Framework Development and Process Analysis of Organizational Knowledge Creation in Academic Research Projects

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ABSTRACT

This paper proposes a work guide for analyzing the process of organizational knowledge creation in an academic research project, integrating basic concepts in several existing knowledge creation theories. This guide has been developed during the evaluation of projects. We present results of the process analysis of projects that finished recently. We certify evidences of the concepts and remark differences among processes of different projects.

Keywords: organizational knowledge creation, workflow for process analyses

1. INTRODUCTION

Many research projects are being carried out in the academia (or universities) where new knowledge is being created with collaboration among researchers (supervisors) and students. These projects are usually not big in scale (several members) and not short in time (several years). O*rganizational knowledge creation* usually indicates big projects in big companies, but it also can be used for researches in the academia. It is important that after the completion of a project, its leader or some member analyzes the process of the project precisely for improvement in future projects and *on-the-job* education; *i.e.* how members shared contexts, cooperated, obtained, exchanged, and created knowledge. It is also important to compare processes of different projects for recognizing essential factors. However, a good *work guide* or *framework* for such analyses is not enough prepared since research processes usually are progressing unconsciously.

There have been proposed so far many Knowledge Creation (KC) theories such as Equivalent Transformation Theory by Ichikawa [1], Tacit Dimension by Polanyi [2], Knowledge Management Theory by Nonaka et al. [3] and Non-explicit Knowledge Process Support by Meyer et al. [4]. They are useful in concepts but are too abstract in general.

Recently, we successfully finished two projects of which subjects are *Creating New Puzzles* and *Developing Cyber-IRORI* ('Irori' is a Japanese traditional fireplace.). In this paper, we analyze KC processes of these projects integrating basic concepts of existing KC theories and own experience. Through the analyses, we provide a concrete and practical *work guide* (or *framework*) for process analysis of small research projects in the academia. We intend to provide tools for the precise analysis of projects. The use of this framework will enable the identification of factors that were essential to a project's outcome.

Our approach is characterized as an *internal, post, knowledge-oriented* analysis. Here *internal* means analysis by insiders, and *post* means analysis after projects. An internal analysis is sometimes subjective but can be more precise and evident than an *external* analysis because it is based on own experience.

2. RESEARCH PROJECTS

In this paper, we analyze the following two projects that recently finished successfully in the author's laboratory:

Creating New Puzzles [5,6,7,8]: To create new puzzles, we took a systematic approach called *Abstraction and Conversion*. We abstracted permutation puzzles and cyclic puzzles as mathematical models and converted them into other media: graphs, blocks, sounds, robots etc. We implemented puzzle generators and practiced to create new puzzles. (See Figure 1.)

Developing Cyber-IRORI [9,10]: Based on *irori* metaphor, we developed a cyber-IRORI to afford comfortableness in face-to-face communication in a shared informal place such as a refreshing room or lounge. We observed individuals behavior, and evaluated the developed IRORI in the real environment and confirmed that IRORI was effective to catalyze face-to-face informal communication. (See Figure 2.)

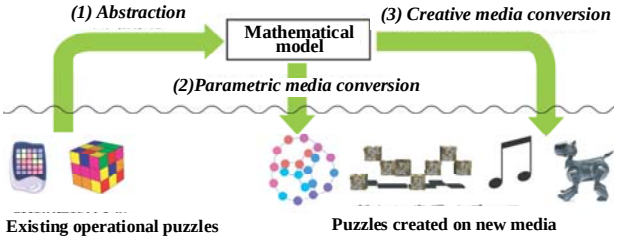

Figure 1: Creating new puzzles

Figure 2: Cyber-IRORI

3. WORK GUIDE AND ANALYSIS

Based on basic concepts presented in the existing knowledge creation theories, we propose a work guide to analyze organizational knowledge creation processes. The following concepts are useful:

(1) Equivalent Transformation Theory [1]:
Equivalent transformation (ET), ET equation, ET thinking flow, and analog and digital routes

(2) Tacit Dimension [2]:
Tacit foreknowledge (or foreknowing)

(3) Knowledge Management Theory [3]:
SECI modes, Ba, knowledge leadership, knowledge assets

(4) Non-explicit Knowledge Process Support [4]:
Social network, knowledge exchange, knowledge categorization, knowledge inventory

Our design of a framework (or workflow) is illustrated in Figure 3 where relationships between basic concepts and steps of the framework are shown. According to the steps, we illustrate schematically results of the analysis of project *Creating new puzzles* as a set of diagrams and tables.

