational culture
- Support travel and professional development
- Encourage use of libraries or information centers more frequently to keep abreast of new developments

KM should address organizational level issues such as creating new or revising old processes to generate knowledge, developing incentives to promote knowledge sharing. It should utilize both formal organizational memory (such as databases, repositories and networks) and informal organizational memory (like culture and personal relationships) to access knowledge. Sharing knowledge through Communities of Practice, consisting of individuals with similar skills and responsibilities, can be beneficial. Communities of Practice is an effective approach to capturing and sharing tacit knowledge. KM can help connect people who will otherwise not be able to meet.

3. Knowledge Preservation

Like all high technology areas, nuclear science and technology depends upon acquired knowledge and accumulated expertise – scientific research reports, data maintenance records etc. Data preservation is a scientific and professional obligation and absolutely necessary in any R&D institute. The collection and storage of all information relating to a research project should be carried out during the development stage and proper quality assurance ensured. All observations and results relating to a project should be complete, written systematically and in detail. Failures should also be recorded. Development and documentation should be a team effort. Information or data can be transferred in electronic or hard copy manuals, databases, project design manuals. It is more difficult to manage the tacit knowledge that the specialists possess. This makes up the core competence within an organization and is a vital component of organizational continuity. Organizational knowledge preservation tools used for capturing tacit knowledge are learning audits, oral histories and exit interviews. Learning audit is a technique in which an individual records his/her actions, feelings, thoughts and experiences on a regular basis. Oral history is a similar technique which tries to capture the history of a project through post retirement interviews that also include anecdotal stories and events which set the scene for the culture and value system of an organization. Exit interviews upon departure of an employee succeed in retaining some knowledge.

4. Succession planning

Succession planning is particularly important in nuclear institutes. Since the early 1950's highly qualified and motivated professionals have brought the nuclear industry at the stage of development where it is today. A large number of these people have either retired or are retiring, taking with them a substantial amount of knowledge and institutional memory. These

people are also aware of previous failures and trials (not properly recorded) which can be of value for future development. To overcome this problem and preserve the knowledge, sufficient number of well qualified personnel should be available. Conducting training of newly recruited people and continuing education of existing people by these about to retire is a must. New members of an organization need to interact with the older members who are a source of institutional memory and knowledge. The new worker should observe and perform various tasks in the presence of experienced persons. Training materials produced in cooperation between an expert and a novice where the expert knows the content and the novice asks questions, have been found to be helpful in explicating the expert's tacit knowledge [10].

5. Nuclear Knowledge Management in Pakistan

Pakistan has an expanding program in the peaceful applications of nuclear science and technology particularly in the nuclear power sector. Pakistan Atomic Energy Commission (PAEC) has a number of research and development institutes where research on a variety of disciplines in nuclear science and technology is being carried out. Pakistan Institute of Nuclear Science and Technology (PINSTECH), is our premier research and development center. Multidisciplinary R&D focused on nuclear science and technology and allied sciences (physical, chemical, material and environmental) is being carried out. PINSTECH has two research reactors, PARR-1 (10MW) and a miniature neutron source research reactor PARR-2, which are used for research, teaching, training and production of radioisotopes for medical, agricultural, industrial and other scientific applications. The importance of NKM was realized in the early 1980s when certain measures were taken to preserve and share knowledge on a scientific basis.

Content Management: The Scientific Information Division of PINSTECH was created more than twenty years ago, as a central resource for acquiring and disseminating scientific and technical information to all users of PAEC. Selective dissemination of information is provided from INIS, INSPEC and Chemical Abstracts. Literature search service on specific topics or broadly defined areas is available to scientists/engineers on request. Support is also given to industry, research institutes, and medical and agriculture centers.

