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Knowledge Capture and Transfer Systems Critical to Ensure Future Success

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Abstract

Increased drilling activity caused by long-term elevated oil price stability is driving technology development and new application practices/techniques at a record pace. The ability to capture, retain and transfer this "new knowledge" is gaining importance due to the rapid turnover and relocation of experienced industry professionals to high-profile projects in remote areas. Combine this scenario with the graying of the industry and the impending "big crew change" and the potential impact of the loss of expertise and knowledge is particularly alarming.

Furthermore, as companies hire new and less experienced employees it is imperative to accelerate their learning curve and reduce the time to attain the required level of competency and performance. The challenges are how to efficiently share the knowledge of seasoned application engineers with new employees while helping them handle the increased work load.

To solve these pressing issues, we have introduced a differentiable knowledge capture and transfer system developed in a cross-divisional initiative to help stem the potential information loss and help foster a culture of continuous improvement in our application engineering groups. The authors will outline the development and structure of the system, its search, retrieval and knowledge-delivery features. They will also demonstrate how the system can be used to accelerate the learning curve, avoid reinvention while facilitating the replication of success across geographic/divisional boundaries by providing decision support.

Introduction

How do organizations transfer critical expertise and the experience of their employees before that knowledge walks out the door and leaves the organization for good? The challenges of knowledge retention and continuity are faced by the business executives in organizations around the globe and in every part of the industry and public sector spectrum. Managing knowledge evolution and delivery across the employee lifecycle, from young mobile employees to older highly experienced individuals, is critical to ensure the long term survival and growth of an individual organization.[1]

In the current age of learning, survival and health of individuals and organizations depends on their ability to learn – question, explore, create and grow. Learning and knowledge sharing is no longer preparation for the job, It IS the job.[2]

Most in our industry would agree that although we never seem to have the time to capture or search for lessons, we always have time to re-live the same mistakes.

In our industry the statistics of the workforce population show a bulge in the 45-55 age bracket. The Society for Petroleum Engineers (SPE) estimates that between 1980 and 1998 the oil and gas industry staffing levels fell from 700,000 to 300,000 people. As of December 2006, the median age of all SPE members is 47. The oil and gas industry is expected to experience a 44 percent attrition rate among petroleum engineers by 2010, and over 200,000 years of cumulative experience and knowledge will be lost to the industry in the next 10 years due to retirement. Almost half of the work force will be new.[3]

Knowledge Management (KM) has become a recognized discipline and core requirement in a majority of industries and organizations. The umbrella KM term has received varying degrees of good and bad press both within individual organizations and in the wider world. Various schools of thought exist on how to best deliver on the "right information, to the right people at the right time" mantra of KM. Various approaches can be used to capture and transfer knowledge in and around the organizational structure, with tools ranging from expertise location systems, content management and search solutions, discussion forums, communities of practice, and best practice and lessons learned databases. The underlying principle in all these approaches is to facilitate the sharing of individual experiences and collective knowledge to increase the performance of individuals at the point-of-need and the department or organization as a whole by reducing the learning curve and reinvention of previously existing solutions.

It is widely recognized that approaches to share explicit knowledge (that which is documented in policies and procedures) are ***relatively*** easier to implement compared to approaches which effectively transfer the tacit experiential knowledge which individuals in an organization possess. And yet it is also widely accepted that the most valuable and most numerable knowledge the organization has is this unspoken, tacit knowledge which resides "in the heads" of their employees and can constitute 80% of the organizational knowledge bank.[4] Successful approaches to transferring tacit knowledge are generally less formalized, organic, and people intensive processes such as peer reviews, virtual collaboration and storytelling techniques. These provide powerful and

effective knowledge transfer environments, though to be truly effective and achieve a degree of longevity, a methodology to document the outcome of these transfers in some shape or form and make it available to a wider audience is required. The remainder of this paper will discuss in detail some of the specific drivers, tools and methodologies we have developed to enable effective transfer of tacit knowledge via a combined narrative and lessons learned system built to enable effective communication across functional groups in our organization.

Specific Benefits

"Knowledge-driven" services are an important differentiator in today's oil and gas marketplace.

