Knowledge Management Design Using Collaborative Knowledge Retrieval Function

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ABSTRACT

Knowledge is a key word in the information age. Organizational knowledge provides businesses with a way to compete effectively and efficiently in the market. The performance of many organizations is determined more by their knowledge than their physical assets. Capturing and representing knowledge is critical in knowledge management. The spread of organizational knowledge has made a difficulty in sharing knowledge. This problem creates a longer learning cycle.

This research proposes a web based knowledge map, using collaborative knowledge retrieval function, as a tool to represent and share knowledge. First, knowledge map gives a comprehensive understanding about what knowledge is needed to achieve objectives, what knowledge sources are available, and which knowledge sources are used by whom. Second, web facilitates knowledge sharing. Third, collaborative knowledge retrieval function will shorten learning cycle. Fourth, the proposed tool is applied to build a web based knowledge for an academic system in higher education.

The result of this research is a design of web based knowledge map using collaborative knowledge retrieval function. Collaborative retrieval knowledge function gives recommendations of relevant knowledge between web documents. The proposed model contributes in shortening the learning cycle.

Keywords: Knowledge map, Collaborative retrieval knowledge function, Web, Learning cycle, Knowledge Sharing.

Introduction

Knowledge is a key word in the information age. Organizational knowledge provides businesses with a way to compete effectively and efficiently in the market. The performance of many organizations is determined more by their knowledge than their physical assets. (Sung-kwan dan Sengbae, 2004).

There are two basic types of knowledge – tacit and explicit. Tacit knowledge resides within people as mental models, experience

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and skills, and is difficult to communicate externally. Explicit knowledge can be communicated externally and captured in formal models, rules and procedures. (Vail E.F,1999). The knowledge process usually involves several stages or sub-processes. The key stages in this process can be defined as: (1) knowledge generation, (2) knowledge representation, (3) knowledge storage, (4) knowledge access, and (5) transfer knowledge (http://rocket.vub.ac.be).

Knowledge generation includes the creation of new ideas, the recognition of new patterns, the interaction and synergy of separate disciplines and the development of new processes. Knowledge generation encompasses both creating new knowledge and acquiring existing knowledge from somewhere else. Knowledge representation, or codification, is the process of putting knowledge into various forms that can be accessed, leveraged and transferred independently of the presence or absence of the individuals that might posses that knowledge. Knowledge storage incorporates both 'hard' data such as numbers, facts, Fig.s, and rules as well as 'soft' information such as tacit knowledge, expertise, particular experiences, anecdotes, critical incidents, stories, artifacts, and details about strategic decisions. Knowledge access incorporates technology in the form of data dictionaries and online databases facilitates the integration of systems knowledge and information. Organisational knowledge management uses repositories and improved access to make critical knowledge available wherever and whenever it is needed. Knowledge transfer is designed to enable the flow of knowledge among and between individuals and groups within an organisation.

The spread of organizational knowledge causes the knowledge stakeholder having the partial understanding of knowledge objects. The organizational knowledge exists in several organization division. This causes management of knowledge become complicated. The management of knowledge is

now considered to an integral part of business activity. Information systems play a pivotal role in enabling knowledge to be managed efficiently and effectively and therefore make a significant contribution to sustaining an organisation's competitive advantage (Peter, et.al , 2005). Thus knowledge management is needed to compete effectively and efficiently.

Hence, given the capability of current information technology, any item stored in computer could be data, or information, or knowledge representation. Information technology facilitates knowledge access. Thus, knowledge management and web-based information technology can never be separated in exploration of modern successful business. The unique aspect of knowledge management in the internet era is application of web-based information technology to knowledge development. (Wang, 2002).

Knowledge map is a tool to represent knowledge. Knowledge representations include data of facts, information of summarized data and cases, knowledge representations for procedures, rules, ideas that guide actions and decisions. All these entities, in the web environment, are web documents that are semantically linked into a network as a knowledge map (Wang, 2002).

