A PROCESS-BASED KNOWLEDGE MANAGEMENT SYSTEM FOR SCHOOLS: A CASE STUDY IN TAIWAN

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ABSTRACT
Knowledge management systems, or KMSs, have been widely adopted in business organizations, yet little research exists on the actual integration of the knowledge management model and the application of KMSs in secondary schools. In the present study, the common difficulties and limitations regarding the implementation of knowledge management into schools' organizational cultures are reviewed and discussed. Furthermore, relevant theories of knowledge management models are summarized, and a model of process-based knowledge management appropriate for schools is proposed.

Based on the proposed model, this study applied a low-cost, open-source software development framework to establish a process-based knowledge management system for schools, or PKMSS. We conducted a 30-day empirical observation and survey at a secondary school in Taiwan. This case study used methods including a satisfaction survey, qualitative content analysis of knowledge discussion, and unstructured interviews to explore the progress, performance, and limitations of PKMSS implementation. It was determined that PKMSS has some value in promoting schools' knowledge management. It not only facilitates the externalization and combination of knowledge and effectively keeps the objectives of knowledge sharing in focus, but it also promotes inter-member interactions. However, this study also found certain restrictions in terms of the classification of knowledge content and system functions. Based on the above findings, we propose relevant suggestions as references for the evaluation and introduction of a KMS in educational organizations.
Keywords: knowledge management, knowledge sharing, secondary education, knowledge management system

INTRODUCTION

Knowledge management encourages an organization's members to share knowledge and improves the organization's efficiency, performance, and competitiveness (Shin, 2004). Commercial organizations in the business sector have adopted different strategies and technologies to manage intra-organizational knowledge. In terms of school organizations, however, there are still many potential restrictions regarding the implementation of knowledge management (Carroll et al., 2003; Tyack & Cuban, 1995). Due to the new era of Web 2.0 and the influence of highly interactive online information technology, schools' internal management and knowledge application procedures are becoming increasingly complex. Therefore, previous studies have considered the need for schools to utilize knowledge management procedures and KMSs (Richard, 2001; David, 1999; Kuo, 2003; McKenzie et al., 2001). A key philosophy in education is the generation and use of knowledge (David, 1999). Therefore, schools should continue to improve their existing operating models and should understand the appropriate procedures of searching, storage, duplication, and application in order to gather necessary knowledge (Richard, 2001). Kuo (2003) further emphasized the trend and necessity of using information technology to conduct knowledge management in schools and believed that school members should gain a deeper understanding of knowledge management. Schools should also actively learn from their members' active feedback about knowledge management to improve their managerial performance (McKenzie, Truc & Winkelen, 2001).

However, efficient knowledge management in schools is difficult. The primary limitations include difficulty determining the objectives of knowledge sharing and the lack of interactive knowledge-sharing behavior within the organizational culture of teachers (Carroll et al., 2003; Tyack & Cuban, 1995). Due to different organizational cultures influence intra-organizational knowledge sharing differently (Yang, 2007; Yang & Chen, 2007; Bock et al., 2005), knowledge management strategies and process models adopted by businesses may not be suitable for educational organizations. Many studies have pointed out the influence of the incentive system on an organization's inter-member

knowledge sharing (Constant et al., 1994; Nelson & Cooprider, 1996; Ryu et al., 2003; Kankanhalli et al., 2005). For most secondary schools in Taiwan with limited budgets, however, the external rewards they can provide may be limited. Therefore, an important topic of this research is how to design and introduce an appropriate knowledge management process model based on the organizational culture of schools. This model may improve intrinsic rewards and motivation and promote sharing and feedback among members of the school (including teachers and administrators). A KMS environment based on the process model will also motivate school members to establish and share knowledge documents to achieve the objective of increasing school performance with knowledge management.

Many researches explored the professional development issues for teachers (e.g., Koçoğlu, 2008; Hou et al., 2009a; Duran et al., 2009; Masood, 2010; Orhan & Yilmaz, 2010) and the application of technology on teachers' knowledge sharing recently (e.g., Erkunt, 2010; Duran et al, 2009; Chang & Liu, 2008). Although research exists on knowledge sharing in the teacher communities (e.g., Joaquín, David and Carme, 2010; Hou et al., 2009a, 2009b; Snow-Gerono, 2005; McCotter, 2001; Olson & Craig, 2001; Hsu, 2004), it focuses primarily on communities for teacher professional development. There is little empirical research on the progress, performance, applications, and implementation of knowledge management models in school organizations. Many knowledge management process models (e.g., the knowledge transfer/creation process) have been widely adopted and discussed (e.g., Nonaksa & Takeuchi, 1995; Hayes and Walsham, 2003; Nissen and Espino, 2000; Tiwana, 2002; Metaxiotis et al., 2003). Thus, if a set of knowledge management process models dedicated to schools could be designed, a more structured knowledge management system could be provided for the relatively isolated organizational culture of teachers (Tyack & Cuban, 1995). Considering the limited information personnel and funding in some schools (especially the vast number of smaller elementary schools and secondary schools), another important question is how to develop KMSs and improve members' internal motivation.

