

The Reality of Team-based Knowledge Sharing and Creation in Professional Cyber Community

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Abstract

Groupware is often regarded as an important tool for facilitating team collaboration. However, most theoretical findings are obtained by using students as subjects. We are interested in knowing the practicability of groupware embedded in a professional community of practice. To gain insights into the reality of knowledge sharing and creation through collaborative technologies in a real setting, we recruited teachers from a teachers' professional cyber community to form special interest groups and conducted three phases of on-job training projects using the grounded action research approach. Teachers from primary and junior high schools were mediated by groupware technology and learned to design lesson plans collaboratively. Various data sources such as system logs, group memories, interviews, and questionnaires were also collected. Through these three phases, we identify several types of processes of team-based knowledge sharing and creation in the professional cyber-community, defined by the causal conditions, action/interaction strategies, and consequences. Some phenomena identified through these three phases are elaborated in this study.

1. Introduction

The elementary educational reform in Taiwan has been moving toward nine-grade joint curricula plan, which integrates learning scope and essential abilities for students from primary to junior-high school education. Within this movement, teachers in primary and junior-high schools are expected to autonomously design teaching materials, flexibly administrate classes and multi-dimensionally evaluate students' learning effectiveness. Teachers specialized in certain subjects are expected to

collaborate for developing integrated lesson plans. Unfortunately, under the small-school-small-class policy, there are a small number of teachers teaching the same subjects within a school. Furthermore, teachers are encouraged to adopt information technology (IT) to teaching subjects, but only a small proportion of teachers specialized in IT. The collaboration of teachers in various specialties and schools can be more diversified and flexible, but it needs to overcome the geographical and organizational barriers. Information seems a proper means to bridge geographical and organizational barriers.

While we are moving to the knowledge economy era, some contemporary school reform efforts suggest a shift from the predominant view of schools as bureaucratic organizations to that of schools as communities [26]. The sense of community, extending from teachers within a school to those across schools, stimulates the development of teachers' professional communities. By virtue of IT, a cyber community with professional community characteristics can be built by utilizing IT to shape the new paradigm of professional practice.

A teachers' professional community web site, called SCTNet (<http://sctnet.edu.tw>), was established in 1999, and aimed at achieving the goal: smart and creative teachers. SCTNet serves as a cyber space for teachers in compulsory education to share and create professional expertise, to shape the norms and values, and to link teachers with other social stakeholders, such as parents, governmental and non-governmental organizations. The SCTNet system was implemented by National Sun Yat-sen University, and co-operated with the Bureau of Education of the local government. It has become the most representative professional virtual community with about thirty-six thousands members by the middle of 2002 in Taiwan. In SCTNet, teachers can share their professional works in terms of lesson plans, research results, and teaching

resources with other community members, and receive comments. Teachers can dialogue on discussion boards focusing on specific subject areas. Teachers with a similar interest can create a special interest group (SIG) to collaborate according to their objectives. Each SIG are mediated by groupware technology and equips with discussion boards, on-line chatting, document repository, e-mail, social network analysis and group member interaction statistics.

Most theoretical findings of groupware are drawn from experiments using students are chosen as subjects [9, 19]. We are interested in knowing the practicability of groupware embedded in the professional community of practice. From 334 SIGs established continually so far, we have found that members are more willing to upload and download resources than dialogue and collaborate both on the web and SIGs. We are puzzled why teachers in the current individual, organizational, and social environmental contexts are reluctant to start professional dialogues and collaboration. Furthermore, we anticipate investigating how teachers utilize IT in supporting their knowledge sharing and creation to strengthen their professional capability in teachers' cyber community. We also identify several types of processes of team-based knowledge sharing and creation in professional cyber-communities, which are defined by the sequence of causal conditions, action/interaction strategies, and consequences. Findings from these three phases of grounded action research are discussed by the end of this paper.

The following section illustrates the research methodology of this study, and we analyze the results of three phases of study in Section 3. The theoretical findings are discussed in Section 4. We conclude this paper with research contribution and limitations in Section 5.

2. Research methodology

In order to investigate the intricate details of team-based knowledge sharing and creation in professional cyber-communities, the qualitative method is used for uncovering and understanding what lies behind any phenomenon. Among various qualitative methods, a number of researchers have suggested action research as a potentially useful method in information systems field [2, 4, 10, 11, 14, 22]. This approach presumes that complex social systems cannot be reduced for meaningful study, nor can sociologic experiments ever achieve repeatability. The fundamental contention of action research is that a complex social process can be studied best by

introducing changes into that process and observing the effects of these changes. It enables a researcher to intervene in the organization while at the same time generate knowledge about the process.

