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CONSTRUCTION KNOWLEDGE EVALUATION USING EXPERT INDEX

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Abstract. While the current global economy can be characterized by the intensification of business competitiveness, leaner organizations, the convergence of products and services, and by vast technological developments, the risks and uncertainties inherent in such a dynamic environment make the management of organizational knowledge even more crucial. Indeed, previous theoretical and empirical-based studies have proven that knowledge leads to organizational success. Knowledge Management (KM) has particularly gained credence, and continues to generate interest, in academic and business circles. KM is of especial interest to project-based industries such as construction, as the effective management of knowledge is critical to the survival and continued advancement of a company. In fact, in the construction industry, the implementation of a knowledge management system (KMS) is currently being considered, and an increasing number of companies have already proposed knowledge management initiatives. However, quality of information must take precedence over quantity, especially in the developmental phases of this KMS. Therefore, how to filter and accurately evaluate quantitative and qualitative data becomes a significant challenge. Yet, thus far, only a few studies examining the improvement of knowledge evaluation have been conducted and that researches only focus on the evaluation methods. This research addresses these issues by focusing on knowledge management and evaluation and by specifically addressing how to evaluate knowledge effectively. Based on the Active Knowledge Management, this study proposes a process model for effectual construction knowledge evaluation using Expert Index (EI). EI is the level of specialty workers achieve in a certain field after engaging in a knowledge activity. The proposed model will not only enable precise evaluation, but will also provide stimulating knowledge activities; thus, if practically applied, this model could enhance actual organizational success.

Keywords: knowledge management; knowledge evaluation; expert index.

1. Introduction

Over time, a series of paradigm shifts have occurred in the dynamics of labor. Agricultural societies dependent on land, capital, and physical labor have been replaced by information-oriented societies in which labor is heavily based on technology and human intelligence. In turn, these information-oriented societies have developed into intellectual societies heavily dependent on knowledge. This shift has affected how productivity is gauged. While, in the past, productivity has depended on how hard people work, in current society, productivity is now measured by how effectively this work is managed. This phenomenon has occurred for various reasons. For example, knowledge and access to information have become instrumental in determining social status. Also, rapid technological developments have caused society to change at an extreme rate and to become more diverse, thus making the efficient management of knowledge even more essential.

For instance, Druker (1999) has predicted a move towards intellectually-based societies. According to his paradigm shift, as opposed to a 20th century industrial society, the coming decades of the 21st century will be defined by an ultra-competitive environment which is characterized by rapid progress in management and the continuous advancement of knowledge management techniques. Furthermore, Druker does not consider knowledge in traditional terms (i.e., as one of the components of production like labor, capital, and land), but as a unique resource that is essential to any enterprise. Indeed, for Druker, knowledge is vital, especially in an ultra-competitive environment, because technical know-how, marketing techniques, understanding customer needs, product design, and innovative reorganization are all dependent on the knowledge resource. As well, managing organizational knowledge has become increasingly important due to the risk and uncertainties inherent in such dynamic environments.

Especially in project-based industries such as construction, effective knowledge management is critical to the survival and advancement of a company (Kivrak *et al.* 2008). However, although the construction industry has made a great effort to be mechanized in many fields, it is still a "labor-intensive" industry, which means that despite the importance of applying theoretical knowledge in the actual construction field, individual experience is still more effective in most cases. Thus, because knowledge derived from the individual's experience can directly impact project success or failure, knowledge management strategies that take individual experience into account

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should be introduced to the construction industry. In fact, the implementation of an effective Knowledge Management System (KMS) is currently being considered, as a KMS can reduce project time and cost, improve quality, and provide construction organizations with a competitive advantage (Shelbourn *et al*. 2006). Also, an increasing number of companies have already proposed knowledge management initiatives.

Furthermore, it is crucial that organizations measure the knowledge of their knowledge workers in order to optimize business processes (Fink 2005). Indeed, as suggested by Skyrme (1998), measurement and management of knowledge-based assets are extremely important for knowledge organizations. However, quality of information must take precedence over quantity, especially in the developmental phases of the KMS. Therefore, how to filter and accurately evaluate qualitative and quantitative data becomes a significant challenge. That said, few studies focused on improving knowledge evaluation have been conducted that solely concentrate on an evaluation method. To address this, this research focuses on knowledge management and evaluation by specifically addressing how to evaluate knowledge effectively. Based on Active Knowledge Management, this research proposes a process model for effectual construction knowledge evaluation using Expert Index (EI) (i.e., the level of specialization a worker possesses after performing a specific knowledge activity). The proposed model will provide challenging knowledge activities that will encourage self-regulation, while motivating users. This model will also enable accurate knowledge evaluation. If practically applied, this model could enhance actual organizational success.

2. Characteristics of the Construction Industry

The construction industry includes the creation of social overhead capital and fixed capital, and the tangible and intangible production activities that are performed to maintain this capital. Generally, the industry has three characteristics that predominantly cause discontinuity in project production: the uncertainty of orders, the unrepeatability of works, and high risk factors due to rapid economy and market changes. Six fundamental industry characteristics, as outlined by previous research, are as follows.

1) The construction industry is based on daily production. Compared to the manufacturing industry, construction projects are heavily affected by their surrounding environments. While the manufacturing industry–which mostly involves indoor processing–is not as heavily impacted by the weather, construction works may be delayed or require re-work due to weather conditions.

2) The construction industry is an order industry that is driven by contractors' orders; this makes it a pre-sales and post-production sales based industry. Also, many products are produced according to these orders. Unlike other industries no function is performed by customers during production.

3) The construction industry has various financial functions. Not only must the industry have guaranteed mechanisms to distribute the risks inherent in the multi-level construction process, it must also possess financing capabilities for investment costs.

4) The construction industry is significantly impacted by cultural customs and traditions. During production, many people–including contractors, employees of out-sourcing and sub-contracting companies, local residents, and etc.–are involved in the production process. As a result, their various customs and traditions affect this process. Thus, information and accounting must be even more clearly defined in order to rationalize the industry and get rid of irrational customs and traditions.