This case study addresses the aforementioned limitations of the organizational culture of schools. We designed a knowledge management process model that promotes knowledge transfer and sharing among the members of a school (including teachers and administrators). Based on the proposed model, we designed system modules that match each knowledge management procedure, and we used free or low-cost open-source software resources to develop a process-based knowledge management system for schools, or PKMSS, that is appropriate for schools and improves their knowledge management performance.

We observed a secondary school in Taiwan and introduced the PKMSS gathering, integration, sharing, and feedback of information knowledge required by school members. We also conducted an in-depth exploration of the actual uses of PKMSS.

The specific purposes of this study are as follows:

(1) To summarize the existing knowledge management models and propose a knowledge management process model appropriate for schools based on their organizational cultures and limitations.
(2) To develop a PKMSS system that meets the needs of schools' actual practices based on the above model.
(3) To observe and explore the progress, performance, and limitations of PKMSS by examining a secondary school in Taiwan.

PROCESS-BASED KNOWLEDGE MANAGEMENT SYSTEM FOR SCHOOLS (PKMSS)

Knowledge management helps an organization discover, acquire, and properly utilize knowledge (O'Dell and Grayson, 1998). The concept and model of knowledge management (Sarvary, 1999; O'Dell and Grayson, 1998; Shin, 2004) and various knowledge management processes (e.g., Shin, Holden and Schmidt, 2001; Nissen and Espino, 2000; Tiwana, 2002; Metaxiotis et al., 2003, etc.) have been widely discussed and studied. For example, Shin, Holden and Schmidt (2001) summarized previous studies and proposed the knowledge management value chain, which can be divided into four major steps: knowledge creation, knowledge storage, knowledge distribution, and knowledge application. Tiwana (2002) pointed out that the basic procedures of knowledge management include knowledge acquisition, knowledge sharing, and knowledge utilization. There is an increasing tendency to apply these knowledge management procedures to business operations.

Due to the increasing diversification and digitization of educational resources and administration, many studies have also pointed out the importance of introducing knowledge management into schools (Richard, 2001; David, 1999; Kuo, 2003; McKenzie et al., 2001). However, many factors influence inter-member knowledge interactions (Bock et al., 2005; Kankanhalli et al., 2005; Wasko & Faraj, 2005; Hsu, et al., 2007), and knowledge interaction is closely related to an organization's culture and characteristics (Yang, 2007; Yang & Chen, 2007; Bock et al., 2005). Therefore, the design of knowledge management procedures must consider a school's organizational culture to ensure that the procedures are appropriate.

This study reviews and summarizes existing literature on knowledge management (e.g., Shin, Holden and Schmidt, 2001; Nissen and Espino, 2000; Tiwana, 2002; Metaxiotis et al. 2003; Nonaksa & Takeuchi, 1995; Gilbert & Gordey, 1996; Davenport & Prusak, 1998; Hendriks 1999; Beckman, 1999) to design a knowledge management process model based on the organizational features of schools. Due to the competitive nature of business organizations, an organization's knowledge management and its performance are often closely related. Furthermore, the external incentives and binding forces of the employment relationship in a business organization make the implementation of knowledge sharing and knowledge transfer different from their educational counterparts. Factors such as information systems, organizational culture, incentives, and knowledge management project groups are all essential to determining whether knowledge management can be implemented (Sarvary, 1999). Educational organizations often lack the organizational culture of knowledge interaction (Carroll et al., 2003; Tyack & Cuban, 1995). Because of the lack of inter-member interactions in the organizational culture, it is often difficult to determine the objectives for knowledge-sharing (Carroll et al., 2003). In addition, rewards are limited, which may affect the performance of knowledge sharing. Schools also lack dedicated departments or teams to introduce knowledge management. Therefore, to keep costs low, another key procedure in school knowledge management is to choose active members to handle its implementation.

