

A Web-Based Asynchronous Distributed Knowledge Creating System for Bridge Design Education

Shao Bing¹, Kobayashi Ichiro¹, Hoshino Yuji¹, Nishimoto Itsuro²

Department of Civil Engineering, Kumamoto University, Kumamoto, 860-8555, Japan¹

LAC Co., Ltd. Tokyo, Japan²

shao_bing@hotmail.com, ponts@gpo.kumamoto-u.ac.jp, hoshino@gpo.kumamoto-u.ac.jp,
itsuro@lac.co.jp²

Abstract

With the development of new technology, traditional education method used in civil engineering has faced challenge. It should pay more attention to how to train students' creating ability.

Based on knowledge-creating theory that is raised by Nonaka and Takeuchi in their book: The Knowledge Creating Company, we propose a systematical method of education in this paper. The main principle is to utilize Web-based BBS technology, enhance the communication among teacher, students. In this way, some problems of traditional education activities can be solved. The process of knowledge creating in university can be perfected through smoothing the four stages: Externalization, Combination, Internalization and Socialization, which are corresponding to Lecture, Study after class, Comprehension and Expression.

As a concrete part of whole system, we have developed a BBS (Bulletin Board System) used in our course "History of Bridge Design". This system has been integrated in our homepage. Details of this system are described. After using over three years, this system is found to be successful.

1. Introduction

With the development of computer and network technology, the styles of human being to live, work and study has been undertaking great revolution. At present, every trade benefits from IT technology. On the other hand, they also face challenge from it. In the same way, education has been standing same impact. New technology supplies us different way to realize one task in order to get the best effect. Traditional teaching and studying methods must be improved greatly to make full use of these modern technologies. Being educationists, we should consider how to utilize IT technologies to

service our work [1].

In the past, the teaching and studying activity were on mono-channel. That is to say, teachers give students lectures in classroom. As feedback, students hand their homework up back. Teachers investigate their teaching effort only by quiz, examination. There are few chances for instructors and students to discuss questions that puzzle latter. Students receive knowledge passively. Even if they arrange time to communicate, the solving of problem is limited to that individual student. It is difficult to let all students to understand and avoid the same question. Lack of interaction was main problem in the past.

Moreover, It is thought that the knowledge conducted in classroom is mainly explicit knowledge. That is to say, this kind of knowledge can be written down in paper, spoken in word tangibly. It can be expressed clearly without ambiguity. But nowadays, a lot of knowledge is difficult to express in language, such as some skills, training of aesthetics. These kinds of knowledge belong to tacit knowledge. There is no sole answer for these kinds of question, such as yes or no, right or wrong etc.

In our department, there are several lessons that are full of this tacit knowledge, typically, History of Bridge Design. This lesson focuses on the classification, characteristics as well as the history of different bridges. The study of this lesson gives students an introduction of different designers and their works. More importantly, it cultivates students' aesthetical capability, which is very useful for students to design or evaluate bridges later. Many questions in this lesson have no specific answer, depending on individual viewpoint. But, we hope to make students understand which is the best solution in all possible answers. In the past, after every lesson, instructors give a topic and let students to discuss in report form. And in next lesson, students' reports were collected and analyzed. Then combined with instructor's opinion, one BEST answer was presented to all students. In this way, it was very difficult for the instructor to

discuss with every student and make clear his or her own opinion.

Such process is actually a knowledge-creating activity in organization: students receive and understand knowledge at hand, then according to personal opinion, form new knowledge (no matter this knowledge is good, bad or even incorrect). Instructor leads students to modify their results to right by his experience, which is accumulated over many years.

In recent years, computer technology, especially network technology, has been developed greatly. This development supplies us more effective tools to realize our educational goal. At present, Web-based technology is very mature and popular. With its powerful function, distributed people can communicate with each other on Internet. It can overcome the shortages existing in past and is very appropriate complement to classroom as a virtual one.