5) Communication amongst construction practitioners and clients is extremely important. During a construction project, the diverse interests of many people (e.g., sub-contractors, contractors, suppliers, customers, and etc.) are complexly related. In brief, in the process of combining human, material, and technological resources, communications between creative knowledge participants and production participants heavily affect project outcome. In particular, communication problems amongst and between purchasers, constructors, and supervisors may deteriorate site situations and cause problems in project processing.

6) Unlike other industries, the construction industry is highly dependent on human capital. Therefore, a highly qualified and experienced workforce plays a significant role throughout the construction process. Due to this particular characteristic, it is extremely important to manage the professional knowledge derived from the different experiences of engineers whether they are professional engineers, certificate holders, or simple technicians. These individual experiences are intangible assets to construction companies that must be managed appropriately.

By comparing the characteristics of the construction industry with those of other common industries, the important business functions of the industry can be more clearly understood.

3. Necessity of KM and Knowledge Evaluation in Construction

As already observed, construction projects are unique and temporary, and construction project teams consist of multidisciplinary groups that work together for a limited amount of time. Generally, when former project member move on to new projects, resign, or retire, much new knowledge is lost, and subsequently, the valuable lessons that could have been learned from this knowledge are not recorded or shared properly. Thus, as know-how, know-what, and experiences are intangible, capturing and applying the tacit knowledge of experts and engineers is critical for future project success and ultimately company success. Therefore, effective Knowledge Management (KM) is vital for construction companies to prevent the hemorrhaging of valuable information gained from previous projects.

As construction knowledge has become increasingly essential in gaining a competitive advantage, accurate evaluation of knowledge is even more critical. Further, inappropriate knowledge can result in accidents or negatively impact productivity.

When evaluating knowledge, who actually evaluates the knowledge is an important factor. In fact, the usage frequency of KMS and its credibility depends on who manages the knowledge evaluation and that individual's level of objectivity. This will bring about more active knowledge management.

4. Present Domestic Practices of KMS

In today's knowledge-driven economy, many construction companies have considered implementing knowledge management strategies, while an increasing number of companies have already proposed knowledge management initiatives. Most construction companies recognize that a KMS can enhance project efficiency.

In fact, almost all of the large companies in Korea currently operate a consolidated KMS of administrative and accounting knowledge, enterprise common knowledge, business core knowledge, and etc. These systems are composed of three functional modules for respectively executing knowledge mapping, knowledge searching, and knowledge evaluation. Knowledge workers register their knowledge, which is then evaluated by a knowledge master or knowledge group. The present condition of the respective KMSs of three large companies in Korea is as follows:

1) D company's Knowledge Management System

D Engineering & Construction Co. currently operates a consolidated KMS for administrative and accounting knowledge, enterprise common knowledge, and business core knowledge; this system uses an ERP system, global baronet system (groupware), and web-based intranet for each division. Knowledge management is currently operated for each division, and this system is the most actively-run knowledge management system that standardizes and systemizes construction characteristics, and establishes an independent knowledge data warehouse, maximizing productivities by performing similar works using historical information.

In this KMS, knowledge is categorized either generally or by theme (i.e., by headquarters). Ideas for the improvement of organizations or certain works are classified as general knowledge, while thematic knowledge includes opinions expressed by members on the themes provided by the company. Proposals corresponding with corporate goals are selected and rewarded. Otherwise, they are given back to those who suggested them.

In the case of a construction company, proposals are selected when the arithmetic average is over 60 and the evaluation level is not 3.

2) H company's Knowledge Management System

Launched in May 1997, H Engineering & Construction Co.'s executive information system assists directors in making prompt decisions by providing information on sales, construction, personnel management, orders, accomplishments, related companies, and etc.

In June 1997, the consolidated personnel management system was redeveloped from a mainframe environment to a client/server environment over 14 months; it is still currently in use. This is a construction cost management system which is unique in the construction industry. It includes designing, estimating, contracting, performing, and budget writing, as well as contractor management and cost management. This system aims for consistent construction work management by unifying estimates for outside contractors, inside cost details, budget, and etc. It is intended that this system will be combined with Enterprise Resource Planning (ERP), therefore composing a consolidated management system.

Furthermore, H Engineering & Construction Co. processes, in real-time, installments and mortgages for reconstructed and re-developed apartments, both at the company headquarters and at the work sites. In the future, this will be expanded to ARS or firm banking. Since 1996, H company has used a self-developed messaging system, but in 2003, it was to choose either a Notes or Exchange server. A KMS has been established based on groupware.

To register knowledge, H Engineering & Construction Co. makes proposals to IDEA BANK, and these proposals are categorized as finished proposals or ideal proposals. Finished proposals include problems, conducting methods, and improvement effects, while idea proposals include problems, improvement methods, and expected results. Proposed knowledge is evaluated by knowledge masters–whose function is to evaluate registered knowledge–at three levels of A, B, or C. According to the evaluated levels, mileages are provided.

Finally, compensation for knowledge, which promotes the knowledge activities of knowledge workers, is conducted by mileage.

3) S company's Knowledge Management System

In 2003, S Engineering & Construction prepared a business plan supporting a system that established a value and accomplishment-focused structure. In the latter half of 2003, after analyzing the data accumulated in the first half of the year, a series of standards procedures were completed. To set up a basis for KM, the usage of a document management system was promoted and inside document standardization was finished in the first half of 2003. A KMS is currently on trial.

With the setup of an EP, an infra system and KMS will be integrated based on the 89 enterprise standards work process. In this work process, after new or recycled knowledge is registered, it is transported to evaluators (i.e., knowledge masters) who subsequently perform evaluation, sharing, training, and consulting.

In this system, knowledge is evaluated at 4 levels by users, and knowledge is accumulated to provide rewards and compensations according to a mileage system. Level 1 knowledge registration corresponds to 200 mileage points and contains a value of 20,000 won. Even if the registered knowledge is not selected, 5 mileage points are provided, making users active in registering knowledge.

For superior knowledge, 3 people are rewarded with 1 million (won for each quarter) and with a grand prize. 1 person is rewarded 3 million won. 2 gold prize winners are rewarded 2 million each. Another incentive method is mileage given to superior employees and excellent departments. By rewarding with mileage quarterly and annually, more users will be able to participate.

To support these activities, the administrators are paid 50,000 won monthly, and knowledge evaluators are paid 50,000 won quarterly. Also, extraordinary activities are awarded each year, which encourages the participation of users.