Knowledge Sharing: Scientists and engineers from within PINSTECH and other centers of PAEC are encouraged to participate in open discussions both formally and informally. Employees are encouraged to give monthly departmental seminars and explain their work. This gives them an opportunity of interacting with their senior and junior colleagues. Exchange of ideas takes place which is useful for problem solving. PINSTECH cooperates and extends the benefits of its research facilities to researchers of other organizations and students from universities. PAEC has been holding a summer college of 2-3 weeks duration, since 1976 on a regular basis. Two or three topics on physics and allied sciences, which are of current interest and their applications for technological development with special reference to the needs of the developing countries, are covered each year. Eminent scientists from the developed and developing countries share their knowledge and expertise with participants from developing countries. Participation of PAEC research centers in various IAEA programs has also played an important role in the free sharing of knowledge and in exposing our scientists/engineers to more developed nuclear centers of the world.

Knowledge Preservation: Researchers are encouraged to write detailed technical reports besides publishing papers in journals. A proper system of documentation and identification of these technical reports has been introduced. The reports are assigned a report number after review and vetting. This helps in preserving knowledge gained through research. With a lot of people retiring or reaching the retirement age, an Expert Advisory Pool (EAP) has been set

up to retain critical knowledge and expertise. Retired employees who have a good performance record are hired on renewable contract basis. Young people can interact with them and learn from their experiences.

Succession Planning: For the sustainability of nuclear science and technology, it is imperative that highly qualified and trained scientists, engineers and technicians of various disciplines are available. PAEC has set up training centers for imparting training to its employees in various disciplines. In addition there are four educational institutes that offer undergraduate programs in Computer and Information Sciences, Masters and Ph.D programs in Engineering (Nuclear, Systems, Process and Materials), Physics, Medical Physics, Nuclear Medicine and Computer Sciences and Biotechnology, which ensure a steady supply of manpower for PAEC's various programs.

These measures have resulted to a large extent, in sustaining the development of nuclear science and technology in the country. Starting with a modest program in the 1960s, Pakistan has now embarked upon a large program relating to the peaceful applications of nuclear science and technology for its socio-economic development.

6. Conclusion

KM techniques must be applied in nuclear R&D organizations, for the enhancement of their performance and ensure their sustainability and survival by preservation of knowledge. Benefits will be increased innovativeness, enhanced efficiency, and better decision making, reduced duplication of effort, faster responsiveness and improved quality of work.

REFERENCES

[1] PARIKH, M, "Knowledge Management Framework for High Tech Research and Development", Engineering Management Journal, **13**, 3, (2001) 27-33

[2] MALHOTRA, Y., "Knowledge Management, Knowledge Organizations and Knowledge Workers: A view from the front lines". (1998), http://www.brint.com/interview/maeil.htm

[3] NONAKA, I and TAKEUCHI, H., The Knowledge Creating Company, Oxford University Press, New York, (1995) .

[4] SPENDER J., "Competitive advantage from tacit knowledge? Unpacking the concept and its strategic implications", in Organizational Learning and Competitive Advantage, Mosingeon, B. and Edmondson, A., Eds, Sage Publications, London, (1996), 56-73

[5] CARAYANNIS, E.G., "Measuring intangibles: managing intangibles for tangible outcomes in research and innovation", Int. J. of Nuclear Knowledge Management **1**, 1/2, (2004), 49-67

[6] STUMPF, W., "The management of nuclear knowledge and expertise for sustainable development", Int. J. Nuclear Knowledge Management, **1**, 1/2, (2004), 165-176

[7] SRIKANTAIAH, T., "A Note on Content Management and Knowledge Management", in Knowledge Management Lessons Learned, Koening, M.E.D. and Srikantaiah, T. Eds., Asist Monograph Series, Information Today Inc. New Jersey, (2004), 149-156

[8] ARMBRECHT et. al., "Knowledge Management in Research and Development", Research Technology Management, **44**, 4, (2001), 28 – 48

[9] KOENIG, M.E, "Knowledge Management and Research on Research: What has been learned?" in Knowledge Management Lessons Learned, Koening, M.E.D. and Srikantaiah, T. Eds., Asist Monograph Series, Information Today Inc. New Jersey, (2004), 113-120

[10] RINTALA, N and HYTTINEN, L., “Methods for sharing tacit nuclear knowledge and expertise”, Int. J. Nuclear Knowledge Management, **2**, 1, (2006), 38-45