This study examined the characteristics and limitations of school organizations (mentioned above) and analyzed the factors that influence the applicability of different knowledge management process models in schools. We refer to the well-known knowledge transfer process proposed by Nonaksa & Takeuchi (1995) and various studies of the knowledge-management process (e.g., Shin, Holden and Schmidt, 2001; Nissen and Espino, 2000; Tiwana, 2002; Metaxiotis et al., 2003, etc.) to design a process-based knowledge management model that meet the needs of schools. Two critical teams are needed for the project group that introduces the proposed model to a school: (1) the knowledge management team, consisting of managers who specialize in knowledge management or KMSs, and (2) the knowledge construction team, consisting of members with knowledge expertise and high knowledge-sharing motivation. Any organizational member who utilizes organizational knowledge is classified as a knowledge user (including all members of the knowledge management team or the knowledge construction team). The specific procedures and corresponding knowledge transfer behaviors of our model are shown in Table 1.

The above process model needs to be implemented with a KMS in order to understand its potential performance and limitations. Though there are some studies on the KMS in education (e.g., Spector, 2002; Plass, 2002), they are mostly focused on proposing a KMS framework rather than developing an educational KMS based on a process model of knowledge management. Based on our proposed model and relevant KMS studies (e.g., Chua, 2004; Spector, 2002; Plass, 2002; Bowman, 2002), this study designed and developed the PKMSS system that addresses the concepts behind each procedure in Table 1. The features of each module of the PKMSS and the corresponding knowledge management procedures are shown in Table 2.

As shown in Tables 1 and 2, when knowledge management is in progress, knowledge types also change and generate meaningful knowledge transfer behaviors. During actual practice, knowledge constructors transform tacit knowledge into explicit knowledge through externalization. The Knowledge Searching and Knowledge Discussion Modules that allow the internalization and socialization of inter-member discussions and observations are provided. Through compilation by knowledge managers/users and inter-member discussion and evaluation, explicit knowledge is combined to form more sophisticated knowledge. Through the e-newsletters issued by the Knowledge Feedback Module, members' internalization motivation and behavior are encouraged. The feedback mechanism also encourages members to learn professional knowledge from other members through the internalization process of reading newsletters and discussing. The entire process meets the knowledge transfer model proposed by Nonaksa & Takeuchi (1995).

Table 1. Procedures of the knowledge management process model for schools

Procedures of School Knowledge Management	Description	Corresponding Knowledge Transfer Behavior
Knowledge Generation and Acquisition	The knowledge construction team generates working knowledge by writing digital work reports and promotes "externalization" and documentation of tacit knowledge. This effort is integrated into the daily routine, saving the members from extra work. The combination of a knowledge construction team and digital work reports helps a school acquire professional and accurate knowledge.	Externalization of knowledge
Sharing and Communication of Knowledge	Through a KMS, the documented knowledge is announced and shared. An environment that allows the "internalization and socialization" of inter-member discussions and observations is provided. In order to provide the school with the necessary correct knowledge, the senior knowledge managers determine what knowledge is to be shared, and these documents are only shared	Internalization of knowledge Socialization of knowledge

	after being approved by the knowledge management team. This helps avoid the distribution of incorrect or redundant knowledge and helps the community focus on the key objectives of knowledge sharing.	
Application and Evaluation of Knowledge	In this stage, knowledge users can "combine" the knowledge and apply it to actual practice by integrating the published knowledge documents. The approved knowledge is evaluated by an online voting and discussion mechanism, which allows users to evaluate and comment on knowledge documents. The knowledge management team may check the click rate or response rate of the knowledge documents. They may also check the knowledge users' online polling to determine the status of knowledge application and review comments. This mechanism provides information on how the knowledge management strategy should be adjusted.	Combination of knowledge
Knowledge Compilation and Feedback	After the KMS has operated for some time, the knowledge managers regularly compile the important and critical organizational knowledge as e-newsletters and send them to all the members as feedback to actively "combine" knowledge. Knowledge compilation allows the combination of knowledge in a sophisticated and professional manner. This mechanism also increases the knowledge construction team's motivation to write the digital work reports, thus achieving the objective of writing the knowledge documents. This improves knowledge users' level of participation, prompts them to review and "internalize" existing discussions or documents, and helps them focus on the objectives of knowledge sharing.	Combination of knowledge Internalization of knowledge

In this process, crucial organizational knowledge is gradually shaped and applied and becomes the knowledge needed by an organization. Knowledge managers report the crucial practical knowledge to users and knowledge constructors, potentially stimulating new knowledge and forming a cycle of increasing knowledge sophistication by reviewing and innovating knowledge documents.

