Knowledge Management as an IUGREEE Thrust

Knowledge management has long been an important part of successful engineering practice. It is now rapidly becoming even more important as a result of the recognition by industry leaders and management science consultants that knowledge is the source of all sustainable competitive advantage. Throughout industry, engineering organizations are recognizing the urgency to develop an infrastructure and methods to manage knowledge profitably. This urgency must now be acknowledged by universities such that knowledge management is integrated into the education they provide future engineers. The ubiquitous spread of the Internet coupled with rapid advances in information technology have enabled today's students to have immediate access to the global explosion of information and alternative means of acquiring knowledge. The IUGREEE must take an active role regarding the urgency of revamping engineering education to incorporate the principles of knowledge management as an integral part of the student's experiential learning.

Knowledge and Knowledge Management

Any discussion of knowledge management involves the use of the terms *data*, *information*, and *knowledge*, so for our purposes, let us consider *data* as any sets of measurements. *Information* is a statement of fact about data, or as Peter Drucker [6, p. 5] has stated, is data endowed with relevance and purpose. A characteristic of knowledge is that it is never static. Knowledge is always being revised and expanded. We define *engineering knowledge* as processed information, including engineering models, experience, and know-how, etc. [1]

Knowledge management involves:

- The capture, storage, and accessing of knowledge
- Effective utilization of knowledge
- Identification and filling of knowledge gaps

Knowledge management treats two kinds of knowledge: *explicit* knowledge and *tacit* knowledge. Nonaka and Takeuchi [4] state that explicit knowledge "can be articulated in formal language including grammatical statements, mathematical expressions, specifications, manuals, and so forth." This kind of knowledge thus can be transmitted across individuals formally and easily. . . . However, a more important kind of knowledge is *tacit knowledge*, which is hard to articulate with formal language. It is personal knowledge embedded in individual experience and involves intangible factors such as personal belief, perspective, and the value system." Stewart [5, Chapter 5] provides colorful examples of explicit and tacit knowledge as well as informal warnings against too rigid distinctions among data, information, and knowledge.

Knowledge management in industrial firms

In most firms, knowledge is a highly valuable asset. Return on this asset depends on the firm's ability to capture, store, retrieve, modify, and use knowledge as well as its underlying data and information. Each firm must answer questions such as how will more effective knowledge management help the company? How will it increase quality of products and processes, cut costs, and speed time-to-delivery? How will it affect the bottom line? Answers to these questions involve determining the often-hidden *costs of knowledge* *management failures* and the *costs and benefits of instituting effective knowledge management culture and practices.*

Many companies have tracked the amount of time spent in performing functions multiple times because they were not performed properly the first time. *In manufacturing, the impact of rework on schedules and costs is obvious. Determining the cost of engineering rework is more complex*, because it involves not just the direct engineering costs but also, in view of the high leverage of engineering design decisions, the resulting waste in production, marketing, and service costs. Changes made late in a project are extremely expensive both in costs and in time-to-delivery. Inadequate knowledge management is often what causes less than optimal designs to be adopted, because possible alternatives are not fully generated or considered and competing alternatives are not thoroughly evaluated.

Design rationales are difficult to capture for knowledge bases because critical decisions are often made before documentation is being assembled. Frequently, work must be repeated because no individual or institutional memory is available to explain why certain decisions were made on earlier projects.

Davenport and Prusak [2] relate knowledge management experiences at 39 organizations. Many of these involve qualitative measures of success, and some have been able to quantify their success in cost reductions or freeing resources for other functions. These and other case studies [3, 4,5] show that effective knowledge management can *cut costs, enhance product quality,* and *speed time-to-market*. In short, it provides competitive advantages.