Lin and Hseuh (2006) proposes the architecture of the knowledge map management system. Knowledge map management system has three main tasks: the knowledge map creation, knowledge map maintenance, and the collaborative knowledge retrieval. Lin and Hseuh (2006) have introduced the procedure of knowledge map creation and maintenance. But the procedure of the collaborative knowledge retrieval function has not been proposed.

The purpose of this paper is to develop knowledge map with collaborative knowledge retrieval function in order to shorten the learning cycle. The research demonstrates knowledge map with collaborative knowledge

retrieval in a higher education academic system.

Section 2 defines knowledge process, knowledge map, and learning cycle. Section 3 presents the proposed procedure. Section 4 presents a case study to demonstrate a detail description of the procedures. Finally, Section 5 describes conclusions.

Knowledge process, knowledge map, and learning cycle

Knowledge process

The knowledge process usually involves several stages or sub-processes. The key stages in this process can be defined as: (1) knowledge generation, (2) knowledge representation, (3) knowledge storage, (4) knowledge access, and (5) transfer knowledge.

Knowledge generation

Knowledge generation includes the creation of new ideas, the recognition of new patterns, the interaction and synergy of separate disciplines and the development of new processes [Ruggles, 1997, Castells, 2000]. Knowledge generation encompasses both creating new knowledge and acquiring existing knowledge from somewhere else. According to Nonaka and Takeuchi [1995] organisational knowledge creation is a continuous, iterative process. This process is not confined within the spatial boundaries organisation, but takes place between and across organisations. Knowledge (or facts and information) can be obtained by activities such as scanning and interpreting the external environment, capturing the voice of the customer, undertaking research and development, etc. Crawford, [1996] argues that the most valuable knowledge generation involves identifying problems and suggesting solutions to rectify them. Knowledge generation requires tools, which pushes

individuals to think beyond their current functional and organisational boundaries. In general, knowledge creation and acquisition refers to the development of knowledge bases [Dodgson, 1993]. Knowledge bases are created through the acquisition, storage, interpretation, and manipulation of information both from within and outside the organisation. They usually take the form of collections of anecdotes, experiences, technical data and other types of judgement and decision supporting inputs. The purpose of developing these systems is not only to avoid 're-inventing the wheel', but also to accelerate the innovation process by facilitating synergy and idea re-combination taking into account all available inputs simultaneously.

Knowledge representation

In order to reuse knowledge, some form of representation of knowledge must take place. Knowledge representation, or codification, is the process of putting knowledge into various forms that can be accessed, leveraged and transferred independently of the presence or absence of the individuals that might posses that knowledge [Ruggles, 1997]. Auditing and categorising knowledge is a difficult task as it is hard to accumulate and change. Patton and Carlsen [1998] have argued that representations can range from strict and formal codification (such as policies, guidelines and procedures attached to specific organisational processes) to an archive of tacit elements (such as narratives and stories and lessons learned from particular experiences). Tools such as knowledge maps help address where to find knowledge within and between organisations. They are designed to help people to find what they need to know whether it is a person, place or thing. Knowledge maps are also used to sketch the knowledge flows within a process, from acquisition (including generation) through development, storage and transfer.

Knowledge storage

Previous research indicates that organisational memory incorporates both 'hard' data such as numbers, facts, Fig.s, and rules as well as 'soft' information such as tacit knowledge, expertise, particular experiences, anecdotes, critical incidents, stories, artifacts, and details about strategic decisions [Morrison, 1993]. It is important to have mechanisms, which can store and retrieve all kinds of data, information and knowledge. Most organisations have various kinds of information systems such as inventory control systems, budgetary systems, and administrative systems to store 'hard' data or facts. However, they do not have similar systems to capture store and communicate 'soft' information and knowledge. Brown and Duguid [1991] have also argued that ideas generated by employees in the course of their work rarely get shared beyond a small group of colleagues or team members with whom they collaborate. They believe that organisational learning can be considerably improved if these experiences and narratives are stored electronically for future reference.