In Susman and Evered's [28] action research model, the first phase, called diagnosing, involves the identification of primary problems that are to be addressed within the host organization. The second phase, action planning, specifies the organizational actions that should be taken to relieve or address these problems. These planned actions are guided by the theoretical framework of the action researcher. The third phase, called action taking, implements the planned actions. The fourth phase, evaluation, includes analyzing whether the planned actions achieved their intended effects. The last phase, specifying learning, specifies what was learned during the action research project. This is when the knowledge gained is applied within the organization and communicated to the scientific community.

However, much of the literatures on action research currently seem to assume that theory evolution and exposition will occur as a natural consequence of problem formulation. Checkland [6] criticized that the problem with action research arises from the fact that it cannot be wholly planned and directed down particular paths. Baskerville and Pries-Heje [3] thus suggest that action research may be refined to improve their ability to contribute rigorously to information systems research. Their approach improves the rigor by integrating two techniques of grounded theory [12] in the phases of action research. First, the theory-data during the action cycle are represented by grounded theory notation. Second, the coding process of grounded theory becomes the essence of the evaluating, learning and diagnosis phases of action research. The iteration between data and concepts will stop while reaching theoretical saturation.

Since we have the opportunities to access the complete data in SCTNet and host the on-job training for teachers from primary and junior high schools, we hope to apply the grounded action research approach to validate a theory in such a real situation, gain feedback from this experience, modify the theory from feedback, and then practice the new strategies.

3. The research project

We launched three on-job training projects by enrolling teachers who were interested in applying IT to pedagogy or developing lesson plans collaboratively. First, we recruited members via SCTNet to form six SIGs in the year of 2000. Several teachers from primary and junior high

schools learned to design lesson plans through collaboration facilitated by the groupware embedded in SCTNet. Further, another six teams were established in 2001 and some changes corresponding to the reflection of Phase I outcomes were introduced. In the late of year 2001, we launched the third phase of on-job training by changing some settings, and ten special interest groups are examined.

The pedagogical assumptions underlying our design of the on-job training can be classified as collaborativism and socioculturism according to Leidner and Jarvenpaa's categorizations of learning models [17]. Since the realism of context is high, and the learning is through sharing and creating knowledge. Besides, knowledge is personally experienced, and the learners have full control of the learning progress. A learner considers the amount of the knowledge they can contribute versus knowledge the learner can gain from the sharing process. We acted as facilitators to coordinate several resources available to support these teachers' collaborative processes without much intervention, since we have identical viewpoints with Leach [15] that the practice of the community itself creates the potential 'learning curriculum.'

During their collaboration process, various data are collected, including (1) information shared in SIGs, (2) observation during the three on-job trainings, (3) three questionnaires filled out at different phases, (4) semi-structured interviews with team leaders, one most and one least active members of a team at the end of phase I study, and (5) focus groups conducted at the end of Phase II study. Followings are several phases of our studies elaborated according to Susman and Evered's action research model [28]. We will specify learning and discuss them in Section 5.

3.1. Phase I (10/25/2000~12/06/2000)

3.1.1. Diagnosing. As mentioned earlier in Section 1, teachers in primary and junior schools were asked to develop lesson plans autonomously, but we found that members in most SIGs are more willing to upload and download resources than dialogue and collaborate in the community. Furthermore, we anticipate investigating how teachers utilize IT in supporting their knowledge sharing and creation to strengthen their professional capability in teachers' cyber community.

3.1.2. Action planning and taking. An on-job training project to exercise the collaborative lesson plan development is launched. Five to seven teachers can form a team facilitated by SCTNet's SIG

functions to design lesson plans of integrating IT with subject pedagogy. Six SIGs (A_1, A_2, \dots, A_6) was formed, and each team was granted with high flexibility to elect its team leader, to develop a lesson with a variety of tools and scenarios, and to set the goal to reach within the seven-week collaboration. To promote "creative chaos" [24], teachers within the same team came from different schools and did not know each other until joining the team.