Table 2. Functions of PKMSS Modules

PKMSS Modules	Function Description	Corresponding Knowledge Management Procedures
Work Report Module	Provides an interface for knowledge constructors to write digital work reports, allowing tacit knowledge to be externalized and documented.	Knowledge Generation and Acquisition
Knowledge Searching Module	Announces the latest knowledge documents and allows users to browse or search for knowledge documents by inputting key words.	Knowledge Sharing and Communication
Knowledge Discussion Module	Serves as a forum that allows users to discuss and comment on published knowledge documents.	Sharing and Communication of Knowledge Application and Evaluation of Knowledge
Knowledge Evaluation Module	Consists of a voting mechanism that allows knowledge users to evaluate published knowledge documents. Knowledge managers may also reference this information and compile the knowledge that has been applied or discussed. The compiled knowledge promotes the effective integration and transfer of crucial knowledge.	Application and Evaluation of Knowledge
Knowledge Feedback Module	Provides an interface that allows knowledge mangers to edit the compiled critical knowledge and sends out e-newsletters. This approach actively disseminates crucial knowledge to members and encourages	Knowledge Compilation and Feedback

	knowledge constructors to continue their work. This approach also deepens knowledge users' learning impressions and encourages them to continue reading, internalizing knowledge, and engaging in discussions.	Sharing and Communication of Knowledge

The PKMSS utilizes the APM framework (i.e., Apache, PHP, and MySQL). All the development software is free and allows for customization by a school's information staff. The system is fully web-based and easy to learn. The provided modules allow knowledge managers to configure, edit, add, or delete files and to manage the PKMSS without program-writing or website-designing skills. We used this system to combine knowledge management theories and information technology and conducted an empirical case study to understand the process.

As for the user interface, Figure 1 shows the Knowledge Searching Module in the PKMSS as an example. As shown in the figure, knowledge documents which have been approved by the knowledge manager are shared in the module. The module provides the document list, the searching function, and the title, category, and detail content of the knowledge document. Members of the community can browse, search and go to Knowledge Discussion Module to comment on the documents. In each module of the PKMSS, the system provides a friendly interface for users to access, apply, manage, and evaluate the knowledge documents.

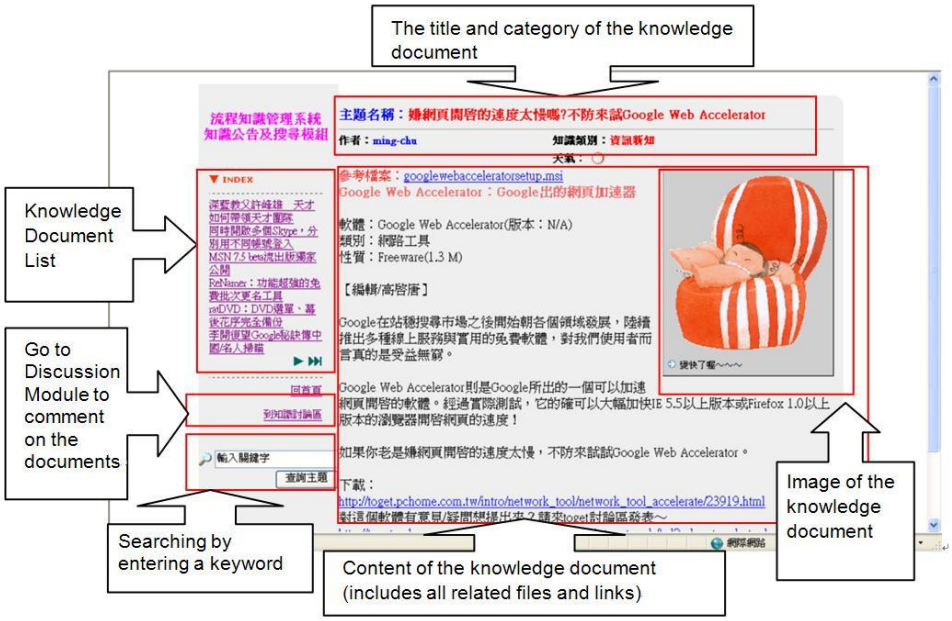

Figure 1. The interface of the Knowledge Searching Module in the PKMSS

METHOD

Organizational Background and Participants

A secondary school, located in Taipei City, Taiwan, was selected as the site for our introduction and observation of the PKMSS. The core professional knowledge we hoped to introduce to the school was "knowledge relevant to the Internet information technology." With the growth of Internet technology and educational technology, the school's teachers and administrators frequently use information technology to facilitate teaching and administration. Although the teachers have participated in workshops provided by training facilities, they still face problems when attempting to apply the technology, and not all the problems that arise were covered during their training. In addition, different members have received different amounts of training on different content. Thus, their information literacy also differs. Consequently, the members may not be able to fully share their knowledge, solve each other's problems, or receive timely assistance, thereby hindering the organization's performance.