Knowledge access

In traditional types of organisation, knowledge and information are fragmented in that they are located in many different places in the organisation. For instance, knowledge such as best practice accounts, lessons learned and experiences about particular processes or procedures resides with the professionals, managers and engineers, while customer information, reports and procedures are often scattered across paper files and electronic databases. In order to leverage this scattered knowledge and increase organisational performance it is imperative to integrate these systems, databases and applications to support knowledge management objectives. Organisational knowledge integration can be made possible by the cross-platform, open standards capabilities of an organisation's

intranet, which allows access to information from multiple sources. Technology in the form of data dictionaries and online databases facilitates the integration of systems knowledge and information. Organisational knowledge management uses repositories and improved access to make critical knowledge available wherever and whenever it is needed. Hypermedia -based information systems, for example, are highly beneficial in areas that deal with large, complex, richly connected, and crossreferenced bodies of information. These systems along with full-text retrieval systems and document management systems can help store and retrieve vast amounts of organizational knowledge with the use of modern access facilities such as navigation, queries, and personalised pathways [Cormican, 2000].

Knowledge transfer

Knowledge transfer is designed to enable the flow of knowledge among and between individuals and groups within an organisation. The cornerstone of the practice of management lies in being able to effectively communicate policies, procedures, technical reference and quality standards, all of which form an organisation's asset of knowledge-based information. Knowledge transfer or distribution refers to the process through which an organisation shares this knowledge and information among its members, thereby promoting learning and producing new knowledge or understanding. Brown and Duguid [1991] have argued that a lot of learning and innovation takes place in informal networks, or 'communities of practice'. Groupware or collaborative systems facilitate the formation and sustainable development of such networks. They allow the joint construction and exchange of experiences and insights and enable the creation of social networks. Thus, they not only support communication but also collaboration. Hypermedia systems allow people to create, interpret, collate, and share information from a

variety of media sources such as text, graphics, audio, video, and images.

Knowledge map

Knowledge map is a tool to represent knowledge. Lin and Hseuh (2006) propose the architecture of the knowledge map management system. The architecture is depicted in fig.1. Knowledge management systems have three main tasks:

1. Knowledge map creation

The knowledge map creation has 2 components: knowledge map and knowledge map navigation. The knowledge map navigator is used for guiding knowledge browsing according to knowledge map generated in advance by the knowledge map manager. It is useful for knowledge seekers to obtain the concept hierarchy existing in documents contributed by the community.

2. Knowledge map maintenance

The knowledge map maintenance has three components: documents, knowledge map manager, and knowledge seeker. The knowledge map manager is the kernel of the knowledge map management system. The knowledge map manager is responsible for coordinating the knowledge map navigation, document seeking, and learning recommendation with user's requests. The knowledge seeker is used for retrieving documents from the document base to answer users's requests.

3. Collaborative knowledge retrieval

The collaborative knowledge retrieval has three components: learning history, learning history analyzer, and learning advisor. The learning history in this research is defined as the set of concepts (knowledge categories) accessed by community residents in a specific problem solving process. The learning history analyzer facilitates the learning adviser by

using sequential pattern analysis techniques to generalize and store the common access patterns as the learning history repository. The learning advisor exerts collaborative document retrieval to exploit past knowledge activities to shorten the individual learning cycle.
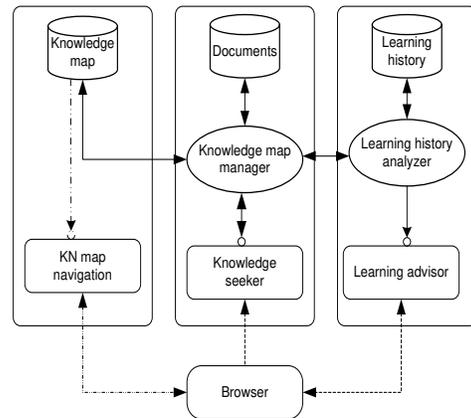

Figure 1. Knowledge map management system (Lin dan Hsueh, 2006)

Learning cycle

Lorsbach (2006) defines the learning cycle as an established planning method in science education and consistent with contemporary theories about how individuals learn. The learning cycle consists of three phases (Allard dan Barman, 1994): exploration, concept introduction, and concept application.