2. Theory of knowledge creating

After investigating several Japanese successful companies in detail, Nonaka and Takeuchi, very famous researchers in enterprise management, propose a dynamic set of organizational management theories in their book *The Knowledge-Creating Company* [2].

The book contends that Japanese firms are successful because they are continuously innovative – not merely imitating as some thoughts – and because they create new knowledge, disseminate it across the organization and embody it into its products and technologies. They argue that human knowledge can be divided into two kinds. One kind is "explicit knowledge", which can be articulated in formal language including mathematical expressions, manuals and so on. This kind of knowledge can be transmitted across individuals formally and easily. It has been the dominant mode of knowledge management in the Western philosophical tradition. The key of Japanese company's success is because of a second kind of knowledge "tacit knowledge", which is hard to articulate with formal language and to share among individuals [3]. This more personal form of knowledge is embedded in individual experience and involves intangible factors such as personal belief, perspective and the mental model. In the West, tacit knowledge has been overlooked as a crucial component of collective human behavior. In contrast, tacit knowledge - and diffusion of learning from individual to team or organization is a crucial source of Japanese companies' competitiveness.

It is the movements between these two kinds of knowledge that form the process of creating new knowledge among individual, team and organization through a spiral process that contains four stages:

Externalization, Combination, Internalization and Socialization, as shown in figure 1.

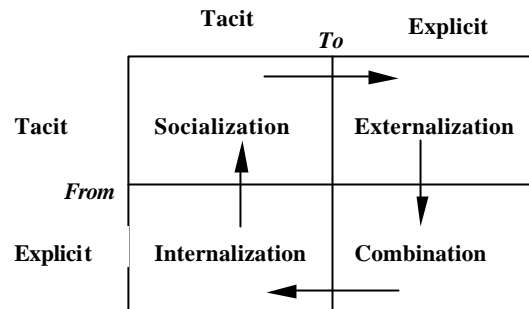


Figure 1 The four models of knowledge

Socialization: This is a process from tacit knowledge to tacit knowledge by sharing experiences. It occurs in groups. Through sharing experiences that someone accumulates for a long time, others observe, imitate him to know which is better and which is worse in different answers or how to do in order to get the best result for one question. Only dissemination of information as in traditional classroom is not enough.

Externalization: This is a process of articulating tacit knowledge that we have mastered into explicit concepts, by using of metaphor, analogy and model. This process is crucial for knowledge creation because new and explicit concepts can be derived from tacit knowledge. Metaphors link contradictory things or ideas; analogies resolve these contradictions and show similarities; models describe new idea graphically, making the knowledge available to the rest of the class.

Combination: This is a process for students to combine explicit knowledge received in classroom with that from other sources such as reference book etc. in order to get his or her new explicit knowledge. In this process, different knowledge is combined, transformed through self-study or discussing with other students. So it is needed for every student to go through a lot of reference books. After that, discussion among them should be held in order to combine all the new knowledge they acquired. In this way, organizational new knowledge is created.

Internalization: This is a process reversing explicit knowledge to tacit knowledge. Individuals extract knowledge from newly-created organizational tacit and explicit knowledge through "learning by doing". By learning from others, every student can understand the problem clearly. In traditional classroom, this is difficult because one student couldn't understand what the others are thinking.

Accordingly, each knowledge transformation type cannot be taken into account alone or disconnected from

the others: successful socialization may require that externalization, combination and internalization are performed effectively. This fact offers a new argument to request organization to be effective in all four knowledge transformation types, which has been already underlined by Nonaka and Takeuchi. Moreover it indicates that supporting any knowledge transformation type requires supporting the other ones too, namely, supporting a smooth switching between them.

If the organization is a physical group, the progress of the above perhaps is not difficult. On the contrary, if the member of the group is distributed, such as our situation after class, it will be not easy to realize smoothly. However, the IT technology supply us the way to accomplish it. One of pilot project in our laboratory has been done as a course material: "History of Bridge Design", which has been integrated in our homepage [4]. Details can be found at the following URL:

gdp1.erec.kumamoto-u.ac.jp/life/kobayashiwork/dobokusi/5.