For our organization, every application of a product or methodology provides an opportunity to learn and improve upon the technology and service. An organization needs to be able to harness its collective experience every time it analyzes an application, and then to share individual experiences with other engineering functions within the organization. Ultimately the benefits that can be realized from a correctly structured and implemented knowledge repository affect many aspects of our organization. Efficient transfer of application lessons across the globe to all engineering communities delivers;

- Improved effectiveness and success of new technology introduction via more thorough understanding of interaction in an environment. The ability for fast and efficient transfer of knowledge around new technologies can accelerate their acceptance by the industry.
- Effective decision support and fosters organizational standardization. A system that doesn't discriminate between what went well and what improvements are required delivers not only positive experience on how performance was enhanced, but where we also learn from or negative experience and problem avoidance.
- Access for all personnel to expert knowledge regardless of location or time zone eliminating geographic or organizational boundaries.
- Naturally builds global Subject Matter Expert communities and provides an avenue to share and discuss applications and lessons.
- Organizational knowledge retention sustaining the organization's expertise over time.

Efficient knowledge systems can rapidly raise the engineering expertise in an organization by allowing less experienced engineers to benefit from the wisdom of Subject Matter Experts (SMEs), accelerating their learning curve and engineering competency, expertise which translates directly into cost savings. This yields a more powerful collective experience where the sum of the whole greatly out weighs the individual parts. Ultimately this fosters a collaborative environment of intra and cross divisional learning and our goal of a holistic approach to all application solutions.

In concert with the value derived internally in our organization these factors are all brought into play in delivering products and services to our clients. These benefits include:

- Enhanced technology development cycle
- Greater understanding of all our applications
- Improved risk management. Effective KM is not just saving cost/time but improving our customers' decisions making and operational planning efficiency.

Knowledge Capture and Transfer System

In developing our knowledge capture and transfer solution we leveraged on the experience and a previous incarnation of a lessons learned system within our organization.[5] While the previous solution was robust and enabled better communication of knowledge within a small expert community, over time we recognized a number of "improvement opportunities" which would enable our organization to leverage more effective, valuable and sustainable knowledge transfer to a wider sphere of knowledge workers (engineers, research, sales etc.) in the organization's drilling community.

We defined several objectives that the new system should fulfill:-

- Allow knowledge capture for individual applications in addition to engineering project formats.
- Increase flexibility in the detail required when capturing an application to facilitate increased re-use of tacit knowledge.
- Streamlined knowledge review and validation process
- Increased size and distribution of user community
- Increased volume of experiences documented.

Development Process

Using well proven Total Quality Management techniques for process improvement and our own knowledge mapping techniques the development team followed a structured methodology to assess the needs of the target user-base and design a system which would leverage from existing tools and ongoing research initiatives. An overview of the development process is presented below:-

1) Map functionality in existing knowledge systems:
    a. Map domain attributes required.
    b. Review capability of existing related systems.
    c. Select Target Applications to harvest / link to.
2) Users Knowledge Mapping:
    a. Assess previous and potential expanded userbase – Who?
    b. Map customer base to domain attributes – who needs to know what?
3) Knowledge Capture Process Mapping:
    a. Map and critique current knowledge capture processes in participating divisions.
    b. Identify & resolve process issues.
4) Knowledge Categorization / Taxonomy Development:

   a. Integrate with parallel initiatives for document categorization.
   b. Application Engineering competency mapping.
   c. Real-world environmental classification.
5) System Design:
   a. 'Harvesting' existing functionality in target systems.
   b. Design Meetings – "Designing on-the-fly".
   c. Develop alpha /beta testing schedule.
   d. Data migration.
6) Implementation & Testing:
   a. Customizable user interface using structured layout documents.
   b. Internet standard protocols, HTML and JavaScript.
   c. User access via web browser within normal portal environment.
7) Training & Rollout:
   a. Classroom & Computer based training (CBT).
   b. Guerilla rollout and formal product launch.

The process will be documented in detail as a separate publication. For the purposes of this paper it is sufficient to state that utilizing this holistic process enabled the development team to fully understand the requirements of the end users in developing a well structured, taxonomy-driven knowledge capture tool which provides end users with flexibility and control on the detail of what is captured and shared.

Knowledge Classification & Narrative Communication

Structured knowledge representation enables end-users to easily classify the context of a lesson learned using terms and definitions familiar to them in their domain. Additionally, as we discuss later, this structuring is the enabler to highly complex search and query construction in this system. However, many classically structured lessons learned systems can prove to be too inflexible and restrictive in the knowledge representation they contain and consequently fail to accurately represent the true nature of the knowledge requirements of the users as these requirements change over time due to such things as advances in technology. The end result of this inflexibility? - As the intended user base rapidly loses interest in using a system which doesn't adequately fulfill their needs, the community, and the investment inherent in building the community and its tools quickly dies and is lost.