1. During exploration phase, the students are engaged in solving problem or task. This challenge is open-ended enough to allow students to follow a variety of strategies, yet specific enough to provide some direction. The purpose of this phase is to engage the student in a motivating activity, requiring hands-on experiences and verbal interaction, that will provide a basis for the development of a specific concept or concepts and vocabulary pertinent to the concepts. This phase also provides an excellent opportunity for students to become aware of their

personal concepts about specific natural phenomena and for instructor to assist students in questioning their understanding of the natural world as well as help them with misconceptions they may uncover. For example, in a lesson of the major differences between plant and animal cells, the exploration phase would consist of students examining different cells (e.g., onion skin, squamous epithelium, and elodea) under the microscope. The students would make drawings of the cells and identify differences and similarities observed in the cells.

2. In the second phase, concept introduction, the instructor gathers information from the students about their exploration experience and uses it to introduce the main concepts of the lesson and any vocabulary related to the concepts. During this phase, the instructor uses textbooks, audiovisual, other written materials, or mini-lectures. Using the cell lesson as an example, the instructor would have the students report their microscopic observations and have them identify specific differences and similarities they observed between the plant and animal cells. The instructor would then use this information to explain the major differences between plant and animal cells. This mini-lecture could use overhead projector and include a short audiovisual presentation of the other plant and animal cells.

3. The final phase, concept application, lets students study additional examples of the main concepts of the lesson or take on a new task that can be solved on the basis of the previous exploration activity and concept introduction. In the cell lesson, students could be presented with preserved slides of additional examples of the plant and animal cells. They would be challenged to identify each cell as plant or

animal and explain the reason for their choice.

Research context

This research proposes a knowledge map with collaborative knowledge retrieval. Knowledge map, in the learning cycle context, facilitates the exploration phase. The knowledge map user browse the knowledge map for the development of a specific concept or concepts and vocabulary pertinent to the concepts. It is like students in cell lesson that was explained before. Knowledge map, in the knowledge process context, is a tool for knowledge representation.

The proposed procedure

Knowledge map building

This research uses the knowledge map management system that is proposed by Lin and Hseuh (2006). This research modifies the knowledge map management system that is proposed by Lin and Hseuh, under an assumption that the knowledge map navigation and knowledge map maintenance are the basis of knowledge map. These two main tasks of knowledge map management system are supported by collaborative knowledge retrieval function in order to shorten learning cycle. Our proposed framework is depicted in fig 2.

In this research, knowledge map design uses knowledge model approach. Knowledge representations include data of facts, information of summarized data and cases, knowledge representations for procedures, rules, ideas that guide actions and decisions.
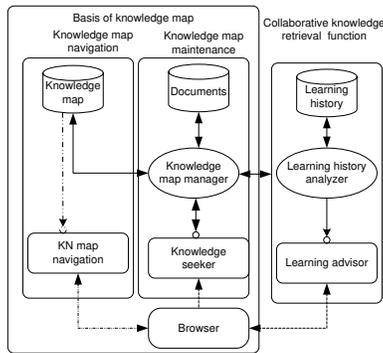
Figure 2. Knowledge map management system (Lin dan Hseuh (2006) model modified)

All these entities, in the web environment, are web documents that are semantically linked into a network as a knowledge map (Wang, 2002).It means knowledge map is a knowledge representation where knowledge objects are linked into a network. Knowledge engineers make use of a number of ways of representing knowledge when acquiring knowledge from experts. These are usually referred to as knowledge models (Milton, 2003). Three important types of knowledge models are:

1. **Ladders**: Ladders are hierarchical (tree-like) diagrams. Some important types of ladders are concept ladder, composition ladder, decision ladder and attribute ladder.