5. Present Overseas Practices of KMS

At present, many countries in the world, especially the developed countries, are expending considerable effort to promote the construction of a KMS, attracting a great amount of attention to KMS construction and its corresponding benefits. In reality, there are many enterprises that have achieved very good results in implementing knowledge management. Significantly, these organizations tend to attach importance to knowledge sharing. The following shows the present condition of the respective KMSs of 2 large international companies.

1) Turner Knowledge Network

In 2002, Tuner developed Turner Knowledge Network (TKN). TKN provides an innovative web-based knowledge network solution that facilitates faster, more consistent employee growth and development, enhanced recruiting, retention and development, increased on-the-job safety awareness, cost saving, and increased value to customers. This network began delivering knowledge through an organization of over 4,700 employees across 41 business units in 27 states on 1600 projects. It also delivers information to over 25,000 subcontractors representing over 250,000 trade and craftsmen (Turner 2008).

TKN is a web-based portal that contains a Learning Management System (LMS) that facilitates the transfer of knowledge and best practices throughout the enterprise system. This portal also provides links to newly released company and industry news, the weather, benefits, and other useful links. Employees register for the LMS for both web-based and instructor-led learning that is appropriate to their position and role. With this LMS, employees can track skill requirements, analyze gaps in skills and proficiencies, and register for learning that addresses these knowledge gaps in areas such as Leadership, Management, and Technical skills. Some examples of web-based courses offered through Turner University include: OSHA (Occupational Safety and Health Administration) 30-Hour Certification, Prolog (Project Management and Collaboration Software) offered as TurnerTalk, Mechanical, Electrical and Plumbing, Career Counseling, How to Read a Financial Statement, Business Skills and PC Skills, as well as courses on the Turner philosophy regarding ethics and compliances, values and customer service.

Employees can also use the Document Management System to access documents and forms needed in every step of the construction process and to access related sites. The information housed in the Document Management System represents 100 years of Turner experience, knowledge, and know-how. By providing access to best practices, Turner is improving efficiency by leveraging lessons learned. Turner can also use the information provided by these systems to help assimilate new hires–from all over the U.S. and from diverse backgrounds and cultures–by familiarizing them with the company's common goals and objectives.

Over the past 6 months, 1000 subcontractors have logged onto TKN and 500 have registered for courses, OSHA being the most utilized course. Internally, Turner employees have registered for over 5,000 courses, with 750 employees taking the OSHA 30-Hour Certification Course, which saves time away from the job and travel costs. Since April of this year, Turner has saved an additional $70,000 in online PC skills training. Also, building the Turner Knowledge Network and Turner University continues to help distinguish Turner within the construction industry as a world-class employer and builder of choice.

Turner envisions the TKN as the driving force in bringing entire project team members (Turner staff, owners, architects, and subcontractors) into one central location for project collaboration and information sharing and learning. TKN reinforces Turner's commitment to developing its members' knowledge and skills and improving the construction industry.

2) Knowledge On-Line (KOL)

Fluor is one of the world's largest publicly owned engineering, procurement, maintenance services, and construction organizations. Fluor's primary objective is to develop, execute, and maintain projects on schedule, within budget, and with excellence. Fluor employs nearly 35,000 people and maintains a network of offices in more than 25 countries across six continents.

In the 2007 Global MAKE (Most Admired Knowledge Enterprise) study (BNET 2007), Fluor was distinguished for maximizing the value of its intellectual resources and capital. With global projects all over the world, sharing knowledge with remote locations is essential to Fluor's success. Thus, Flour's knowledge management system is a consolidated, web-based global community of organizations that facilitates the leveraging of global expertise, enables collaboration, and provides clients with high value solutions. This enterprise-wide approach to knowledge management allows Fluor employees to connect to the same practices, procedures, and experts, regardless of their location. In other words, Fluor's KM strategy helps the company achieve its business objectives by connecting people to people and solutions to challenges.

Fluor utilizes a single, enterprise-wide solution which is called Knowledge OnLine (KOL). Accessible to all employees, regardless of location, KOL supports knowledge sharing and collaborative activities. This portal is where all Fluor's knowledge communities are located. It supports various tools and techniques for enterprise collaboration including: content management for items such as practices and procedures; discussion forums where any employee can ask questions; email links, subscriptions, and instant messaging; personal profiles to identify skills and subject matter expertise; and an integrated search across all communities and all aspects of Knowledge OnLine.

As employees form the core of Fluor's intellectual assets and knowledge-based services strategy, employee

buy-in and participation are critical to the company's ability to grow. Indeed, a key factor of Fluor's success, which distinguishes it in the global community, is its capacity to capture, share, leverage, and improve what employees know in a global environment. However, like most organizations, Fluor is faced with the challenges of an aging workforce, as well as a growing number of jobs being work-shared (supported by global offices) overseas. To address these challenges, Fluor motivates employees with benefits that encourage them to make themselves more valuable to the corporation.

Putting domestic and overseas practices of KMS together, some points of similarity are found. Focusing on this research, each system has the evaluation and reward system encouraging employees to use KMS. But, this system falls short of their expectations. In the following chapter, some problems are explained in detail.

6. Problem Statements

Focusing on the operating KMS, the biggest problem in running a KMS is knowledge workers not registering for that KMS. Therefore, companies must promote the KMS by providing incentives for knowledge workers to register knowledge. However, despite incentives, knowledge workers tend to equate registering their knowledge with losing their capacities. Indeed, they often perceive that their personal knowledge is more important than the rewards of registering, and that they will lose their competitive edge if they lose their knowledge.

Groupware is the system each company used to run before their KMS. Currently, groupware is still being used. Also, because most of the companies currently operating KMS, operate a KMS based on groupware, much information has been imported to these KMS from the groupware. However, this imported information is not standardized and does not conform to knowledge registration standards regarding storing information at a knowledge map depository. Therefore, companies have actually been registering all knowledge except for confidential company information and adult matters.

Indeed, the current KMS configurations have limitations. While monetary incentives appear to be insufficient in promoting the KMS, under the current knowledge evaluation methods, expert masters or expert groups gain too many works. Thus, experts must evaluate and store knowledge in bulk. Also, there is still no method for determining the actual specialty of experts and the reliability of knowledge evaluation continues to be low. Furthermore, in small and medium-sized enterprises, there is no capacity to organize an expert group.