3. Analysis of traditional method

Although the conclusion of Nonaka and Takeuchi is focused on the knowledge creating in companies, it has same effect on the educational activities. The progress of teaching and studying in classroom of university is similar to the knowledge creating in enterprise. Being organization, they have the same characters.

In the traditional classroom, teacher is the commander of the learning and studying activities. He gives lecture to students, answers their question, correct students' wrong thought and so on. So the teacher is in higher level than students. The communication among students is finished through the teacher (See Figure 2).

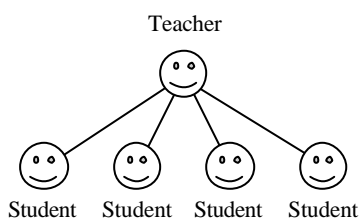


Figure 2 Traditional education structure

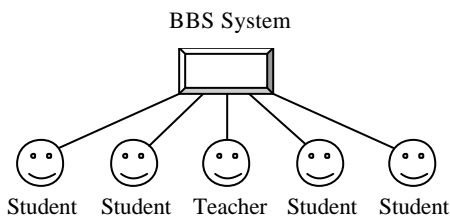


Figure 3 Knowledge creating structure

With the development of technology, we hope introduce the computer and network to substitute some functions that are been in charged by teachers. So, in this situation, the BBS system is located at the top of all the activities. Teacher is in the same position as students or slightly more influential than students (Refer to Figure 3).

In addition, the teaching and studying activities in university correspond to the above four stages (Figure 4).

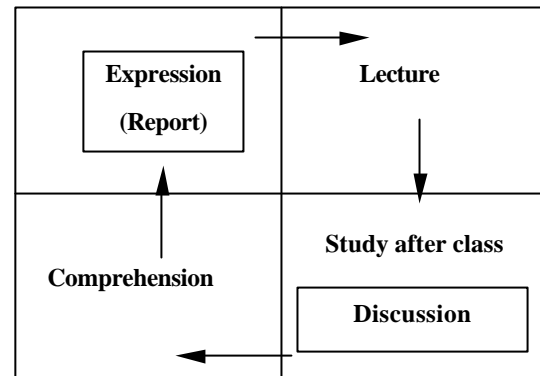


Figure 4 Equivalents in education activities

Lecture: Giving lecture is actually the progress of externalizing the knowledge and experience owned by the instructor. In the classroom, teacher plays leader role. Students receive and understand the knowledge from teacher. So this is externalization according Nonaka and Takeuchi. Ideal externalization should be realized by letting all students express their opinions clearly. But because of the limitation of time and their knowledge, it is impossible to discuss completely freely. However, this gives hint that we should give students more chances to declare their views.

Study after class: Studying by students themselves is the progress in which students absorb the knowledge (including not only explicit knowledge but also tacit knowledge). Through investigating of different sources of knowledge, such as reference book, relevant information and so on, they can understand why instructor did so, why instructor didn't do in other ways. They can analyze and compare different answers and get the conclusion of themselves. The conclusion gained by them can be correct or wrong. This is actually combination of different knowledge. And this is also the knowledge creation because things they didn't know/understand are new knowledge for individuals themselves even if this knowledge has already been existing.

Comprehension: Getting conclusion is actually comprehension. Comprehending needs students study by heart, not just receive materials simply. The traditional method focuses on the transform of information. Students perhaps know WHAT well but don't know WHY. In this

way, the materials are only information. Only combined with practical examples it can be translated into knowledge. Namely, the knowledge is capability. Students should be able to do something with the knowledge, not only knowing it. After information has been transferred to knowledge, the internalization process is over.

Expression: In traditional teaching and studying activities, student and teacher communicate on some topics with each other only in homework and report form. Moreover, This is happened between teacher and individual student in peer-to-peer interaction and communication form. Exchange between or among students is lacking. As a group, the chance of communication among them is too deficient. The main reason of this is that there is no suitable place for them.