2. **Network Diagrams**: Network diagrams show nodes connected by arrows. Depending on the type of network diagram, the nodes might represent any type of concept, attribute, value or task, and the arrows between the nodes any type of relationship.

3. **Tables and Grids**: Tabular representations make use of tables or grids. Three important types are forms, frames, timelines and matrices/grids.

In this research, we select ladder as knowledge map design approach, because ladder is a standard knowledge engineering technique (Milton, 2003).

In this research, we follow the procedures of building the knowledge map that is adapted from Kim et.al (2003). Knowledge map building, in this research, consists of 4 steps:

1. Defining organizational knowledge
2. Knowledge extraction and profiling
3. Knowledge linking (ladder)
4. Knowledge map validation

Collaborative knowledge retrieval

Collaborative knowledge retrieval can be developed by generalizing document retrieval patterns from individual knowledge access histories (Lin and Hseuh, 2006). There are several methods to generalize pattern recognition:

1. k-nearest neighbour
2. market basket basket analysis

Mobhaser (2001) research has shown that the market basket analysis recommendation framework can, in fact, improve on the kNN-based collaborative filtering both in terms of the precision and coverage of recommendations, while at the same time maintaining the computational advantage over kNN attained due to the off line discovery of frequent patterns. Thus, in this research we use market basket analysis approach as the proposed algorithm.

In this research, we use 3 phases to design collaborative knowledge retrieval function. These three phases is used in Mobhaser (2001) research. The three phases are:

1. Data preparation,
2. Pattern discovery, and
3. Recommendation

These phases are relevant with three component of collaborative knowledge retrieval function in Lin and Hseuh (2006). Data preparation phase equals with learning history component. Pattern recognition equals with learning history analyzer, and
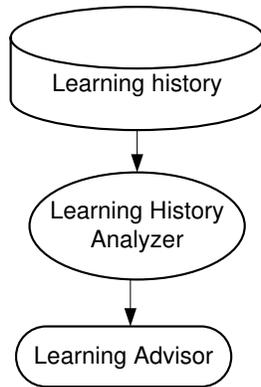
Figure 3. Collaborative knowledge retrieval function (Lin dan Hsueh, 2006)

recommendation equals with learning advisor. The collaborative knowledge retrieval function model is depicted in Fig. 3.

Learning History

Learning history component stores document access history (log). This component consists of several fields which are depicted in table 1.

Table 1. Document Access History (log)

Field	Type
ID (Primary; auto_increment)	int(255)
sessionid	varchar(255)
ID_dokumen_web	int(255)

The major step of the learning history approach are depicted in Figure 4.

The learning history in this research is defined as the set of concepts (knowledge categories) accessed by community residents in a specific problem solving process. The learning advisor exerts collaborative document retrieval to exploit past knowledge activities to shorten the individual learning cycle.
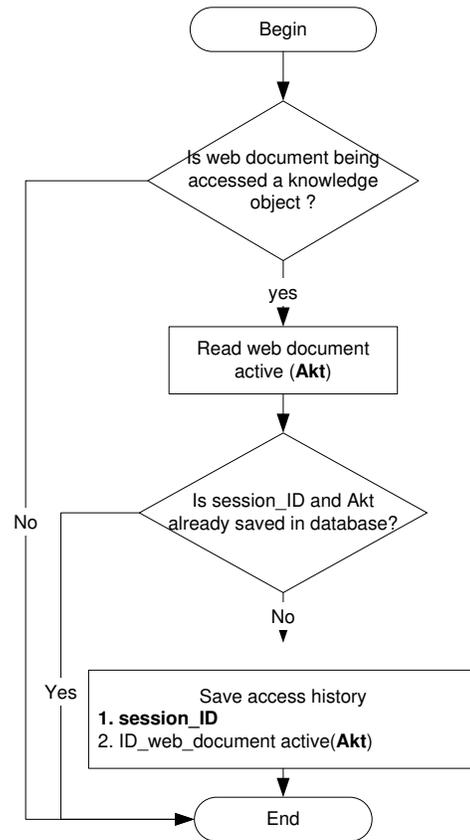

Figure 4. Learning history procedure

Learning history analyzer

The learning history analyzer facilitates the learning advisor by using sequential pattern analysis techniques to generalize and store the common access patterns as the learning history repository. The major steps of the learning history analyzer approach are depicted in Figure 5.