To solve these problems, motivation and self-regulation are essential. Based on this context, a new knowledge evaluation method is proposed in the following chapter.

Lastly, although the importance of knowledge evaluation has been emphasized, only a few studies have been conducted. Table 1 shows four worldwide related literatures. Ahmed *et al.* (1999) deals with the measurement of KM not knowledge on KMS. Yogesh Malhotra (2003) is about the value of knowledge assets. Housel and Bell (2001) focuses on the management of knowledge through measuring it. Lee *et al.* (2003) proposes the evaluation model of construction knowledge. The front 3 researches don't cover the knowledge evaluation on KMS and the fourth research focuses on the evaluation itself. However, this research not only proposes new knowledge evaluation model, but also considers the relation between KMS and the knowledge evaluation that cannot be found in other researches.

Table 1. Related Literatures

Author	Title / Objectives
Pervaiz K. Ahmed *et al.* (1999)	"Measurement practice for knowledge management"
	To present a holistic model of KM which dynamically incorporates both tactical as well as strategic elements
Yogesh Malhotra (2003)	"Measuring Knowledge Assets of a Nation"
	To develop the theoretical and pragmatic foundations for management and measurement of knowledge assets to facilitate this vision of holistic growth and development
Housel and Bell (2001)	"Measuring and Managing Knowledge"
	To provide a framework for managing and maximize the return on knowledge assets
Lee *et al.* (2003)	"Knowledge Evaluation on the Construction Industry"
	To present a evaluation model for more objective evaluation. (The results of evaluation for storing knowledge are very different by evaluator because of the subjective evaluation, in spite of the standard.

7. Success Case of the Portal

In the world of information technology, the cyber world is nowadays another world itself, which has the complete potential to improve or destruct the real world. A variety of internet portals and clubs lead this world. Especially in Korea which has developed IT technology, there are many web portals, and one of the best popular sites is 'Naver'.

Naver, the leading Korean Internet portal composed of e-mail, internet café, blog, Q&A, shopping and so on, is so dominating in the Korean market that some news media coined the term, "Republic of Naver." In the first quarter of 2008, NHN (the company that operates Naver) posted operating profit of 128 billion won (approximately $128 million), 15 times higher that of Daum Communication, the closest runner-up. The stark contrast shows in the market value as well – at some 9 trillion won ($9 billion), NHN is worth more than ten times that of Daum. Google would be much more likely to be called a Goliath than a David in many countries, but at least in Korea, Google's 2 percent search market share is sharply dwarfed by Naver's 76 percent. So what catapulted it into the country's top portal site? Among industry experts, there seems to be an almost unanimous consensus that it all started with the introduction of Knowledge iN (a kind of Q&A), a knowledge search service that enables web users to ask questions or answer ones posted by other users.

Table 2. Knowledge iN point

Subtraction point				Addition point			
Activity	Point	Activity	Point	Activity	Point	Activity	Point
Desertion of question	–20	Deletion of trouble	–1	New joining	+100	Registration of trouble	+11
Deletion of question	–1	Closed ID	–20	Log-in	+3	Advising	+1
No answer	–1		–50	Answering	+2	Selection of advise	+10
Deletion of answer	–5	Help me (Request)	–50	Selection of answer	+10	Help me (Selection of answer)	+10
Additional point	–n	Alert	–n	Voting	+2	Selection of incomplete answer	+10
Desertion of trouble	–10			Evaluation	+1	Honored Knowledge iN	+1000

Knowledge iN allows users to ask just about any question – be it the best French restaurant in Seoul, why toenails grow faster than fingernails, or how to dump boyfriends in a cool way. Then almost instantly, answers come from other web users, often driven by Knowledge iN's internal reward system. When your answer gets chosen as the best advice by the asker, you earn 10 points (named of Naegong in Korean – Internal skill); as your points go up, your level within Knowledge iN changes progressively, such as 'Superhuman' level at 65,000 points. Naegong point in Knowledge iN classified by knowledge activity is as Table 2. Though the quality of its contents is sometimes questionable, Naver's Knowledge iN now has roughly 10 times more entries than Wikipedia. It is used by millions of Korean web users on any given day. Some people say Koreans are not addicted to the internet but to Naver.

Under this environment, common people naturally care about their own levels psychologically and they want to be a first level like 'Superhuman'. As the web matures, this psychological reward surpasses a monetary one. This reward system is the key success factor leading Naver to the best portal. This research focused on this and suggested 'Expert Index' indicating a level on the web following a reward.

8. Expert Index (EI)

Expert Index (EI) is the level of specialty workers achieve in a certain field after engaging in a knowledge activity. For example, in Table 3, if Lee registers good knowledge in the brick work category of the KMS knowledge bank, his Expert Index on brick work goes up 20 points. In this way, every worker could receive points according to the knowledge activity performed. This approach is similar to the mileage point of knowledge compensation. However, EI is directly applied to knowledge evaluation and affects over the length and breadth of KMS.

Table 3. Example of Expert Index

Field \ Name	Lee	Kim	Choi	…
Brick work	160	10	31	…
Window work	20	250	25	…
Concrete	0	40	630	…
⋮	⋮	⋮	⋮	

9. Evaluation Process

The overall evaluation process is presented in Fig. 1. First, workers register their knowledge in a specific category, then, workers receive a 20 point EI. Simultaneously, the system auto-forwards the proposed knowledge to knowledge board and to the e-mail addresses of the high EI group. Every worker can participate in evaluation on the knowledge board. On the other hand, through e-mail only 30 high ranking (level 1 and 2) persons can evaluate knowledge. Naturally, both cases are different in point, such as a 0.2 EI point for the former case, and 10 EI point for the latter.