Recognizing this potential stumbling block to the longevity of the system we designed-in the capability to allow users of the system to extend the taxonomy as and when required. The system allows the users to create new attributes and definitions (which are then validated and approved by domain gatekeepers) to continually extend the knowledge representation over time. In so doing we are able to drive familiarity with a common classification vocabulary and the powerful integration capabilities into the community. Simultaneously, this allows the end user knowledge workers to evolve the classification schema for us. The system and its classification schema grow organically according to the developing requirements of the user community, allowing it to evolve over time to better suit their needs.

We built the system's structure to make capture and transfer of lessons learned easier by making input follow a more "narrative style" as opposed to simple entry keywords. Several textual fields in the database "walk" the user through an approach to document their tacit knowledge and to "tell the story" of the scientific method used in the analysis and the outcome, performance and their personal recommendation of "what to do next time" – this we term the "Local" best practice.

The end result, in knowledge transfer terms, is a system which enables effective transfer of tacit to explicit knowledge in a narrative communication of the experience. The narrative lessons learned knowledgebase allows the collection of information which may or may not necessarily be of direct use to the end user, but which is presented in a form that allows the reader of the knowledge entry to make informed decisions on the knowledge and to apply derivatives of that collective experience in analogous scenarios around the world.

Application Knowledge - Capture

Users access the secure knowledge system site via active directory control passwords within their normal portal environment. User registration is self driven and each user has the ability to define an individual profile which is used to subscribe them to periodic, domain specific knowledge updates via e-mail newsletter **(Figure 1)**.

In recognition that varying levels of knowledge complexity may be captured, and indeed wellsite data and information is not always readily available or even acquired, three structured forms are available, prompting for progressively increasing levels of detail.

At the lowest level, a simple form termed "Bulletin" is designed to capture specific 'bites' of information and learning in a text entry field with a facility to add supporting attachments and links.

Common to all three forms are just six mandatory inputs to describe Location, Client, Lesson Title and Knowledge Category which are used to drive the simplest of three search and retrieval functions.

At the discretion of the user the form may be "upgraded" to allow more detail to be captured as and when information becomes available. All existing data entries will be preserved into the upgraded form. The next level "Briefing" adds categorized sections to describe the well class, simple drilling environment and drilling system description and a structured format for detailing the lesson learned.

Finally the highest level entry "Technical Lesson" adds more detail to well classification, enhanced drilling environment descriptors include a stratigraphy profiler and additional entries for the drilling system. e.g. mud type, BHA type, Bit size and class. Additional sections to describe rig class are added along with a problem and best practice descriptor linked to the organisation's best practice databases.

Experience has shown that simplifying data entry encourages user uptake, so mandatory inputs have been kept to a minimum with data entry simplified using pick lists and free text cells which support cut and paste from other desktop applications. Supporting attachments and links permit the author to add picture, log information and reports etc. Where more than one lesson is being entered for a specific environment a 'new from old' function provides the ability to re-use previously entered environmental attributes for a new lesson.

Application Knowledge - Transfer

On entering the system the user is automatically in the lessons "View By" panel. From here they can chose to view all lessons by; Location, Client, Field and Knowledge Category. This can be refined by selecting a second view criteria e.g. View by Client will show all country locations for which lessons have been entered for that specific client. Selecting a country from this view will return all lessons for that client in the selected country of interest.

Flexible search capabilities for knowledge retrieval allow for basic searches to locate all entries made in a specific location, or for a particular client or field or author using one or more of the mandatory fields. All documents are fully text indexed facilitating a simple or Boolean word search tool similar to common internet search engines. Alternatively, complex highly structured queries containing multiple criteria search the database for any value contained for over 50 specific classifying attributes. This advanced search method is based on the user selecting from any one or more of the pick lists contained within the highest level technical lesson form. In this top level search we could for example select to review all lessons drilled through sandstones of less than 10,000psi Unconfined Compressive Strength (UCS), using a medium-set PDC on a rotary steerable BHA at +50 degree inclination. Such a complex querying function delivers an unprecedented capability to our engineers, enabling them to establish potential risks and proven solutions to manage these risks in similar environments.