Moreover, the school's information center receives calls from different departments asking for help regarding computers or the Internet. Certain problems share common attributes and can be solved by users themselves through certain procedures. Currently, most problems are solved by instructing the callers over the phone; if problems persist, the information staff goes to the site to address the situation. This practice is inefficient and does not allow common information-related knowledge to be distributed or accumulated into organizational knowledge. Therefore, the school hopes to introduce and manage knowledge relevant to Internet information technology using the PKMSS system. The school administration hopes to acquire the tacit knowledge held by its information staff or members who are information specialists. The tacit knowledge will then be shared, applied, and transferred to help the organization

efficiently solve information-related problems, improve the school's information service, and establish the information service knowledge database.

After the research team promoted the PKMSS in the school for about a month, 45 members signed up for the knowledge management project. Based on the members' information backgrounds, we appointed one knowledge manager (the director of the school's information center) and nine members of the knowledge construction team. All members who registered and joined the knowledge application were considered knowledge users (including knowledge managers and knowledge constructors). These users included members who worked at different levels and positions, including the principal, directors, teachers, administrators, and nurses. All of the above members acquired the basic skills of PKMSS through the same training program.

Design and Procedures

The process of introducing knowledge management to an organization is complex. In order to gain a deeper understanding of the knowledge management process and the performance and limitations of the system as proposed in this study, we applied both quantitative and qualitative analysis methods, including satisfaction surveys, qualitative content analysis of online discussions, and unstructured interviews. In the first step of this study, the researchers provided all participants with an introduction and training in PKMSS. Then, based on the assigned groups, the knowledge constructors wrote digital work reports about the knowledge and experiences of their daily work. The knowledge manager then evaluated and gave feedback on these reports. All knowledge users used the PKMSS modules to discuss, ask questions, provide additional information/comments, and evaluate the posted knowledge. The entire observation lasted 30 days. After the observation period, a survey on knowledge management satisfaction (see the section 3.3 below) was conducted to assess member satisfaction. The entire online discussion content in PKMSS was recorded and analyzed to understand the process of knowledge sharing/application among members. Finally, we conducted open-ended, unstructured interviews with the members to explore their attitudes about the knowledge management project and PKMSS. The interview question was, "What are your thoughts and comments about PKMSS?"

Instrument

We adopted an instrument that measured five dimensions of user satisfaction about knowledge management systems (USKMS) devised by Ong and Lai (2004). This instrument specifically deals with KMS satisfaction. It was rigorously tested with high reliability and validity; the Cronbach's alpha was 0.94, including 21 items and five dimensions (i.e., knowledge content, knowledge mapping, knowledge manipulation, knowledge community, and personalization). In the PKMSS, some functions of these dimensions are not provided. Therefore, some items in the USKMS were removed or adjusted for our study. Additionally, we included questions that evaluated the effectiveness of general online information systems (e.g., Rai, Lang and Welker, 2002; Muylle, Moenaert and Despontin, 2004) to understand whether users were satisfied with the interfaces and operations of PKMSS. The compiled and organized questionnaire contained 15 questions that included the four dimensions proposed by Ong and Lai (2004): knowledge content, knowledge mapping, knowledge manipulation, and knowledge community. The questionnaire also included the dimension of "system use," added by this study, for a total of five dimensions. The questions are listed in Table 3.

Table 3. Satisfaction Survey Questionnaire on PKMSS

Dimension	Question
Knowledge Content	Q1. PKMSS provides correct content.
	Q2. PKMSS provides integral content.
	Q3. PKMSS provides logical content.
	Q4. The content provided by PKMSS is easy to read.
	Q5. PKMSS provides practical content.
Knowledge Mapping	Q6. The knowledge classification of expertise in PKMSS is clear and easy to understand.
	Q7. The classification of expertise in the PKMSS is consistent with my cognition.
Knowledge Manipulation	Q8. PKMSS makes it easy for me to search/retrieve knowledge documents.
Knowledge Community	Q9. PKMSS makes it convenient for me to discuss with other people in the knowledge community.
	Q10. PKMSS makes it convenient for me to input comments and feedback in the knowledge community.
	Q11. PKMSS makes it convenient for me to share knowledge with other people in the knowledge community.
	Q12. PKMSS makes it convenient for me to access the shared content from the knowledge community.

System Use	Q13. I think that operating PKMSS is quick and easy. Q14. I think the user interface on PKMSS is friendly. Q15. I think the hyperlinks in PKMSS correctly state where they will take me.