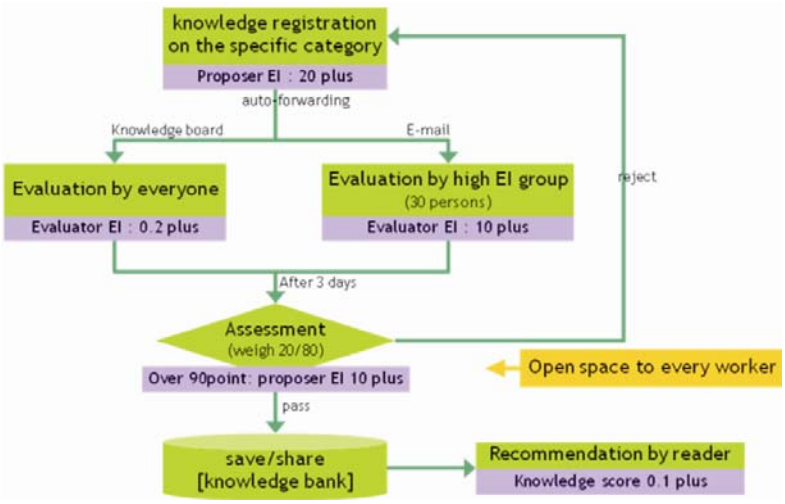

Fig. 1. Knowledge Evaluation Process

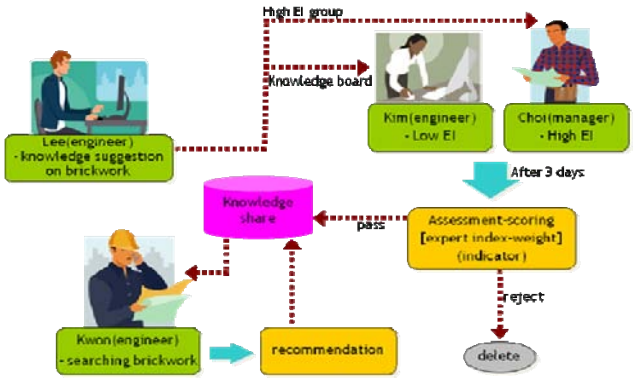

Fig. 2. User Scenario

Furthermore, in this process, there is no external enforcement and that is under self-regulation. After 3 days, the score to evaluated knowledge is calculated by the system weighing 20 (Knowledge board)/80(e-mail). If the score over 90 point, the proposer who register the knowledge gets 20 EI bonus point. After saving, workers share the knowledge and then the knowledge score recommended by reader goes up 0.1 point.

User scenario on the process is illustrated in Fig. 2 and detailed EI point is presented Table 4.

This model classifies the level by EI ranking as shown in Table 5. 1~10 ranking is level 1 and 11~30 ranking is level 2. These level 1 and 2 groups is given to expert evaluation, moreover level 1 could be linked to monetary rewards. As seen in previous section, the psychological approach in the cyber world is so much powerful. As usage of the system goes up, the impact of the 'level' will be getting bigger.

Table 6 shows the scoring table according to evaluation. The knowledge under 10 point is rejected and the proposer fails to get EI point. The rejected knowledge cannot be share.

Table 4. EI point classified by Knowledge Activity

Class	Activity	EI	Remark
General	New joining	+10	
Knowledge	Registration	+20	
	General evaluation (Knowledge board)	+0.2	10 times a day (Limitation)
	Expert evaluation (E-mail)	+10	
	Desertion of expert evaluation	–1	
	Over 90 (knowledge score)	+20	

Table 5. Ranking Level

Expert Index Ranking	Classification of level
1~10 ranking	Level 1
11~30 ranking	Level 2
31~60 ranking	Level 3
61~100 ranking	Level 4
101~ ranking	Level 5

Table 6. Scoring Table

	Evaluation	Originality / Effort				
Evaluation	Grade	Best	Good	Normal	Bad	Poor
Actuality	Best	100	90	75	60	50
	Good	90	75	60	50	40
	Normal	75	60	50	40	25
	Bad	60	50	40	25	10
	Poor	50	40	25	10	0

Table 7. Example of Calculation

Class	Evaluation (knowledge board)					Evaluation (E-mail)				
Evaluator	a	b	c	d	e	A	B	C	D	E
EI	20	30	40	10	30	110	200	120	100	110
Score	75	60	75	90	60	75	40	60	40	90
Calculation	(75·20+60·30+75·40+90·10+60·30)/130=69.2					(75·110+40·200+60·120+40·100+90·110)/640=58.4				
Total	69.2·0.2+58.4·0.8=60.5									

As above, overall process is so simple and easy. But, in KMS, simplification is so critical issue. Also, this system could affect worker's motivation through the open space.

This process is similar to the existing evaluation model. But, the expert group in the existing model is selected by the headquarters at random considering position. This difference can affected knowledge activities enormously. It is the point replacing passive with active.

Table 7 shows example of calculation for knowledge score. It's assumed that five common people evaluate knowledge on the knowledge board and five expert level's people evaluate knowledge on their e-mail. Each evaluator has his own EI on that category. Some could have high EI and others could have low EI. So, calculation of score reflecting evaluator's EI is made, that is, the concept of weighting is given. Finally, total score is calculated by 20:80 weighting and this shows that expert evaluation is more critical than general evaluation due to high expertise of Level 1 and 2 groups.

10. Validation using System Dynamics

As discussed, Expert Index is the useful concept to the knowledge evaluation and lively knowledge activities. But logical basis is insufficient to support benefits of the suggested process. In this regard, this research validated it using System Dynamics.

System dynamics is a methodology for studying and managing complex feedback systems, such as one finds in business and other social systems. In fact it has been used to address practically every sort of feedback system. While the word system has been applied to all sorts of situations, feedback is the differentiating descriptor here. Feedback refers to the situation of X affecting Y and Y in turn affecting X perhaps through a chain of causes and effects. One cannot study the link between X and Y and, independently, the link between Y and X and predict how

the system will behave. Only the study of the whole system as a feedback system will lead to correct results.

System dynamics modeling uses causal loop diagramming to represent a modeler's understanding on the system. In a causal loop diagram, variables are connected by arrows that denote the causal influences between variables (Park 2005).

This diagram consists of arrows connecting variables (things that change over time) in a way that shows how one variable affects another. Fig. 3 shows an example of causal loop diagram.