All entries are classified by one or more knowledge categories allowing users to find quickly all current knowledge related to their areas of interest, links to other users' profiles and to receive regular e-mail notification on subject areas they may be interested in. i.e.

Drilling applications:-
- BHA Design
- Bit Design
- Drilling Parameters
- Optimization & Procedures
- Mud Selection
- Etc …

Specialized Drilling Methods:-
- ECD Management
- Casing & Liner Drilling
- Under balanced
- Etc …

For Subject Matter Experts this means a global awareness of field operation learning's rather than a limited region focus.

Our applications knowledge is now "De-Complexified" – complex with today's exponential growth of information accessibility, the trick is to separate the relevant information from that which is not needed at a particular decision point. So it's not just a matter of simplifying the information but removing the complexity to arrive at the answer in the form of the most relevant knowledge instead of information overload.

When the organization's goal becomes to transfer the basic information or data to a solution, this organization effectively becomes applications centric in its approach to operations.

Knowledge Quality

An essential aspect of this Lessons Learned system is the knowledge validation or review process implemented. Distinct to other types of knowledge transfer systems such as discussion forum or narrative databases, this system relies on inputs from a diverse user community supplying relevant technical and performance information. To ensure user confidence that the knowledge contained in the system can be readily re-used we implemented a dynamic review process drawing together the experience of a global community of Subject Matter Experts. These SMEs review each entry into the system. However the review process needed to be flexible enough to allow for instantaneous knowledge transfer as well as a rigorous validation process.

New entries are published by authors directly to the system and are immediately visible to other users. At this stage the entry is flagged with a red "traffic light" indicating to other users that the entry is unvalidated at this stage. Simultaneously a network of Gatekeepers are notified of the existence of the entry via email. Once published, the system Gatekeepers are notified via e-mail and a structured review process is then applied utilizing the organizations SME network to validate the new entry. The systems workflow follows the entry's validation and its status is notified to users via a simple traffic light system. This process allows for rapid dissemination of new entries in the system whilst allowing this background validation process to occur, and users are able to readily assess the "Quality Status" of the entries before re-applying those lessons **(Figure2)**.

Application of Knowledge

Knowledge Management tools are integral to the Continuous Improvement Cycle embraced by applications centric organizations. Our experienced Applications Engineers and Geoscientists strive to use a structured process that involves logically identifying, understanding and then overcoming the barriers to improved performance through the Planning, Drilling and Post-Well Analysis stages of the cycle.

Knowledge capture enables re-use of previous experience at all stages in the optimization process to avoid problems and replicate previous success whether in a local or analogous remote environment **(Figure 3)**.

KM related tools and processes are needed to support the ever increasing requirement for service companies to routinely

demonstrate applications competence and experience to their clients. Significant service value-enhancement is achieved for our organization by active incorporation of KM techniques and processes which supports our decision making at the customer interface.

Conclusions

The Knowledge Store is a powerful tool aiding knowledge transfer and retention in our dynamically changing workplace at a time when our organization faces unparalleled challenges in its knowledgebase management.

The system fast-tracks engineer development by making applications knowledge and Subject Matter Experts more accessible and expands the community knowledge networks across the globe and between divisions. It promotes an organizational culture change allowing people to actively seek easy to find knowledge, facilitating more efficient ways to work – "filing cabinet engineering" is replaced by real optimization. Knowledge transfer aids in the identification of analogous applications, provides decision support which avoids repeating mistakes and enables replication of success.

User acceptance of the system has been rewarding, many individual testimonials show that the user-base now regard the system as a valuable part of their networking toolkit. The system is now a primary resource for technical and performance information from around the globe, enabling the re-use of information and knowledge ascertained from individual contributions outside their traditional personal networks.

Traditional G&G / Drilling silos are deconstructed – communities of practice have a vehicle to interact as knowledge begins to overlap traditional lines or disciplines.

Online and ILT training courses have successfully widened the audience and acceptance of the knowledge tool and encouraged uptake and input.

Since the launch of the system we have witnessed a consistent increase in the user-base of geoscientists, bit optimization and drilling performance application engineers utilizing the system for knowledge entry, search and retrieval. This userbase shows a consistent increase month on month with incremental growth of 10%. The number of "user accesses" and searches in the system shows a 20% increase in frequency per month **(Figure 4)**.