Instituting effective KM usually requires changes in the culture (values, norms, and behaviors) more than additional technology. In fact, improving the knowledge management of a company involves [2,3]:

- Culture: knowledge sharing vs. knowledge hoarding. Trust.
- Organizational infrastructure
- Senior management support
- Alignment of rewards with KM benefits
- Technology infrastructure (computers, software)
- Training in KM as needed
- Intellectual property considerations
- Evaluation of KM activities
- Special considerations of KM in engineering

In competitive industries, *a crisis exists in expanding knowledge management activities* because (1) the amount of knowledge pertinent to many products, processes, and design projects is increasing rapidly, (2) competition and pressure to reduce costs are shortening the time scales of product and process development projects, and (3) increased rates of personnel turnover are seriously impeding firms' abilities to retrieve and reuse knowledge [1]. The crisis is often compounded by limited expertise in knowledge management practices.

Knowledge management in engineering education

A crisis exists in engineering education, as in industry, in regard to knowledge management because many academics are unaware of pertinent developments in industry and engineering practice, so education programs are rapidly falling behind current best practices. Industry dissatisfaction with some aspects of engineering education, a primary reason for the establishment of IUGREEE, is still ignored or denied by many academics. As always, crises of inaction or of complacency are little recognized as crises.

Historically, universities have been exemplars of knowledge management, especially the organization, storage, and retrieval of knowledge in discrete fields and the generation of new knowledge in some fields. Now, however, it is industrial firms that are advancing the frontiers of KM far beyond university capabilities. It appears that university faculties are largely uninformed on KM developments that are essential to the competitiveness of many firms. The first step for academe is therefore to learn what is being accomplished by KM developments in industry.

The second step for academe is to institute a KM approach to its own activities: teaching, research, administration, planning, etc. The incentives to reduce costs and improve quality of output are nowhere near as great in academia as in competitive industries, but achievements in these areas can help solve problems that are widely recognized, at least outside academia, as shameful and inexcusable. In discussing the management of professional intellect, Peter Drucker [6, p. 14] has pointed out that a challenge management faces is giving its organization of specialists [a description of faculties] a common vision, a view of the whole. This is frequently lacking in today's universities, and the lack is encouraged by the typical academic reward system.

Especially in engineering programs, knowledge management considerations should be integrated pervasively throughout the teaching, and not only in design courses where the need may be most obvious. They can be incorporated into science courses for data, calculation methods, history, tutorials, reference material, and supplemental (or replacement) course offerings. In engineering science courses the same can be done with the addition of current effective methods of calculation, estimating, and presentation of results. Obviously, KM considerations are absolutely essential for effective engineering design courses where knowledge is brought together and applied to solve significant needs. However, this *must not* be the first time students encounter KM. This would be to repeat the widespread mistake in engineering curricula of introducing for the first time in capstone design courses principles and procedures that students should be experienced with before they enter the capstone course.

Nothing here suggests that *courses in* knowledge management should be established. Surely there are aspects of KM that can be formally taught, but this should be done within other courses. One strong reason for this is that having a course in KM inevitably leads many faculty members who do not teach it to conclude that the course covers KM so that they have no responsibility to teach it. Here again a mistake frequently made in design teaching must not be extended. KM must be *pervasive* in engineering education just as it is in engineering practice in industry.

What IUGREEE should do now regarding KM

The IUGREEE must take the lead and work with the NSF to sponsor a focused national workshop on KM. We must assume that academia is simply ignorant of the impact of KM and therefore an educational approach is definitely the first step. Following the national workshop, the Engineering Dean's Council needs to devote a full meeting to the issues raised by KM and the proposed IUGREEE University Model for instituting KM into engineering education.

If the reforms in engineering education that IUGREEE intends to accomplish by 2010 are realistic, one would expect to see some changes starting by now in academia, even if specific directions have not yet been fully established. Evidence of this is scarce. Therefore, the industrial members of IUGREEE must carry the message regarding KM to the College of Engineering advisory councils that they are members of to emphasize the importance of integrating this concept into the education of engineering students.

Both industry and academia need to come together to form a joint task force to find common solutions to the issues both confront regarding the explosion of information and knowledge within the engineering profession.

The problem solving of tomorrow cannot be accomplished with the knowledge provided by today's engineering education!

References

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May 1999