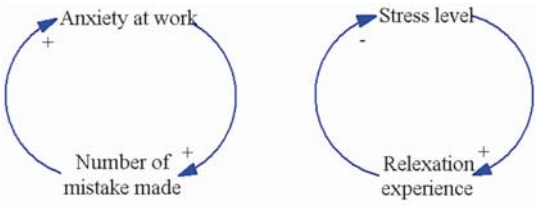

Fig. 3. Example of Causal Loop Diagram

Each arrow in a causal loop diagram is labeled with an "+" or an "-." "+"" means that when the first variable changes, the second one changes in the same direction (for example, as your anxiety at work goes up, the number of mistakes you make goes up, too). "–" means that the first variables causes a change in the opposite direction in the second variable (for example, the more relaxation exercises you do, the less stressed you feel).

In the diagram, the arrows come together to form loops, and each loop is labeled with an "R" or a "B" "R" means reinforcing; i.e., the causal relationships within the loop create exponential growth or collapse. (For instance, the more anxious you are at work, the more mistakes you make, and as you make more mistakes, you get even more anxious, and so on, in a vicious, upward spiral). "B" means balancing; i.e., the causal influences in the loop keep things in equilibrium. (For example, if you feel more stressed, you do more relaxation exercises, which bring your stress level down.)

Causal loop diagram can contain many different "R" and "B" loops, all connected together with arrows. By drawing these diagrams with your work team or other colleagues, you can get a rich array of perspectives on what's happening in your organization. You can then look for ways to make changes so as to improve things. For example, by understanding the connection between anxiety and mistakes, you could look for ways to reduce anxiety in your organization.

11. Analysis on Generic and Current Model of KMS

Fig. 4, the causal loop illustrates a generic model of KMS focusing on use of KMS and quality of information. The most important factor on KMS is the 'use', that is use of the system. This may be driven primarily by number of user. As diagramed in Fig. 4, number of user is influenced by the user satisfaction on KMS. A bigger satisfaction leads to a higher number of users. If use of KMS goes up, registration of information on the system naturally goes up. Then volume of information increases and this leads to much information that user want and many loads on KMS. The former enhances the usability of KMS, but the latter brings down that. So, main loop of this generic model is a balancing loop. Meanwhile, increasing volume of information leads to efforts for improving knowledge evaluation. As stated above, quality of information must take precedence over quantity, especially in the developmental phases of this KMS. This effort leads to higher quality of information following higher quality of evaluation. Then reliability on information goes up and reliability on KMS goes up. Finally, this meets on user's satisfaction. Also, use of KMS is affected by mass psychology and word of mouth within organization. Most Knowledge Management System has the logic as seen in Fig. 4.

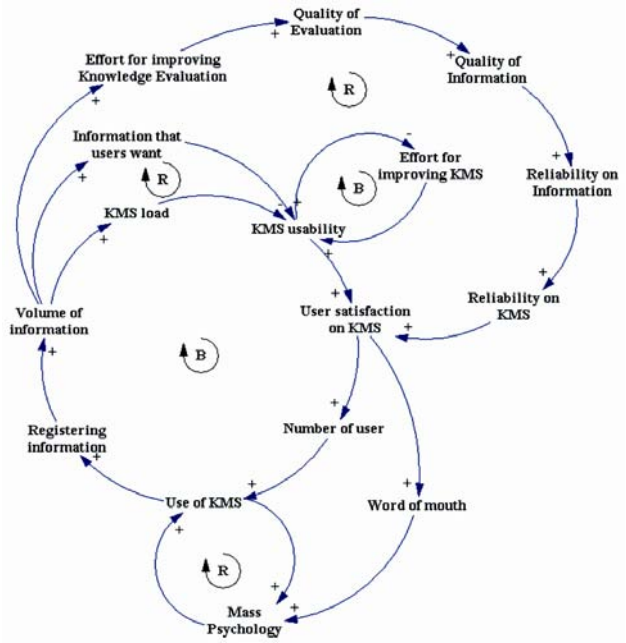

Fig. 4. The Generic Model of KMS

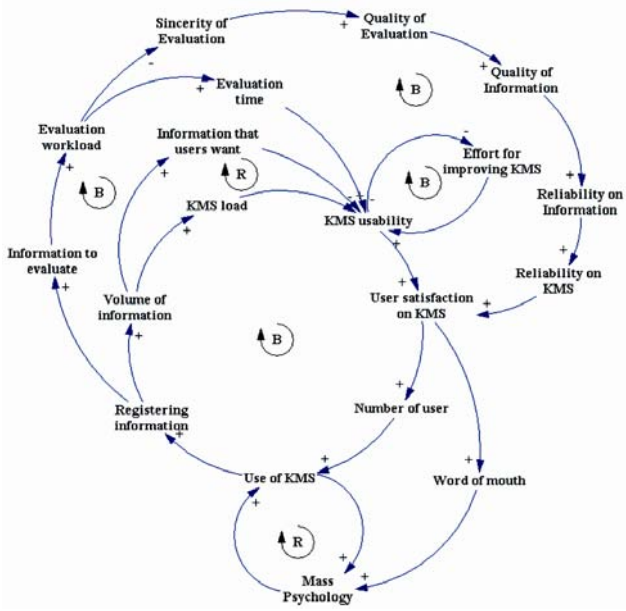

Fig. 5. The Current Evaluation Model of KMS

Fig. 5, the causal loop illustrates a model of current KMS focusing on knowledge evaluation. The current evaluation method most companies use is the system that designated experts evaluate knowledge as stated above. First, if registration of information increases following many uses of KMS, information to evaluate increases at the same time. Then, evaluation workload to experts is bigger and bigger and experts put off the work from day to day. As a result, this affects worse usability of KMS. Also, heavy workload for evaluation leads to bad sincerity of knowledge evaluation. This is related to quality of evaluation and quality of information, and finally this make worse user's satisfaction on KMS.

In conclusion, we validated that current evaluation method forms only balancing loop. So, this method does not enhance both use of KMS and quality of evaluation.