After the completion of the project, the supervisor, based on his knowledge of the course of the project (see Figure 4), intuitively identified an organizational and knowledge network among related persons (see Figures 5 and 6, and Table 1) and assembled a list of critical individual knowledge (see Table 2) for each member of the research team based on a knowledge classification model [4]. It is possible to state what kind of specific declarative knowledge and skills an individual contributed to a project and what kind of weak declarative knowledge manifested itself during the course of a project. Clarifying time sequence and organizational network is most important as the first step of the analysis. In Figure 4, phases and SECI modes are identified. In Figure 5, we can recognize the importance of knowledge flow from professionals in the outside.

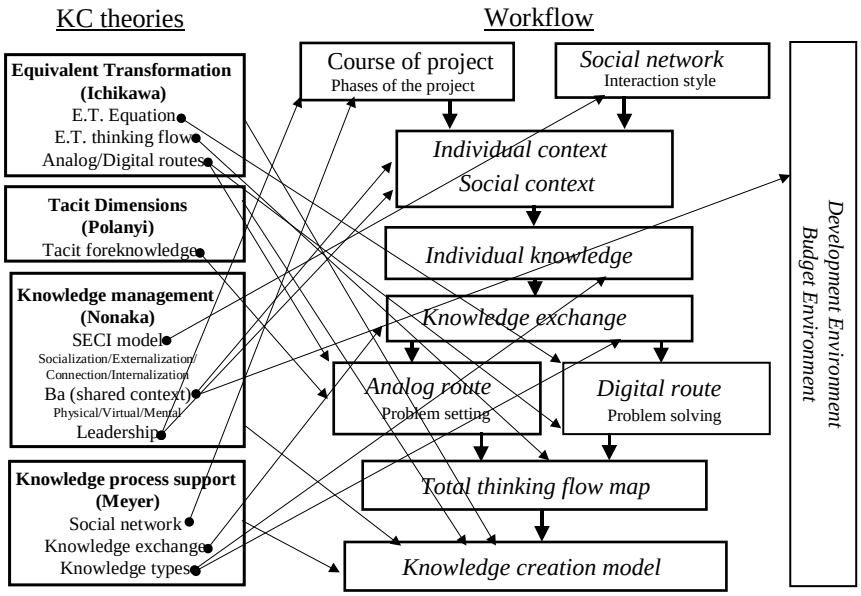

Figure 3: KC theories and proposed workflow