4. Reformation of traditional method

In pedagogics, we think the perfect educational system should include not only the traditional classroom, but also the DISCUSSION and EXPRESSION section (Refer to figure 4). That is to say, besides the teaching and studying activities in classroom, we need other ways to make our education system more efficient.

According to this thought, we develop a computer aided study system for the course: History of Bridge Design. This system mainly uses BBS (Bulletin Board Systems) technology. There are several sections in it, such as Schedule, Discussion, Report, Relevant People, Reference, and so on.

4.1. Schedule section

In the section of Schedule, the information about the course is introduced, such as the sketches of some certain bridges, their detail information, history and so on. Figure 5 illustrates an example that was given in version 2000. In this schedule, ten topics would be discussed during the course.

Pictures as figure 6 and figure 7 are given in web pages to explain the details. Figure 6 shows Ganter Bridge in Switzerland designed by Cristian Menn. Firstly, in a classroom, teacher shows pictures of Menn's works and comments on the main point. Then he explains Menn's characteristics from the viewpoint of design concept such as strength of materials, structural analysis, economics, aesthetics and so on. Finally he demands students to analyze the architecture of Ganter Bridge. Figure 7 is Kelheim Foot Bridge designed by Jorg Schiaich, which is one of the most outstanding cable supported bridges in the world. In this case, teacher asks students report about the harmony of bridge and cityscape after they investigate same type bridges.

1	Short History of European Bridge Design
2	R. Perront and European stone Bridges
3	M. Seguin and Tournon Suspension Bridge
4	G. Eiffel and Garabit Viaduct
5	R. Mallart and Salginatobel Bridge
6	C. Menn and Ganter Bridge
7	E. Fressinet and St-Michel Bridge
8	J. Schlaich and Kelheim Foot Bridge
9	J. Muller and Isel River Bridge
10	S. Calatrava and Bilbao Bridge

Figure 5 List of engineers and bridges refer to topics



Figure 6 Ganter Bridge



Figure 7 Kelheim Foot Bridge

4.2. Discussion section

In the Discussion section, every student can present his or her question to teacher or other classmates in order to discuss with them (see figure 8). In this way, students are forced to use Internet to deal with their study from their university time. This is very important and useful for their future work in society. More importantly, one student's question and its solution can be shared by all



Figure 8 Discussion

the others. So this will help to solve efficiently the problems which most of students face. And this also supplies a place for students to combine their explicit knowledge with others to form their own new knowledge. Additionally, this BBS gives chances for those who couldn't enter classroom because of the limitation of space or time. Here is a place for instructor and students to communicate about the course beyond the classroom.

4.3. Report section (See figure 9)

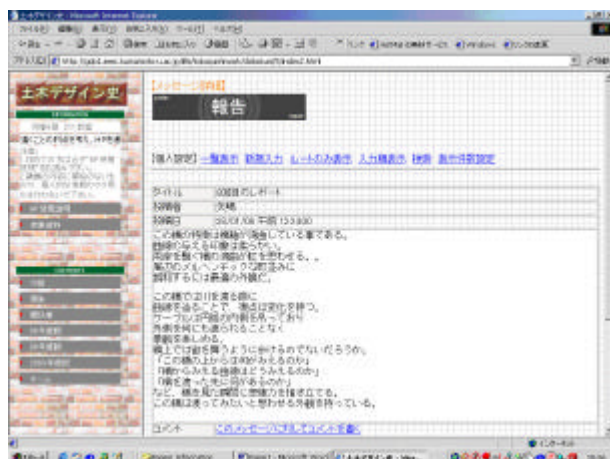


Figure 9 Report

The section of Report is only used for students to submit their report to teacher formally. Students are asked to give their opinion about some topics those are assigned by teacher. Because of the openness of this system, students are forced to discuss questions sincerely. Their opinions will be presented not only to teacher but also to the others. On the other hand, every student can learn and absorb useful opinion from others to expand their knowledge. So here is a good place for whole class to share their explicit knowledge.