12. Analysis on the Suggested Model of KMS based on EI

As shown in previous section, several problems that obstruct lively KMS are proved by the causal loop. Now, we will find how introducing Expert Index affect the loop. First, introduction of EI enables to decrease evaluation workload because of many experts on each category. Then, this links to reduction in evaluation time and better sincerity of evaluation. Consequently, this leads to enhancement of KMS usability and user's satisfaction on KMS. Second, if a worker registers information or knowledge, his EI on that category rise, then feeling of achievement on EI goes up and this links to use of KMS. So, this loop is formed to the reinforcing loop. Third, rise of EI following use of KMS leads to psychological rewards surpassing monetary rewards and this influences motivation. Motivation is the one of the most important factor. This influences both evaluation time and sincerity of evaluation, same as evaluation workload. Besides, there is the other psychological factor influencing motivation. Use of KMS leads to bigger gap of EI between high users and low users, and this brings about psychological competitiveness. This sense of rivalry leads to anticipation for high EI, in the end, this encourages the motivation. Finally, the EI model is reinforced more and more as time goes on as shown in Fig. 6.

In conclusion, we validated introduction of EI enhances revitalization of KMS and quality of knowledge evaluation. Autonomy and psychological side are the key points in evaluating knowledge as well as in operating KMS.

13. System Development

This research has initiated as a part of Web-based Distributed Lean Construction Information System (Lean Construction Research Center, LRC2) Project. The overall aim of LRC2 Project is to promote the information reliability created during construction production process and develop a supporting system to improve processes of design/supply/construction phase. The detailed objectives of each division of the project are listed hereafter.

1) Provide a tool for examining the sequence of work processes before construction and measuring the construction progress to establish a material delivery and supply chain system based the 'Just-In-Time' theory including RFID (Radio Frequency Identification) and ADC (Automatic Data Collection) for maker activities of a concrete and a drainage system.