3.1.3. Evaluating. The consequence of collaborative lesson plan development via team-based knowledge sharing and creation is categorized at three levels: *individual, group, and organizational levels*. Two major concepts of individual level consequences are *self-efficacy of using IT in teaching* and *professional social network enlargement*. Individual self-efficacy is measured by three dimensions: *concepts, abilities, and applications*. Individual self-efficacy of using IT in teaching was low in average among the six teams. In addition, two other dimensions of group level consequences are *product* and *goal attainments*, as shown in Figure 1 (which also describe information from Phase II & III). Since we focused on the collaborative process of innovating lesson plans, the team product was measured in terms of novelty, degree of combination, and feasibility. To prevent subjective bias, we asked three experts to evaluate the product of each team. The results indicated that Team A_2 was ranked as superior while Team A_1 was inferior. Interestingly, several participants in these teams suggested the provision of on-line chatting, and regarding it as an important vehicle to motivate knowledge sharing. Some also suggested newest progress about the SIG should be provided to keep them informed. Besides, their experiences in sharing and collaborating with other colleagues were few.

3.2. Phase II (04/11/2001~06/06/2001)

3.2.1. Diagnosing. We were disappointed at both of the processes and products of knowledge sharing and creation these six teams had achieved in Phase I because more professional dialogues were expected. The most discouraging observations were that some SIG members still had no idea about how to collaborate with others by the end of project and some forwent the habits of knowledge sharing after the on-job training project ended.

3.2.2. Action planning and taking. Based on the lessons learned from Phase I study, we modified

several settings and redesigned the nine-week training project. First, to cater to the need of

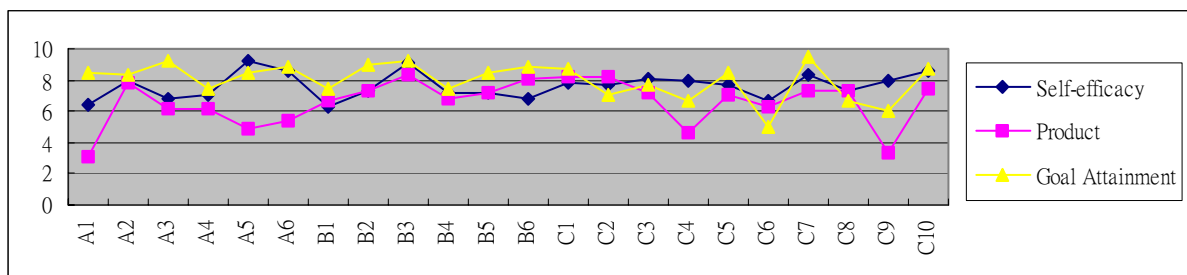


Figure 1. Consequences of three phases

synchronous communication that proposed by several participants in Phase I, on-line chatting mechanism was introduced into SIG environment. Moreover, they can understand SIG members' activities and interaction status via new SIG functions.

To make explicit about what had learned, the agenda of Phase II study added the reflection phase, including practicing teaching, review seminar and suggestions from an expert. The participants thus had opportunities to bring their lesson plans into practice and then to reflect from their practicing. Furthermore, we invited those experienced teachers to join SIGs to stand by in order to answer possible questions in teams' collaborative processes on line. Specifically, we allowed teachers from the same schools to form teams (B₅ and B₆), which might be used for comparing with those teams composed of teachers from different schools. Another six SIGs (B₁, B₂, ..., B₆) were formed to excise collaborative lesson plan development from 4/11/2001 to 06/06/2001.

3.2.3. Evaluating. The evaluation of SIGs in Phase II had shown that self-efficacy of using IT in teaching was higher in average in Team B₂, B₃, and B₄. However, Team B₁'s self-efficacy was relatively low. The participants thought that the greatest gain was social network enlargement. For instance, members of Team B₃ said, "*We made several friends who had a common goal and ideals, and at last we understood that we were not lonely on the road of education.*" Besides, the products of Phase II study are generally superior to Phase I as shown in Figure 1.

The function of synchronous communication was seldom utilized in these SIGs, and only Team B₄ with high IT capability felt comfortable toward IT and regarded on-line chatting as the most suitable vehicle to collaborate. Therefore, their high IT capability also positively affected self-efficacy of applying IT in teaching. Besides, the consensus of Team B₃ was originally to adopt discussion board to communicate, but afterward they not only use the SIG on the SCTNet but by phone as well.

In the questionnaires and interviews with SIGs members in Phase II, we find the professional sharing and cooperation culture between colleagues among the schools of Phase II is generally more popular than those of Phase I. Comparing with the *individual context*, the levels of the habit of cooperation and propensity to share in Phase II are generally higher than Phase I as well.