Learning advisor

The learning adviser is responsible for recommending documents according to the learning history generalized by the learning history analyzer. The major steps of the learning history analyzer approach are depicted in Figure 6.
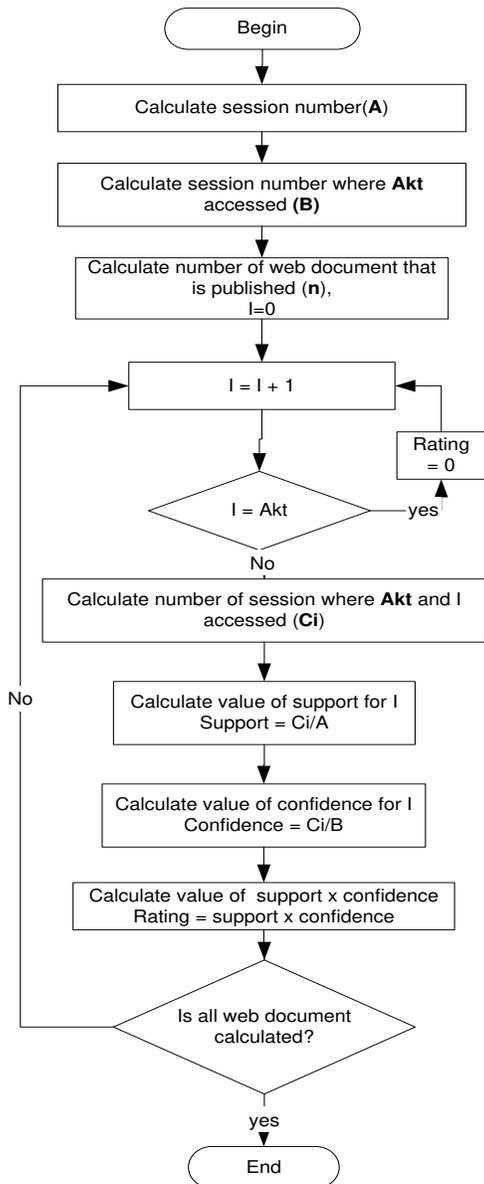
Figure 5. Learning history analyzer procedure

In this case study, we build the knowledge map in the higher education academic system, especially about standard operating procedures. The higher education academic system consists eight components:

a. New Students Enrollment
b. Registration
c. Study planning
d. Lecture evaluation
e. Lecture and laboratory activity
f. Middle and final semester examination
g. Final examination
h. Graduate celebration

2. Knowledge extraction and profiling

According to deep investigation and analysis, every component of standard operating procedure consists of 5 elements:

a. The purpose of SOP
b. The scope of SOP
c. The definition in SOP
d. The user of SOP
e. The procedure of SOP

3. Knowledge linking (ladder)

Based on the comparison of ladder forms, thus process ladder is fit with the higher education academic system component. Because the standard operating procedure is made based on process approach, we can
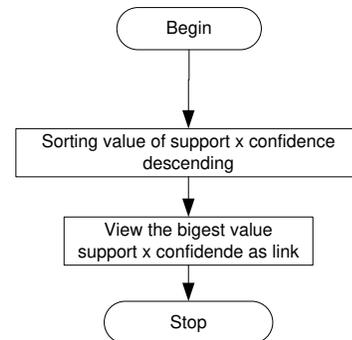
Case study

Knowledge map building

Knowledge map building, in this research, consists of 4 steps:

1. Defining organizational knowledge

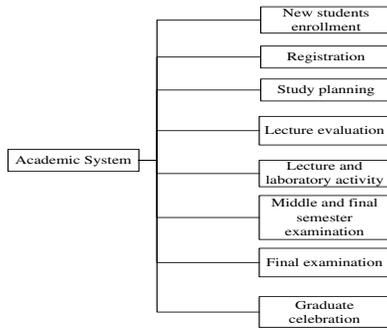*Figure 6. Learning Advisor procedure*

Figure 7. Process ladder higher education academic system component

depict the knowledge model of higher education academic system component in Figure 7.