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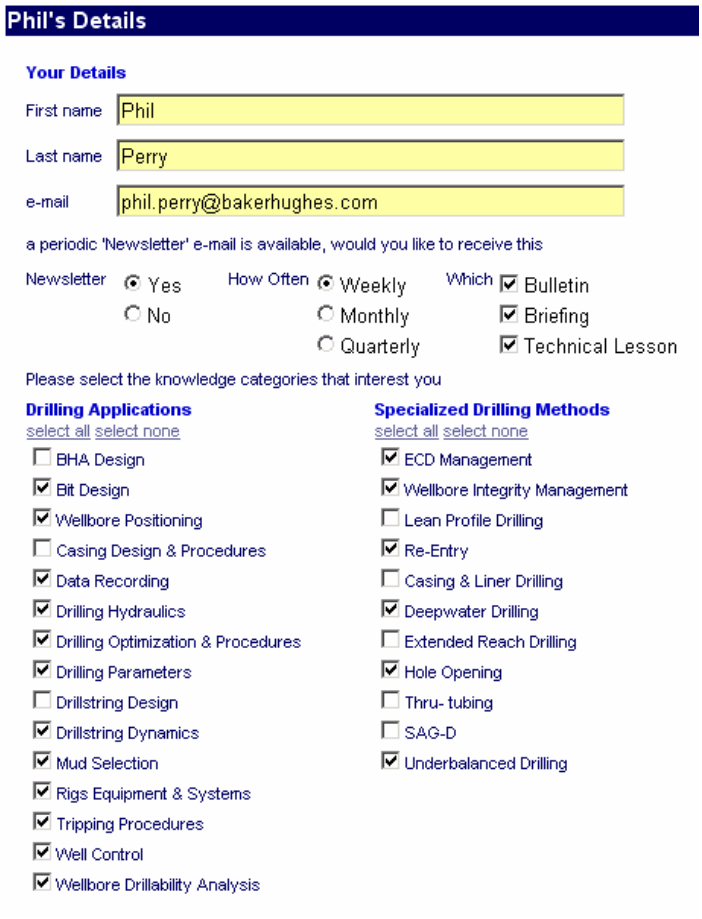

Figure 1: User profile entry for domain specific subscriptions.

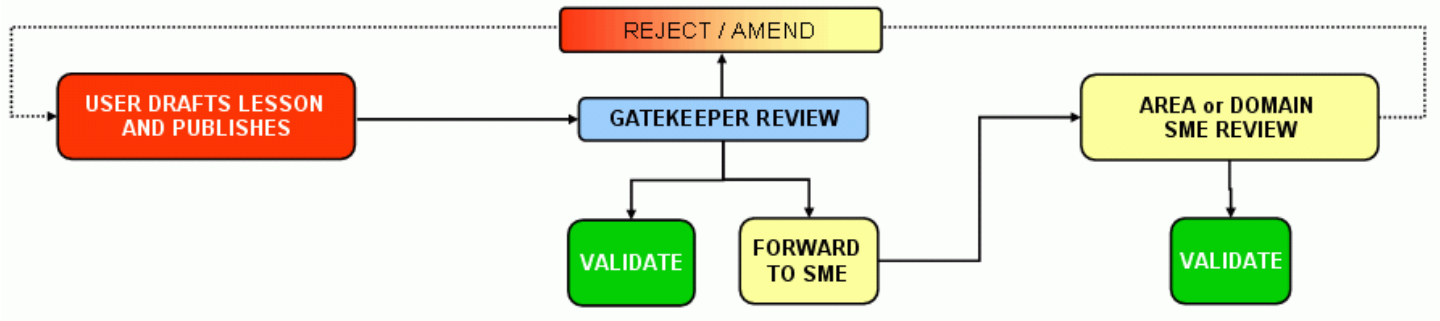

Figure 2: Review process schematic.