Furthermore, the agenda of the on-job training in Phase II is planned to hold prototype/product demonstration among teams, practice teaching within the team, and review/reflection seminar among teams. Teams successfully complete the reflection phase had higher self-efficacy of applying IT in teaching than those of Phase I. Finally, there were no obvious differences between teams composed of members from the same or different schools.

3.3. Phase III (11/14/2001~06/05/2002)

3.3.1. Diagnosing. The processes and products of knowledge sharing in Phase II were somewhat improved, but there were still members 'gotten lost' in the collaborative process. Besides, although several experienced teachers joined these SIGs as mentors, their guidance on line had failed to encourage much professional dialogue as expected. Again, they did not internalize the habit of knowledge sharing after the on-job training ends.

3.3.2. Action planning and taking. Swap et al. [30] suggested mentoring and storytelling were ideal vehicles to transfer knowledge. To overcome the problem revealed by some members that they had no idea about how to collaborate with teammates, we collected better examples in both phases and composed a detailed story about the collaborative process. Furthermore, we gained the approval of the Bureau of Education of the local government to provide experienced teachers as mentors to guide SIG members both on line and physically. We did hope

SIG members to have the habit of knowledge sharing and thus prolong the agenda of this on-job training process. The extent schedule was immersed into their daily practice, and we remained non-intervened with their collaborative processes. Ten SIGs (C_1, C_2, \dots, C_{10}) were established in the third phase of on-job training from 11/14/2001 to 06/05/2002.

3.3.3. Evaluating. The processes and products of knowledge sharing in Phase III were improved only to a limit extent. However, most of their products had achieved acceptable level except Team C_4 and C_9 . Noticeably, their self-efficacies were generally high. This may due to the prolonged reflection phase and proactive participation of mentors. Besides, Team C_1, C_2, C_{10} built the habit of knowledge sharing even when the on-job training process ended.

4. Research results

Since the grounded action research adopts notation and coding process of grounded theory, we adopt the grounded theory model to represent the research framework as shown in Figure 2.

(1) *Contexts*: This part identifies essential factors in various contexts affecting the process of team-based knowledge sharing and creation in professional cyber-communities. Due to the page limitation, we trade the provision of context richness for interesting constructs.

(2) *Process*: The process involves action/ interaction strategies, causal conditions, and consequences.

1. Action/interaction strategies. Grounded theory is an action/interaction-oriented method of theory building [29]. The action/interaction strategies can help to investigate the process of team-based knowledge sharing and creation in professional cyber-communities.

2. Causal conditions. Action/interaction has such properties as processual, purposeful and goal oriented. Failed action/interaction is as important to look at as action/interaction taking place. From both outcomes, we may specify reasons indicating causal conditions.

3. Consequences. Outcomes from different conditions with various action/interaction strategies for team-based knowledge sharing and creation are consequences.

Figure 2 depicts the theoretical model of team-based knowledge sharing and creation in professional cyber-communities, which the categories and concepts developed from iteration between data and concepts. On top of Figure 2 is the context for knowledge sharing and creation in professional

cyber-communities. Among these contexts, several factors that become the causal condition (arrow 1) affect the strategies that a team adopts (arrow 2), and thus the consequences are different (arrow 3). The causal conditions consist of two levels: individual level (active to ask for help, habit of cooperation, propensity to share, and perception of communication media), and group level (group roles, knowledge creation roles, group norms, cohesiveness and leadership styles). Analyzing data gathered from three phases, action/interaction strategies can be codified into three categories: *collaboration strategies, using IT strategies, and knowledge sharing and creation strategies*. We classified collaboration strategies into two categories: *task performing and team maintenance strategies* as shown in Table 1. Table 2 lists the definition of using IT strategies. Furthermore, Table 3 shows the knowledge sharing and creation strategies adopted by these teams. The consequences are viewed in individual level (self-efficacy and professional social network enlargement), group level (goal attainment and product quality), and organizational level (application gap).

The team-based knowledge sharing and creation in professional cyber-communities can be summarized with the process aspect: Several teachers join together as teams in professional cyber-communities to develop lessons plans of applying IT to pedagogy. Although coming from different schools, due to the similar professional training process and immersing in the similar workplace culture, they exhibit common behavior in various aspects. Each team member is expected to adjust themselves to abstain the professional autonomy or the habit of self-supporting, and learn to proactively share or interact with teammates in the individual level. From the causal conditions of the group level, they should recognize their functional roles and roles of knowledge-related activities in their team. Besides, during the course of the group interaction, the norm of using IT was established, and then members followed this rule to collaborate. These causal conditions have reciprocal effects on their adoption of action/interaction strategies, and thereby contribute to consequences of knowledge sharing and creation.