The questionnaire utilizes a 5-point Likert scale, in which a higher score indicates a higher level of agreement with the statement. One point was given if the respondent was "strongly dissatisfied," and 5 points were given if the respondent was "strongly satisfied." Besides the dimension of system use, the questions in all other dimensions covered topics relevant to the knowledge management process proposed in this study. For example, the dimension of "knowledge content" was used to verify whether the generated and acquired knowledge documents were correct and logical. The dimension of "knowledge mapping" helped us verify whether knowledge classification in the PKMSS was appropriate to the externalization process of knowledge generation, acquisition, and compilation. The dimension of "knowledge manipulation" helped us understand how easy it was to search for specific knowledge. The dimension of "knowledge community" allowed us to verify the effectiveness of knowledge sharing, communication, and feedback.

RESULTS AND DISCUSSION

After the empirical observation was implemented for 30 days and the members who were unable to fully participate during the period were filtered out, a total of 31 members underwent questionnaire and interview surveys. The Cronbach's alpha of the satisfaction survey was 0.92. Based on the question items for each dimension listed in Table 2, we calculated the mean of the mean scores of all questions in each dimension as the satisfaction score of that dimension. The satisfaction scores of the five dimensions are listed in Table 4.

Table 4. Satisfaction scores of the five dimensions on PKMSS

Dimension	N	Mean	SD
Knowledge Content	31	4.17	.498
Knowledge Mapping	31	4.11	.704
Knowledge Manipulation	31	4.19	.703
Knowledge Community	31	4.39	.478
System Use	31	4.31	.531

As shown in Table 4, the participants were positive towards all dimensions of PKMSS. The dimension that yielded the highest level of satisfaction was "knowledge community," followed by "system use." The satisfaction with "knowledge mapping" was relatively lower. The main analyzing framework in this study was based on the dimensions covered in the satisfaction questionnaire. We also analyzed the open-ended interview transcripts and the content of knowledge discussions recorded in the system and conducted a cross-discussion and triangulation with the findings of the satisfaction survey.

The dimension of "knowledge content" (Q1-Q5) mainly focused on whether the content of knowledge documents provided by PKMSS was correct, complete, logical, easy to follow, and practical. The satisfaction score for this dimension was 4.17. The users were quite satisfied with the knowledge documents. Most respondents (93.5%) were especially satisfied with their "practicality" (Q5). This indicates that mechanisms such as sharing, feedback, discussion, and evaluation on PKMSS generate a level of practicality in terms of knowledge generation and acquisition. The knowledge documents in our system were correct, logical, and practical. During the interviews, the members acknowledged the knowledge content and gave suggestions:

Member A: I really like this system because it allows me to acquire all sorts of new information...I believe its greatest advantage is that knowledge can be shared with others, and everyone is motivated to participate.…I wish they would include information such as campus activities, governmental regulations, and human resources in the system in the future….(#0302-5)

Member B: I wish it could be connected with external knowledge management platforms as this would provide more knowledge documents and promote sharing among the school staff. (#0106)

Member C: I wish it could be integrated with other educational resources and subjects. (#0404)

In addition to positive comments, the above excerpts also indicated that the organization's members wanted to see the knowledge documents in the system integrated with other resources. For example, Member A mentioned documents related to the dimension of education administration, Member B mentioned external KMSs, and Member C mentioned professional subjects and knowledge. Because this study only conducted an initial trial run of PKMSS, knowledge themes were limited and only focused on information-related knowledge. However, because the practice of education is complex and covers diverse domains of knowledge, an important topic for future research is how to integrate information from different knowledge sources. The era of Web 2.0 emphasizes active and highly interactive knowledge sharing (Musser, O'Reilly & the O'Reilly Radar Team, 2006). Open, cross-campus educational platforms, such as

teachers' blogs, are increasing (e.g., Author et al., 2009b). Many members (such as Member B above) also wished to see a connection that links the knowledge documents in different community platforms and schools. This kind of knowledge interaction (where the internal system provides diverse and convenient information sharing that allows the practical resources discovered by members in external community platforms to be shared) should be a future trend to promote depth and breadth in knowledge externalization and combination.

The dimension of "knowledge mapping" (Q6-Q7) allows us to understand whether the classification and manifestation of dedicated knowledge in the PKMSS matches users' understanding. The satisfaction score for "knowledge mapping" was 4.11. The questionnaires indicated that users were less satisfied with this dimension in PKMSS compared to other dimensions. Currently, campus information knowledge is classified into ten default categories in PKMSS. However, an inappropriate default knowledge classification in the system may result in users' failure to understand the knowledge classification, hindering knowledge access. Since knowledge document searching in PKMSS currently features listing and searching for knowledge documents and knowledge categories are only listed after a user clicks on a document, users cannot fully understand what kinds of knowledge categories exist and may be confused by how categories are displayed and arranged. An example is the comment given by Teacher D in an interview:

Teacher D: Regarding knowledge announcement in the system, I think it should allow users to freely select the knowledge categories they wish to see. (#0403)

Teacher D recommended that the future PKMSS should allow browsing based on categories of knowledge acquisition. Moreover, similar problems were found when the content of the knowledge forum was analyzed, because some users did not know how to look for the knowledge documents being discussed by their peers. The following is excerpted from the forum and describes how the members felt when they were looking for the knowledge document shared by Member E, who was a knowledge constructor.