Based on the comparison of ladder forms, thus composition ladder is fit with the higher education academic system elements. We can depict the knowledge model of higher education academic system elements for new students enrollment component in Figure 8.
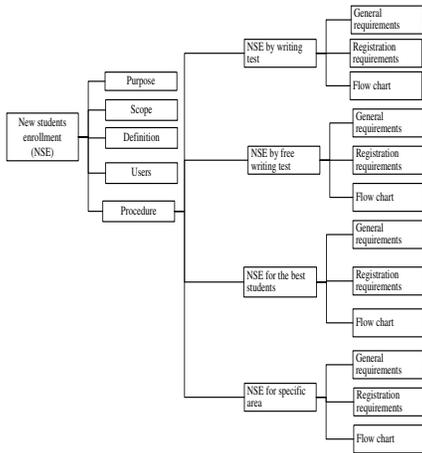

Figure 8. Composition ladder for new students enrollment component

4. Knowledge map validation using prototyping

After the knowledge extraction and profiling step, we transform the knowledge

model into web menu. We depict the transformation of knowledge model into web menu in Fig. 9 and 10.

Figure 9. Web page of higher education academic system component (1st Layer)

Knowledge map consists 40 knowledge objects as web document, 8 agregator of web page (for every component), and 1 main page.
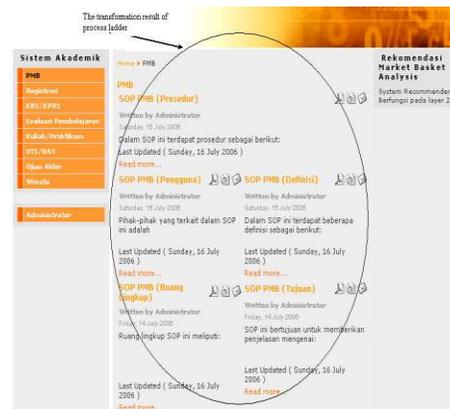

Figure 10. Web page of higher education academic system elements for new student enrollment element (2nd Layer)

Collaborative knowledge retrieval

In this case, the level of recommendation is given in the 2nd layer. For a better understanding, we give a case study. Example:

1. The active knowledge object 1 is being accessed
2. There are 10 users accessed the knowledge map site.
3. The system sets to recommend 2 knowledge objects.

a. Learning history

In this case study, we use the history access as follow in Table 2.

Table 2. Learning History

Access_ID	Knowledge_object_ID_accessed									
	1	2	3	4	5	6	7	8	9	10
1	v	v	v		v	v	v	v	v	
2	v	v			v	v	v	v		
3	v	v			v	v	v	v		
4		v	v		v		v	v		
5		v	v		v		v	v		
6		v	v		v		v	v		
7		v	v		v		v	v		
8	v			v	v		v			v
9		v	v		v		v	v		
10	v	v			v	v	v	v		

b. Learning history analyzer

Learning history analyzer is responsible to calculate the support and confidence values:

1. Session number : 10
2. Number of access for active web document 5
3. Calculate *support* x *confidence* . The results of calculation is depicted in table 3.

c. Learning advisor

From the calculation, the learning advisor sort the support and confidence values. The result of sorting values is depicted in table 4.