Furthermore, the process of team-based knowledge sharing and creation in professional cyber-communities, including action/interaction strategies, causal conditions, and consequences, is classified into six types as shown in Table 4. We evaluate teams' products and assign them into three clusters: *inferior, medium, and superior*. These three levels of team products can be matched with the six types of strategies. Superior teams usually apply Type I and II strategies, medium teams are Type III

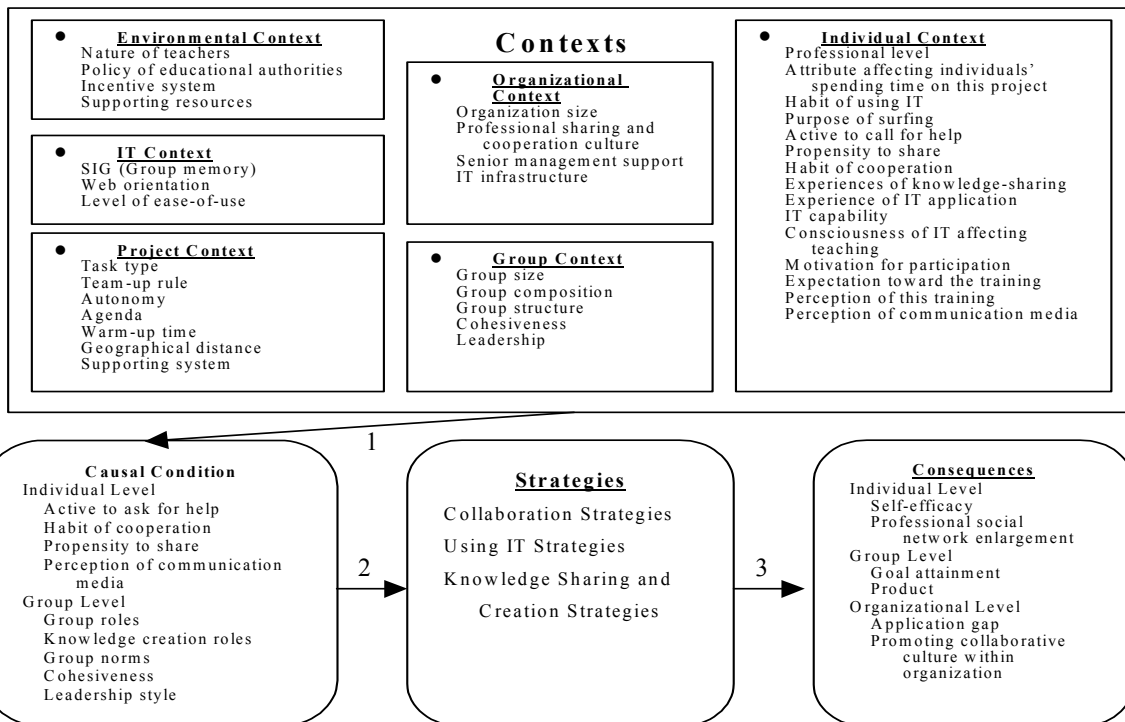


Figure 2. The model of team-based knowledge sharing and creation in professional cyber-communities

Table 1. Collaboration strategies

Strategies	Concepts	Description
Task performing	Initiating	Stimulate the group, and provide new ideas or thought
	Information/Opinion seeking	Seek information or opinion from the group for individuals to make judgments
	Information/Opinion providing	Provide information or opinion
	Coordination	Integrate ideal and practicality, and avoid meandering
	Orienting	Instruct the group correct goals and direction
	Evaluation	Describe the task accomplished, and evaluate the outcomes
	Recording	Recording resolutions and plans
Team maintenance	Encouraging	Accept members' options by praising, agreeing, or stimulating
	Gate-keeping	Oversee and establish the group norm, usually demonstrate themselves
	Following	Follow instructions to perform tasks when the group needs
	Clowning	Promote free and easy atmosphere by some funny

Table 2. Using IT strategies

Strategies	Definition
Emotional expression	Interflows of emotional expressions between members.
House keeping	Inform messages needed for better coordination and enable team going on.
Acknowledgement	Transfer confirmation or answer message.
Information exchange	Share information, resources or experiences with members.
Idea release	Propose ideas or suggestions toward some topics.
Creative revision	Integrating knowledge, documents or experiences into new knowledge objects.