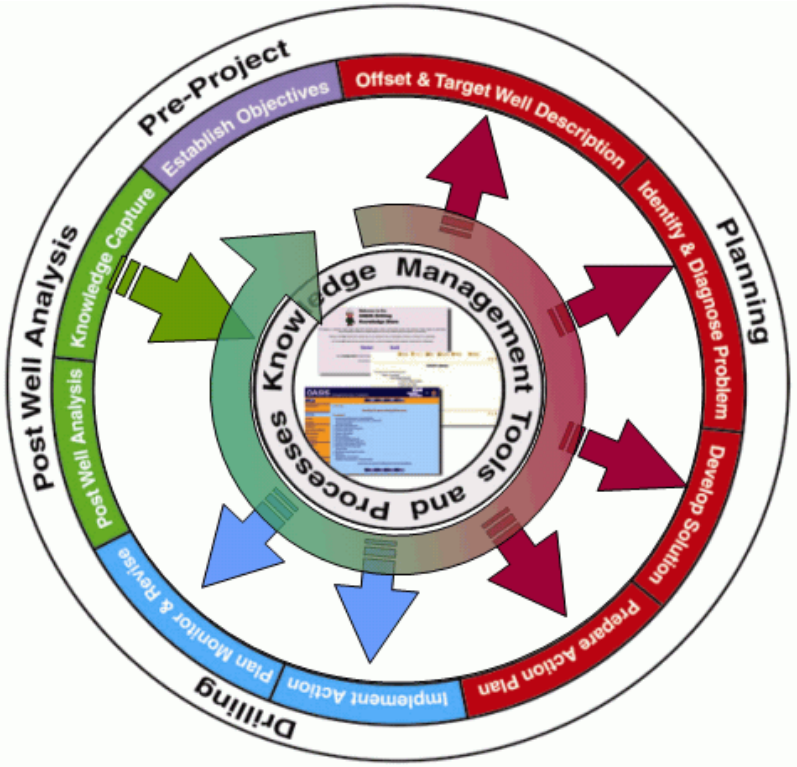

Figure 3: Knowledge re-use in the continuous improvement cycle for drilling optimization

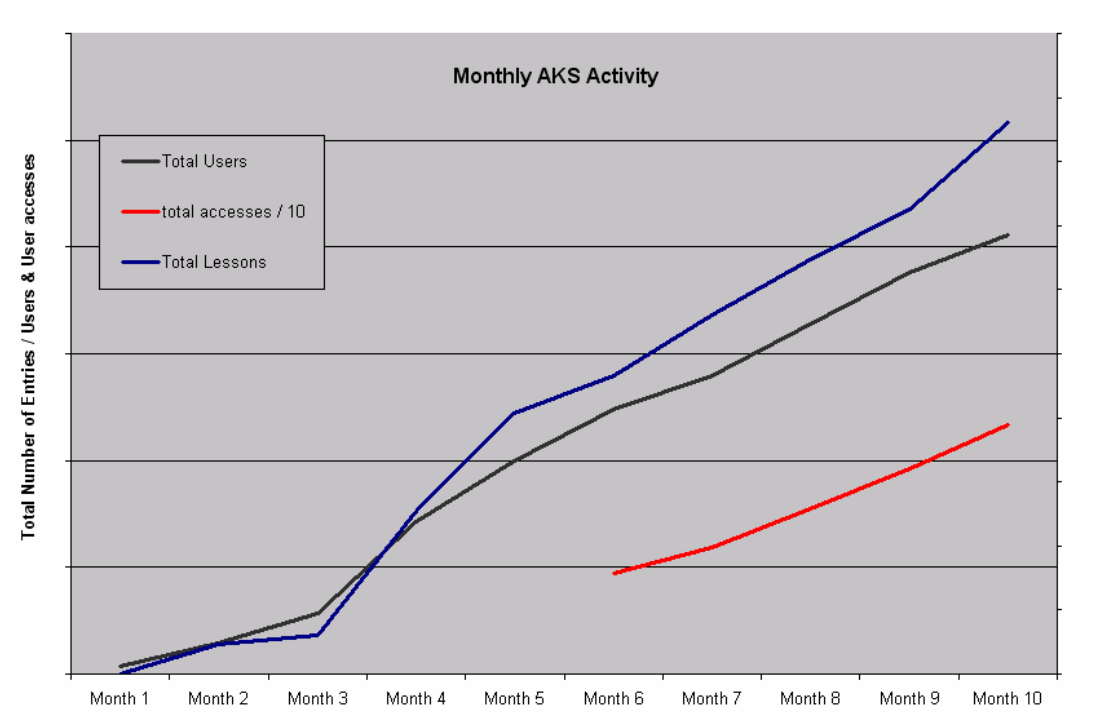

Figure 4: Increasing use of the system