Discussion article number #D0201

Knowledge manager: Teacher E must have given us the links to online virus-removal sites because he has become really tired of getting rid of computer viruses for us. Ha! Anyways, let's give him some applause!

Teacher E (knowledge constructor): Ha, ha! Actually, I just want everyone to regularly update their OS and virus definitions, and develop good online habits such as not opening suspicious files or websites. That's how you stay away from being infected!

...

Teacher G (knowledge user): Thank you, Teacher E. But I would like to ask you where I can access the "great collection" you have shared?

Knowledge manager: Go to "Knowledge Announcement and Search Module," input the key word of "virus removal" to browse the database, and you will see that knowledge document.

Teacher G (knowledge user): Thank you, Knowledge Manager and Teacher E. I've found it. Thanks again.

The above example indicates that the current method in PKMSS that only allows searching using keywords does not really help knowledge users understand the important frameworks of classification in a knowledge domain, and it does not promote effective knowledge internalization and sharing. Important considerations include how to handle the high cognitive load generated by the simultaneous presentation of multiple knowledge categories and how to guide users to access knowledge based on the categories. Further, inappropriate classification may lead to concept confusion or redundancy (Voß, 2007). Therefore, users' understanding of and experience with information-related knowledge should be surveyed and relevant research should be reviewed to develop a system of knowledge classification that is both effective and meets the consensus of an organization's members (e.g., Milton, 2007; Santos-Neto, Ripeanu & Iamnitchi, 2007) in an effort to use knowledge classification to better meet users' needs.

The satisfaction score for "knowledge manipulation" (Q8) was 4.17, and 87% of the users indicated that it was easy to search for knowledge documents via PKMSS and expressed satisfaction with the searching feature. However, the search feature could be improved if searching or browsing could be based on knowledge categories, as discussed in the above section on knowledge mapping.

The satisfaction score for knowledge community (Q9-Q12) was 4.39. This was the highest of all dimensions, and most participants agreed that it was easy to discuss with others, provide comments and feedback, and share knowledge through PKMSS. This also indicates that the mechanisms of knowledge communication, sharing, and feedback in this process are effective and facilitate the externalization and combination of knowledge. Examples include the following excerpts:

Member A: When there were difficulties, I was able to receive help through this system, and the online colleagues were very enthusiastic and provided much assistance. To me, it was very helpful. The greatest reason that

attracted me to use it was that the knowledge documents could be discussed and shared. We were not alone when facing problems, and help was available through the system. (#0301-3)

Member H: PKMSS promotes interpersonal communication among the campus community and promotes knowledge sharing. (#0409)

Member I: When I faced difficulties, there were ways that could help me, and knowledge could be shared with everyone. (#0410)

Member J: I believe this is an excellent platform that facilitates both teaching and learning. When I provided my comments, others also gave their feedback, allowing me to grow during this exchange of thoughts.…The system has an interactive platform that allows us to discuss with our fellow teachers, and we can also get help from the experts when we have information-related problems. It feels very efficient. (#0201-3)

As mentioned earlier, past research indicates that teachers often lack interaction with one another, and it is difficult for them to determine the objectives of knowledge sharing (Carroll et al., 2003). The comments on PKMSS seen above indicate that mechanisms that combine actual practice, knowledge documents, and problem solving may achieve work-related consensus and turn this consensus into knowledge-sharing objectives. Mechanisms such as the evaluation module, e-newsletters, and forums also enhance the community's knowledge interactions. Interactions yield practical resources (such as knowledge documents, newsletters, and discussions) that may provide assistance for teachers whose organizational culture is isolated (Tyack & Cuban, 1995), as suggested by Members A, I, and J. In order to further understand the process of knowledge interaction in the educational community, we include here an excerpt from the knowledge forum. In this example, Member K was interested in a knowledge document and asked more questions in the "Knowledge Discussion Module" to find answers to his problems.

Discussion article number #D0103

Member K: Can I use Ghost to backup the disk partitions? If not, is there any other way to do it?

Knowledge manager: If you "ghost" the entire hard-drive and copy it to another hard-drive, the disk partition information is also copied over. Also, I don't think many people back up their disk partition information.