Table 3. Knowledge sharing and creation strategies

Strategies	Description
Knowledge contributing	Contribute domain knowledge
Catalyst providing	Provide ideas or information to stimulate new knowledge flows
Knowledge/catalyst integrating	Combine knowledge/catalyst to generate new knowledge flows
Task performing	Perform task to trigger new knowledge flows
Listening	Ask or wait for knowledge flows from others

Table 4. Six types of team-based knowledge sharing and creation in professional cyber-communities

Action/interaction strategies	Type I	Type II	Type III	Type IV	Type V	Type VI
Collaboration strategies	<ul style="list-style-type: none"> ● Initiating ● Information/ opinion seeking or providing ● Evaluating ● Recording ● Orienting ● Encouraging ● Gate-keeping ● Coordinating ● Clowning 	<ul style="list-style-type: none"> ● Initiating ● Information/ opinion seeking or providing ● Evaluating ● Recording ● Orienting ● Encouraging ● Coordinating ● Gate-keeping 	<ul style="list-style-type: none"> ● Initiating ● Information/ opinion seeking or providing ● Evaluating ● Recording ● Coordinating 	<ul style="list-style-type: none"> ● Work isolatedly ● Monopolizing ● Evaluating ● Coordinating 	<ul style="list-style-type: none"> ● Work isolatedly ● Many free riders ● Coordinating 	<ul style="list-style-type: none"> ● Many free riders ● Monopolizing
Using IT strategies	<ul style="list-style-type: none"> ● House keeping ● Acknowledgement ● Information exchange ● Emotional expression ● Idea release 	<ul style="list-style-type: none"> ● House keeping ● Acknowledgement ● Information exchange ● Idea release 	<ul style="list-style-type: none"> ● House keeping ● Acknowledgement ● Information exchange ● Idea release 	<ul style="list-style-type: none"> ● Housekeeping ● Acknowledgement ● Idea release 	<ul style="list-style-type: none"> ● Housekeeping ● Acknowledgement ● Idea release (few) 	<ul style="list-style-type: none"> ● Less on-line interaction ● Idea release (few)
Knowledge sharing and creation strategies	<ul style="list-style-type: none"> ● Knowledge Contributing ● Catalyst Providing ● Knowledge/ Catalyst Integrating ● Task Performing ● Listening 			<ul style="list-style-type: none"> ● Knowledge Contributing (unidirectional) ● Catalyst Providing (unidirectional) ● Task Performing ● Listening 	<ul style="list-style-type: none"> ● Knowledge Contributing ● Catalyst Providing ● Knowledge/ Catalyst Integrating ● Listening 	<ul style="list-style-type: none"> ● Knowledge Contributing ● Listening
Examples	B ₃ , C ₁	A ₂ , B ₂ , B ₆ , C ₂ , C ₁₀	A ₃ , A ₄ , A ₆ , B ₄ , B ₅ , C ₅ , C ₇ , C ₈	C ₃	A ₅ , B ₁ , C ₄ , C ₆	A ₁ , C ₉

and IV strategies, and inferior teams adopt Type V and VI strategies.

The additional collaboration strategies of Type I teams are the coordinating and clowning strategies, and additional using IT strategies are emotional expression. The percentage of Type I's strategies for team maintenance is higher than other types. Moreover, Type II's additional collaboration strategies comparing with other types are orienting, encouraging, and gate-keeping strategies, and additional knowledge sharing and creation strategy of Type IV are unidirectional sharing and isolated task performing. Type V's collaboration strategies are isolated works, and have many free riders. Type VI has many free riders and less frequent on-line interaction, and it has a monopolist who spread rumors unfavorable to the on-job training.

5. Discussions

In summary, we elaborate findings from analyzing data obtained from three phases of studies as follows.

(1) Groupware is used as a coordination medium, but may not be an ideal knowledge-sharing vehicle in task-oriented teams.

The location of on-job training institute in distance was far away from those schools where participants worked; however, it provided participants with high autonomy to apply various means of communicating with each other. Although they perceived SIG functions to be ease of use and useful in

questionnaires and interviews, and their suggestions for synchronous communication and aware of activity status of other members, which they consider to be of help to knowledge sharing, has also been fulfilled. However, most teams chose face-to-face meeting and were willing to spend at least one hour driving to meet face-to-face to generate, combine, and revise ideas rather than through these SIG functions. They preferred face-to-face meetings to other communication media. For instance, leader of Team A₆ said,

“Perhaps members’ habit of using IT is still insufficient to communicate only by IT, and using e-mail to contact is uneasy. So that we still met face-to-face to discuss, and used e-mail to exchange the information.”