4.4. Relevant people section (See figure 10)

In the section of Relevant People, the information of all the people related to this class, teacher and students, is published. Names, affiliation, address of email box of them are all included with their portraits here. This supplies not only convenience for them to contact with each other, but more importantly atmosphere as a visual classroom.



Figure 10 Relevant people

The information in BBS is updated regularly and the history is stored in archive form for review as version 1998, version 1999 and version 2000 etc. Every one can investigate them as he likes. This is very useful for student to benefit from all of the previous information and use as reference. Repetitive work can be avoided and the efficiency can be enhanced greatly.

4.5. Reference section

In this section, there are briefly three kinds of reference: Reference books, Additional pictures and Links. Teacher recommends a list of books for students. Students can find these books to help themselves. Additional pictures are representative, such as figure 6

and figure 7. Links are some websites that are helpful for students. From Internet, students can hunt information for their study.

Most information here is not published or difficult to find out (such as Figure 11). So it is very useful to students. Some typical reports from students and those comments from teacher are also presented in web page. All the information should be chosen carefully in order to be representative.

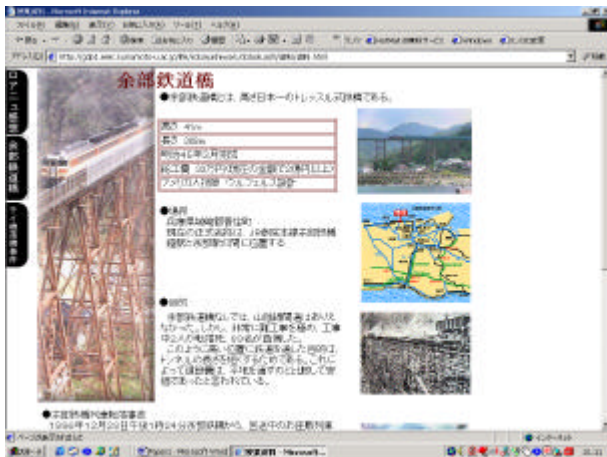


Figure 11 Reference

5. Evaluation

After using over three years, this system is proved to be successful because it can also overcome the defect existing in past and make the knowledge creating process smooth. Traditional method of teaching and studying focuses on proscenium classroom and couldn't give students chances to communicate with each other to make their knowledge socialized. By using BBS technology, our system supply them such a place to satisfy their need. Moreover, the system meets the needs of distributed students. So in point of pedagogy, this is ideal for smoothing the process of knowledge creating in class. But some flaws still exist in the system such as multimedia information cannot be utilized effectively. At present, only text and picture are available for discussing. Video and animation information are unavailable. So briefly, our BBS system is only used as complement and extension of classroom. They consist of the whole education system jointly and complement each other.

In the mean time, by using this system, students' ability to use computer and access Internet has improved greatly. Forced to use this system to submit their homework and report, they have to be familiar with it. After the end of this course, every student illustrates his improved ability to use BBS.

6. Conclusion

Although the theory of knowledge creating focuses on companies, its guiding effect is very useful to our educational activities. But because the knowledge levels of the user (teacher and student) are different, it is impossible to perfectly use it as in the companies. Regarding the process of teaching and studying as knowledge creating, we try to discuss the teaching and studying activities in pedagogy. We hope to depend on this theory of knowledge creating to find a good way to improve the ability of our students. After used for over three years, our system is certified to be very effective.

7. References

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- [2] Ikujiro Nonaka and Hirotaka Takeuchi, *The Knowledge-Creating Company*, Oxford University Press, New York, 1995.
- [3] Arthur Andersen, *Leveraging Corporate Competency with Knowledge Management (in Japanese)*, TOYO KEIZAI INC, Tokyo, 1999.
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