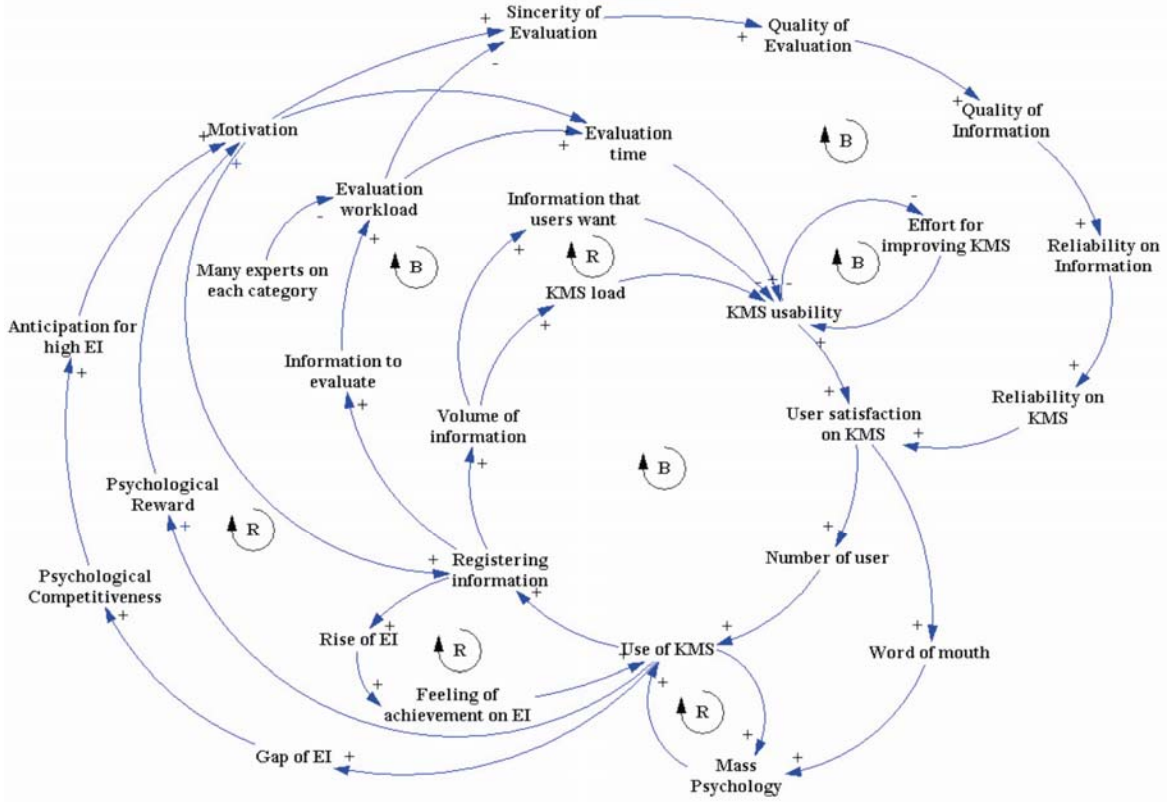

Fig. 6. The Suggested Model of KMS

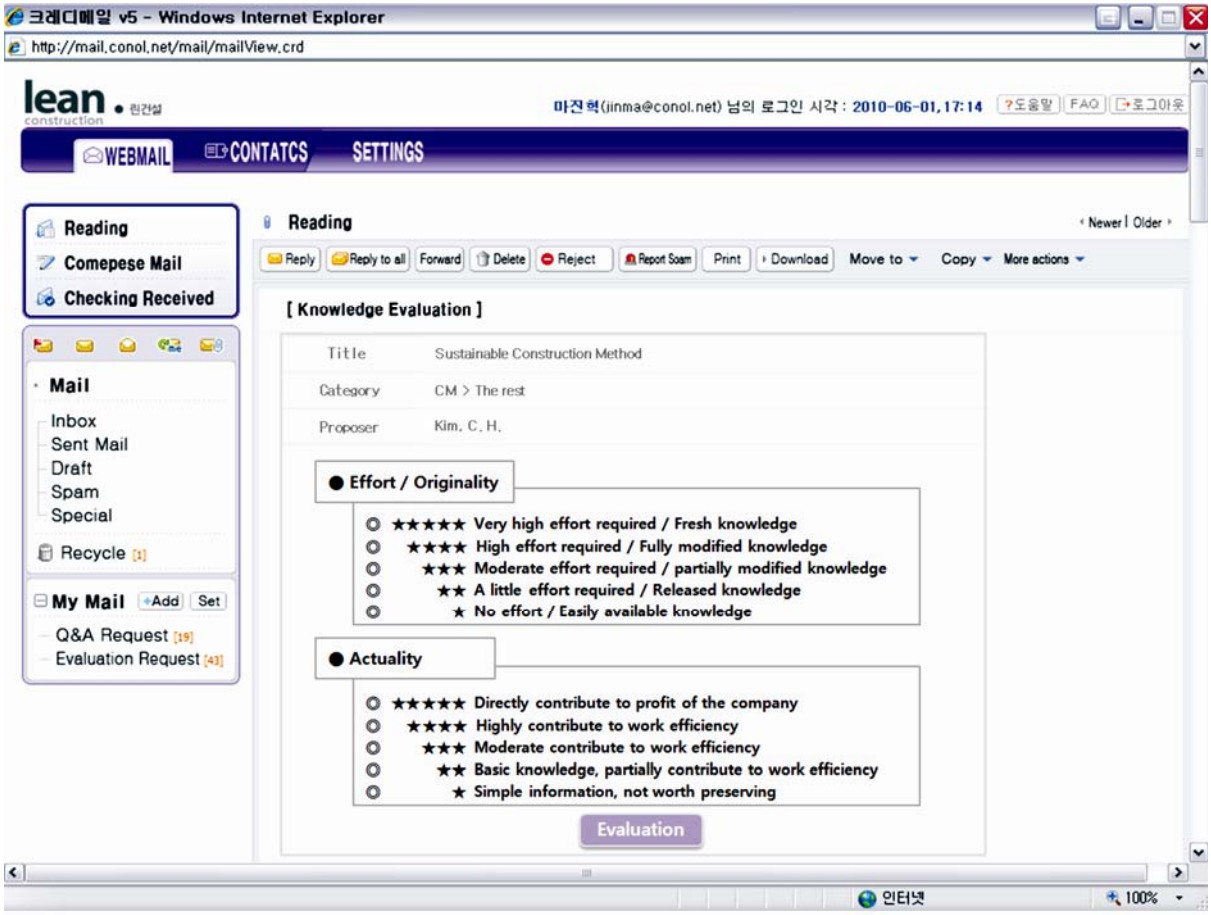

Fig. 7. Knowledge Evaluation by e-mail

2) Develop web-based design management system for managing plan information and cost information of design phase in order to achieve design coordination and optimization.

3) Develop an innovated construction production process management model to improve construction productivity of the domestic construction industry and a simulation system for the construction process, including developing job-site manual and education manual for the construction project participants.

4) Define problems of knowledge management practices within construction industries and develop web-based knowledge management system for the construction organization to improve the performance of knowledge management.

This paper is one of research results of the fourth division, which plays a Pivotal role in effectively managing and integrating information and knowledge created at other developed systems as research project, and providing result management/decision making support/knowledge based information services.

Based on the previous discussion, the system was developed to include the proposed evaluation process detailed above. Fig. 7 shows knowledge evaluation conducted by e-mail. Members of the high ranking EI group (30 persons) evaluate the knowledge that is auto-forwarded to their e-mail addresses. There are different indicators that everyone can evaluate knowledge by to simplify it. For example, indicators such as originality and actuality could be valued by participants. However, while companies can adopt their own indicators, simplification should always be maintained.

14. Conclusions

While the current global economy can be characterized by the intensification of business competitiveness, leaner organizations, the convergence of products and services, and by vast technological developments, the risks and uncertainties inherent in such a dynamic environment make the management of organizational knowledge even more crucial. Indeed, previous theoretical and empirical-based studies have proven that knowledge leads to organizational success. Knowledge Management (KM) has particularly gained credence, and continues to generate interest, in academic and business circles. KM is of especial interest to project-based industries such as construction, as the effective management of knowledge is critical to the survival and continued advancement of a company.

Most companies adopting Knowledge Management evaluate knowledge by expert master or expert group. However, this method has limitations such as the expert group having to deal with too much work and the low reliability of knowledge evaluation.

To address this, a new process was suggested that utilizes Expert Index. Under an EI system (which is based on self-regulation), every worker has the opportunity to be an expert in each field. Also, a high EI can boost

worker morale and reinforce worker's motivation to participate in subsequent knowledge activities. If practically applied, this model could enhance actual organizational success.

Finally, this research contributes to the field because it not only provides more effective knowledge evaluation strategies, it also ensures the continued investigation and implementation of knowledge management.

Acknowledgement

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STATYBOS ŽINIŲ VERTINIMAS EKSPERTŲ RODIKLIU

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Santrauka

Šiuolaikinei globaliajai ekonomikai būdingas konkurencijos didėjimas, organizacijų lankstumas, gaminių ir paslaugų suartėjimas bei didžiuliai technologiniai laimėjimai. Ši dinaminė verslo aplinka kartu susijusi su rizika ir neapibrėžtumais, didinančiais organizacijos žinių vadybos (ŽV) svarbą. Ankstesni teoriniai ir empiriniai tyrimai rodo, kad šios žinios – organizacijos sėkmės šaltinis. Žinių vadyba tampa vis svarbesnė akademinei ir verslo aplinkai. ŽV labai domimasi pramonės šakose, kuriose didelę reikšmę turi projektai. Statyba yra viena iš tokių šakų, joje veiksmingas žinių valdymas, padedantis užtikrinti įmonių išlikimą ir nuolatinį vystymąsi, yra labai svarbus. Šiuo metu statybos pramonėje diegiamos žinių vadybos sistemos (ŽVS) ir vis daugiau įmonių pateikia ŽV siūlymų. Būtina siekti, kad žinių kokybė būtų labiau vertinama nei žinių kiekis, ypač ŽVS kūrimo tarpsniu. Todėl kiekybinis ir kokybinis žinių atsijojimas tampa rimta užduotimi. Deja, iki šiol atlikta mažai tyrimų, kaip gerinti žinių vertinimą. Atliekant šiuos tyrimus dėmesys telkiamas tik į žinių vertinimo metodus. Straipsnyje efektyvus žinių vertinimas nagrinėjamas ŽV metodais. Pasitelkus aktyviąją ŽV kuriamas statybos žinių vertinimo modelis ir taikomas ekspertų rodiklis (ER). ER išreiškia specialistų, įsisavinančių specifinę informaciją, žinių lygį. Siūlomas modelis leis ne tik tiksliai vertinti, bet ir skatinti žinių gavimą. Taigi, taikant šį modelį praktikoje, bus galima gerinti įmonės veiklą.

Reikšminiai žodžiai: žinių vadyba, žinių vertinimas, ekspertų rodiklis.

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