We further analyzed IT using strategies among teams in Phase II & III study, and found that on-line interaction of teams were mainly for housekeeping and information exchange. It is different from IT using strategies of Phase I study. The major IT using strategies in Phase I study are housekeeping and acknowledgement. This could be one of the reasons that the team performance of Phase II & III study is superior to that of Phase I study. However, deep interactions are very few in on-line interaction of these three phases. We attribute this phenomenon to the constraints of technology-mediated vehicles. A member of Team A₂ mentioned that *“It’s difficult to exactly convey my thoughts through IT-mediated communication.”*

Daft and Lengel [7] proposed the information richness theory (IRT) and argued that face-to-face is the richest medium based on four criteria: feedback,

multiple cues, language variety, and personal focus. IS research taking an interpretive perspective conceptualizes communication richness as a function of mutual understanding; that is, one person's reaching an understanding of what another person means [16]. IRT, amended by a critical social theory (CST) perspective, is not gauged by channel capacity or by how well a receiver recreates a meaning that a sender intends, but instead by how well a receiver succeeds in emancipating him/herself from distorted communications [23]. To express explicitly their thoughts and emancipate themselves from distorted communications, online interaction, facilitated by such group support functions as SIGs of SCTNet takes much greater efforts due to information richness limitation.

(2) Failing to sharing knowledge in physical communities may also contribute to the failure in virtual communities.

Findings from the focus group session show that knowledge sharing within primary school teachers was promoted by educational administration with great exertion. Under the small-school-small-class policy, only a small number of teachers teach the same course within a school. Therefore, teachers are encouraged to form "teaching groups" to cooperate for course preparation at their schools. However, the cooperative culture is actually unpopular among the schools to which the members belong, and their experiences in sharing and collaborating with other colleagues were rare, except for some teams categorized as Type I and II in Table 4. We suspect that the phenomenon may attribute to professionalism. According to Quinn, et al. [25], professionals should have codified body of knowledge, problem-solving capabilities, critical reflection, highly commitment to their work, and high level of professional autonomy. Teachers are trained to solve problem on their own, and thus professional autonomy may hinder the frequency of interaction with others unless they feel necessary. Teams in Type I and II felt free to abstain from the professional autonomy, and learned to proactively share or interact with teammates in the physical world, where they might also collaborate smoothly in the virtual world, and then reaped more benefit from the on-job training. As a member of Team B₃ pointed out that they usually cooperated with colleagues at school, so they were used to the collaborative mode in the on-job training. We thus argue that failing to sharing knowledge in physical communities may also contribute to the failure in virtual communities.

(3) Appropriate guidance is important to promote team-based knowledge sharing and creation in professional cyber-communities.

As Leidner and Jarvenpaa [17] predicted, most teachers are accustomed to thinking in terms of what they get out of the training rather than what they contribute to the knowledge created in the training. Some teachers even expressed that they have no idea about how to collaborate with others. To react to this mismatching, we assigned experienced instructors to each SIGs to facilitate the sharing of information and thus enable knowledge to be constructed. The improvement seems to be limited, so we changed to adopt storytelling and mentoring approach [30] in Phase III. The former seems to be effective to eliminate the mismatching. As a member of Team C₁₀ mentioned, "*This on-job training is just what I need. I'm longing to be one of team in the story.*"

Unlike instructors in Phase II only provide guidance on line, mentors in Phase III instruct SIG members both on line and physically. With the experience of contacting face to face, these teachers seem easier to open minds to accept mentors' guidance and suggestions. In general, mentors' contributions seem significantly. Specifically, we have observed that when most SIG members are inexperienced, proactive participation of mentors may stimulate professional dialogue, although sharing knowledge unilaterally by mentors in most times, and finally contribute to superior products.

(4) Team-based knowledge sharing and creation in professional cyber-communities needs heterogeneous composition, but not applicable in organizational level.

The concept of "creative chaos" had elaborated by Nonaka and Takeuchi [24], and seems to be of help to knowledge creation and applicable anywhere. In our opinions, heterogeneity comes from three levels: individual, team, and organization. In the individual level, many studies have shown that the overlapping of skills, traits, and abilities have different effects on non-technology supported group works [5, 13, 27], and heterogeneous specialty has the positive effect on knowledge flowing. Our observations confirm this argument. For example, a member of Team B₂ said,

"This on-job training gives me a chance to experience the collaboration with members of high heterogeneity, which helps us to generate more innovative products."