Member K: Because I made the partitions and it was quite a troublesome process, so I figured if I could "ghost" the partition information, it would make things easier for me in the future. So…I guess your answer was a "yes?" Can I just ghost the whole thing after the hard-drive is partitioned? Or, the operating system has to be ghosted at the same time as well? Also, what I would like to suggest is that the ghost procedures you guys posted seem too simplified. Could you give a more detailed, step-by-step instruction for people such as me who know less about computers? Thank you!

Knowledge manager: Hmm…About that knowledge document, it was intended as a reference for beginners. You can ask any questions about any procedure that you are still confused with.

Member L (another knowledge user): Frankly, there are so many different versions of "Ghost," and they basically work the same way. However, there are different kinds of combination and applications depending on your OS and needs. It is unlikely that you will need all the features of Ghost or to "ghost" all the time! Here is an online article that may help you out!
(The URL of the online article)

Knowledge manager: Thank you, L, for your input. The article you posted indeed has many detailed instructions on how to use Ghost.

In the above excerpt, Member K read and internalized a knowledge document relevant to his needs and asked extensive questions. Furthermore, the member also provided suggestions regarding the content of the knowledge document that served as valuable references for improving the quality of future knowledge-managers' or constructors' knowledge externalization and combination. Knowledge managers and other users were able to propose additional correct input regarding the knowledge document through the discussion mechanism, allowing better knowledge socialization and internalization. This process may provide assistance for the problem of lacking in-depth knowledge interactions in teachers' virtual community as mentioned in previous studies (e.g., Author et al, 2009a; Barab et al., 2001). This has also verified the benefits of PKMSS on schools' knowledge-sharing.

Finally, the satisfaction score for "system use" (Q13-Q15) was 4.31, and the completed questionnaires indicated that 84% of the respondents agreed or strongly agreed that PKMSS yields good system use, including speed, a user-friendly interface, and clear and correct hyperlinks. Some users made recommendations for improvements or additions.

Member M: Could you increase the allowed size of photo uploads? (#0509)
Member N: The content of the newsletter could be further expanded. (#0510)

The limitations of system capacity and newsletter content restrict knowledge externalization and feedback. The issue of capacity involves the cost of the storage device. More knowledge managers would be required if the content of the newsletter were to be improved, resulting in additional costs. Another important topic for future research is how schools

can improve KMS with limited funding. The above discussion gives us an initial understanding of the performance and limitations of PKMSS in a school.

CONCLUSION

The constant improvement of Internet technology and the increasing digitization and complexity of educational practices have made it critical for school organizations to introduce knowledge management (Richard, 2001; David, 1999; Kuo, 2003; McKenzie et al., 2001). Due to limitations in schools' organizational cultures, budget, and incentives, test runs and development of knowledge management processes and models are needed to allow us the development of low-cost and effective knowledge-management solutions for schools.

This study proposed a knowledge management process model and PKMSS system for schools. The month-long observation and satisfaction survey conducted in a secondary school revealed that PKMSS and the mechanisms of knowledge communication, sharing, and feedback are effective and practical in terms of schools' knowledge management. Benefits include the externalizing and combining of knowledge, determining the objectives of knowledge sharing, combining knowledge documents and practices to solve problems, and promoting inter-member interactions.

However, there are many insufficiencies with the current PKMSS, including limited knowledge classification, limited diversity of knowledge content, and limitations with certain system features.

In terms of limitations in knowledge categorization, there has been much research on the tagging system (e.g., Golder & Huberman, 2006; Rivadeneira, Gruen, Muller, & Millen, 2007; Voß, 2007). We recommend that future researchers design school-oriented tagging mechanisms in KMSs that allow teachers to flexibly categorize professional knowledge. These mechanisms could improve the clarity and comprehensiveness of the knowledge map. We recommend that the diversity of knowledge content be integrated with knowledge domains, such as subject-domain knowledge and instructional design. In terms of the limitations of the system's features, a dynamic consideration of cost and users' needs would be required before PKMSS could be further enhanced.

A future study on a larger scale that examines multiple schools is recommended to supplement this case study. Furthermore, there are many factors that affect knowledge sharing (e.g., Bock et al., 2005; Kankanhalli et al., 2005; Wasko & Faraj, 2005; Hsu et al., 2007) and teachers' perceptions of educational technology (e.g., James, 2008; Taiwo, 2009), and their influences on PKMSS are waiting to be uncovered by future studies. We hope that our initial findings and the experience of PKMSS may serve as a valuable reference for knowledge management in schools. This will help schools with a limited workforce and limited funding encourage their members to actively and effectively conduct knowledge transfer, innovation, and sharing.

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