Table 3. Learning History Analyzer

Web_dokumen ke-i	Ci	Support x Confidence
1	5	0
2	4	0.32
3	1	0.02
4	1	0.02
5	5	0.5
6	4	0.32
7	5	0.5
8	4	0.32
9	1	0.02
10	1	0.02

Table 4. Learning Advisor

Web_dokumen ke-i	Ci	Support x Confidence
5	5	0.5
7	5	0.5
2	4	0.32
6	4	0.32
8	4	0.32
3	1	0.02
4	1	0.02
9	1	0.02
10	1	0.02

Thus, the system recommends web document 5 and 7 to be viewed as links. The recommendation link is depicted in Fig. 11.
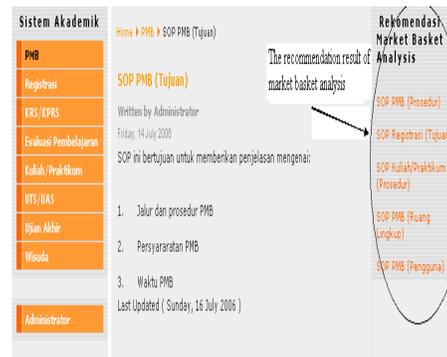

Figure 11. Recommendation links

Learning cycle

The final purpose of this research is to shorten the learning cycle. For a better understanding, we give a case study. Example:

Session id 1 access knowledge object with the knowledge object ID 1,2,3,5,6,7,8,9. the knowledge object position is depicted in table 5.

Thus, the user of knowledge map site with session id 1 has to access 17 web pages, if the system without collaborative knowledge retrieval. The web pages have to be accessed are:

1. Main page
2. NSE agregator page
3. NSE SOP (Purpose) page
4. NSE agregator page
5. NSE SOP (Scope) page
6. NSE agregator page
7. NSE SOP (Definition) page
8. NSE agregator page
9. NSE SOP (Procedure) page
10. Registration agregator page
11. Registration SOP (purpose) page
12. Registration agregator page
13. Registration SOP (Scope) page
14. Registration agregator page
15. Registration SOP (Definisi) page
16. Registration agregator page
17. Registration SOP (User) page

Thus, the user of knowledge map site with session id 1 has to access 10 web pages. The web pages have to be accessed are:

1. Main page
2. NSE agregator page
3. NSE SOP (Purpose) page can be accessed by collaborative knowledge retrieval.
4. NSE SOP (Scope) page can be accessed by collaborative knowledge retrieval.
5. NSE SOP (Definition) page can be accessed by collaborative knowledge retrieval.
6. NSE SOP (Procedure) page can be accessed by collaborative knowledge retrieval.
7. Registration SOP (purpose) page can be accessed by collaborative knowledge retrieval.
8. Registration SOP (Scope) page can be accessed by collaborative knowledge retrieval.
9. Registration SOP (Definisi) page can be accessed by collaborative knowledge retrieval.
10. Registration SOP (User) page can be accessed by collaborative knowledge retrieval.

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Table 5. Knowledge object position

ID	Knowledge object	Agregator page	Agregator name
1	SOP NSE (Purpose)		
2	SOP NSE (Scope)		New students enrollment (NSE)
3	SOP NSE (Definition)	I	
4	SOP NSE (User)		
5	SOP NSE (Procedure)		
6	SOP Registration (Purpose)		
7	SOP Registrasi (Scope)		
8	SOP Registrasi (Definition)	II	Registration
9	SOP Registrasi (User)		
10	SOP Registrasi (Procedure)		

In this example, collaborative knowledge retrieval function reduced 7 web pages in accessing knowledge map site.

Conclusion

First, knowledge map gives a comprehensive understanding about what knowledge is needed to achieve objectives, what knowledge sources are available, and which knowledge sources are used by whom. Second, web facilitated knowledge sharing. Third, collaborative knowledge retrieval function will shorten learning cycle. Fourth, the proposed tool is applied to build a web-based knowledge map for an academic system in higher education. The result of this research is a design of knowledge map based on web using collaborative knowledge retrieval function. Collaborative retrieval knowledge function gives recommendations of relevant knowledge between web document. The recommendation will shorten the learning cycle

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