In the team level, as shown in Table 4, many collaboration strategies were excised in Types I and II teams, and the variety of strategies decreases as moving to Type VI. It reveals the positive proportion between collaboration strategies employed

and collaborative outcomes. In other words, more heterogeneous roles acted in a team exhibit more positive effects on knowledge sharing and creation.

Interestingly, heterogeneity seems to have positive effects on both individual and team levels, but not on the organizational level in our settings. Most people expect to collaborate with members from different schools would have more chances to “light up the spark of intelligence.” For instance, a member of Team B_5 ever mentioned, “*Although we are convenient to communicate with colleagues in the same school, it is still a pity that we don't have the chance to exchange different ideas from different schools.*”

From the process of knowledge sharing and creation, we found that the consequences of teams whose members came from different schools (e.g., Team B_1 and B_4) were not certainly superior to the teams whose members came from the same schools (e.g., Team B_5 , B_6 , C_1 , C_5 , C_7 , C_8 and C_{10}). We may also attribute this phenomenon to the concept of professionalism. Since these primary and junior high schools teachers are trained in the similar teachers training institutes, and then teach in schools with similar cultures, the organizational settings are homogeneous as a whole. In other words, there are no obvious differences between teachers whether coming from the same schools or not. For them, the major identifiable advantage for heterogeneous composition is social network enlargement.

(5) Active reflection is critical to team-based knowledge sharing and creation in professional cyber-communities.

Argyris and Schön [1], Levinson and Asahi [18], and Quinn, et al. [25] emphasized active reflection or dialogue is critical to professional learning. Argyris and Schön [1] argued effective double-loop learning is a reflection of how people think; that is, the cognitive rules or reasoning they use to design and implement their actions. Most people define learning as narrow as mere “problem solving”, and highly-skilled professionals are often good at single-loop learning.

We added the reflection phase, including practicing teaching, review seminar and suggestions from an expert in the agenda of Phase II and III studies. The effect was significant and positive, since participants had opportunities to reflect on their practicing and receiving valuable knowledge from others, and thus contribute to better products. We found that teams in Phase II and III successfully completing the reflection phase had higher self-efficacy of applying IT to teaching than those of Phase I.

(6) Team-based knowledge sharing and creation in professional cyber-communities needs not only idea providers but also task performers.

We analyzed the knowledge sharing and creation strategies among teams in Table 4, and found that teams of inferior performance lacked task performers, although it had idea providers. For example, the major knowledge sharing and creation role of Team A_1 was idea provider, but no one was willing to execute the proposed idea. Similar situation existed in Phase III, where Team C_4 encountered the problem of having creative plan originally, but unfulfilled progresses ceased the further contribution of knowledge later.

Some studies have identified several roles regarding knowledge activities [e.g. 9, 20, 31], but they discussed them from the functional viewpoint, and emphasized the importance of the idea or catalyst provider among these roles. They viewed a catalyst provider as the origin of the knowledge flow emerged. In our observation, a catalyst provider played the role as a knowledge creator, but most of the knowledge flows were triggered when task performers acknowledged the proposed ideas, and put them into schedule to realize them. For example, a member of Team A_2 mentioned that he was released to see his team still moving on, which encouraged him to consider what he could contribute to the team. We can hypothesize that team-based knowledge sharing and creation are triggered by the fulfillment of scheduled tasks. To activate the knowledge flows, a task performer seems to do a more competent job than an idea provider.

6. Conclusions

This study is an explorative research that investigates the process of team-based knowledge sharing and creation in professional cyber-communities. We have adopted the grounded action research and discovered its process defined by the sequence of causal conditions, action/interaction strategies, and consequences. Finally, we discuss some phenomena that are fewer addressed in other experimental studies. The findings can be a basis for further studies of team-based knowledge sharing and creation in professional cyber-communities.

There are some research limitations in the study. Since teachers may communicate via various media, we tried to trace as much piece of knowledge interflowed between them as possible. It was a difficult task and may render distorted or incomplete data collection. Furthermore, the task performed in our settings is a type of generation according to McGrath's classification [21]. Other types of tasks

may reveal different results.

We proposed several suggestions for future research. First, more phases of theoretical sampling to validate our findings are expected. Second, more SIGs established naturally are worthy of further investigating and comparing with those in our settings. Finally, we suggest that future research can empirically test the theoretical model in other professional cyber-communities.

7. References

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