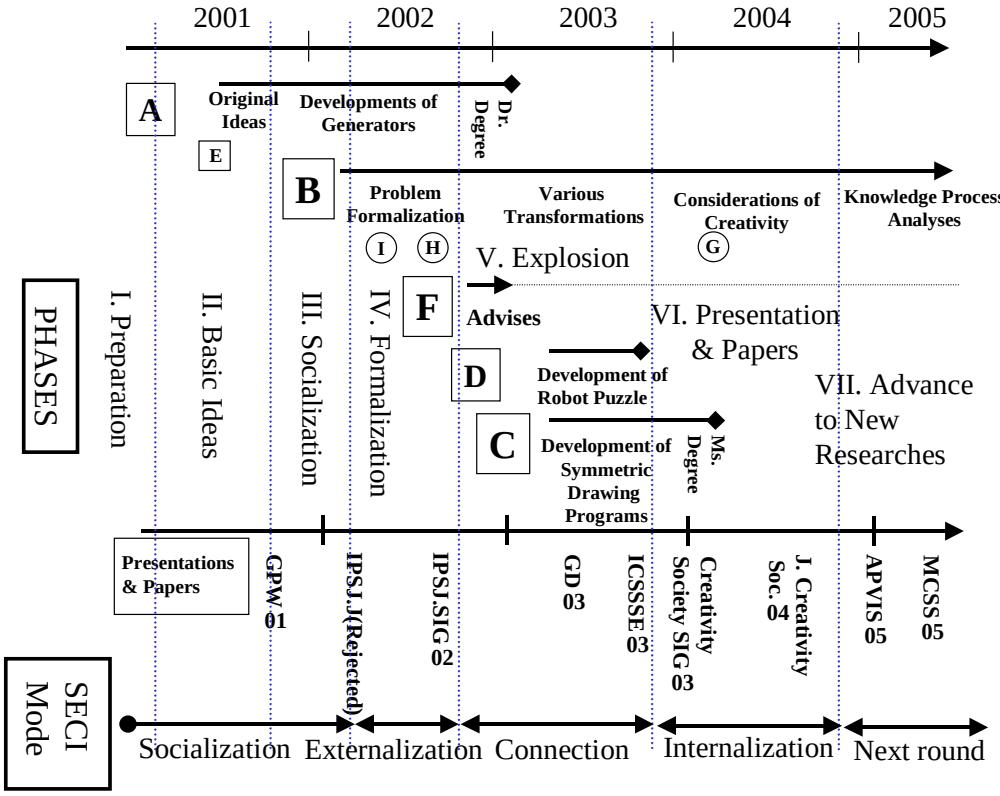

Figure 4: Course of the project

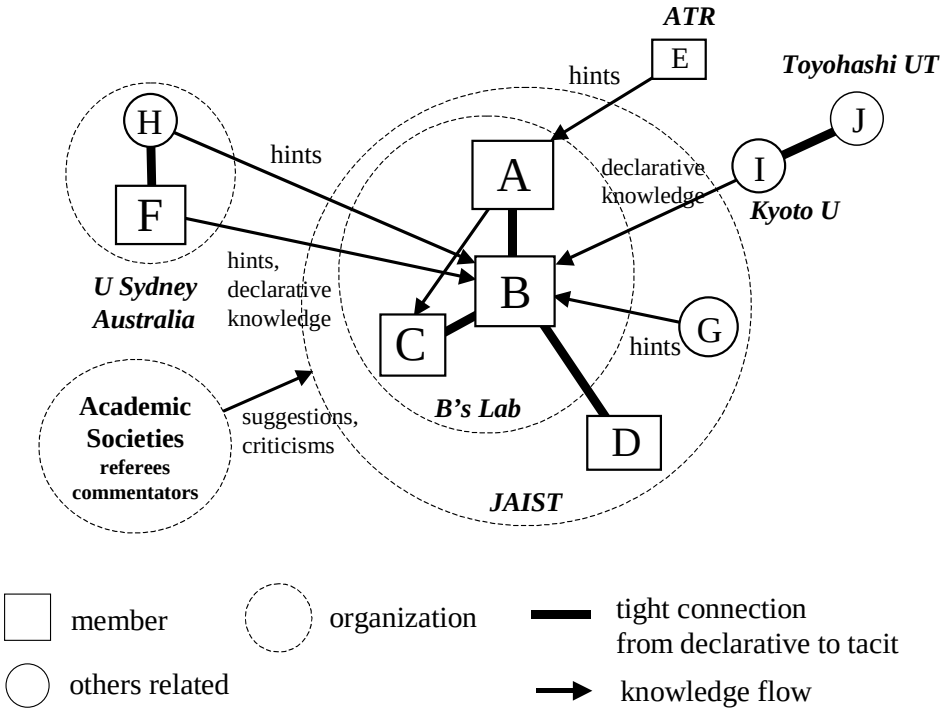

Figure 5: Organizational and knowledge network

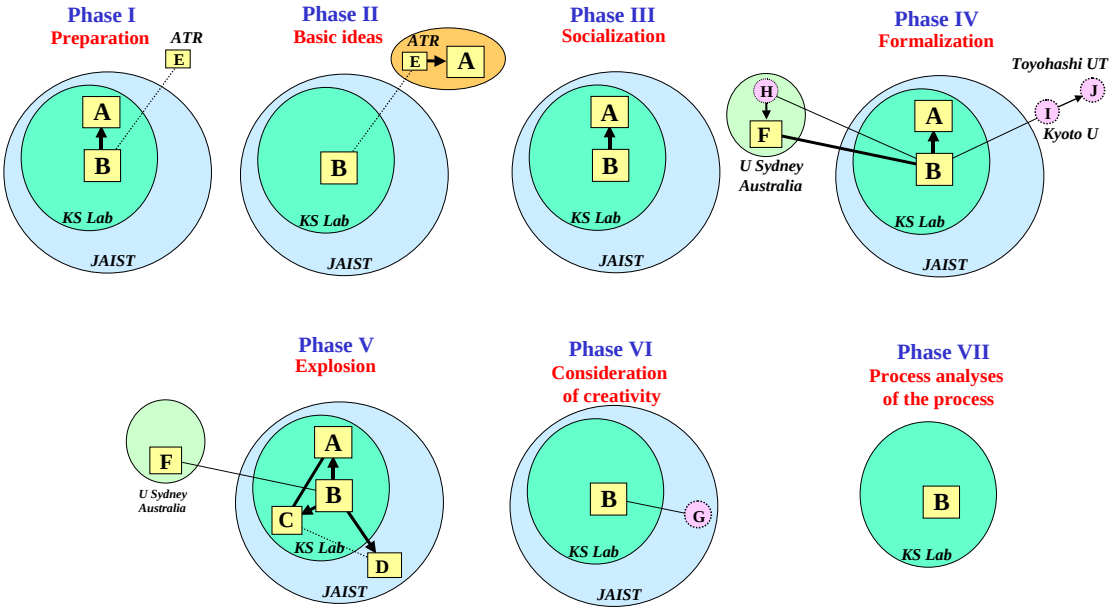

Figure 6: Changes in organizational network

to / from	*A*	*B*	*C*	*D*	*I*	*F*
A	-------	Foreknowledge, Basic ideas	Source code of PP generators	------	-------	-------
B	Mathematical formalization, Theoretical results	--------	How to solve symmetric layout problem	Set of problem solving	Results of analysis	Coauthoring
C	-------	Symmetric layout program, Improvement of generator	-------	------	-------	-------
D	-------	Robot puzzle	-------	-------	-------	-------
I	-------	Let *B* know A's work	-------	-------	-------	-------
F	-------	Hints for heuristic methods, Coauthoring	-------	-------	-------	-------

Table 1: Knowledge exchange

	Explicit Knowledge			*Non-Explicit Knowledge*		
Person	*Declarative Knowledge*	*Conscious access to structural Knowledge*	*Weak declarative knowledge*	*Unconscious access to structural knowledge*	*Acquired skills / procedural knowledge*	*Embodied knowledge*
A	Spring algorithm	How to utilize spring algorithm	Logic of puzzles	Equivalent transformation thinking	Programming skills for developing generators	Artistic senses
B	Graph drawing algorithm, Geometry, Graph theory	Mathematical formalizations	Logic of puzzles	Systems integration and analysis	Mathematical derivations	System thinking
C	Tutte algorithm	-------	-------	-------	Programming skills	-------
D	AIBO control	-------	-------	-------	Integration of IT tools, Programming	-------

Table 2: Individual knowledge

- **Social context**: Revolution is desired in user interface domain.
- **Pressure**: ***A*** have to carry out PhD research
- **Main subject**: "User interfaces with the engagement"
- **Stimulation**: On leaf to ATR for several months
- **Hints**: Toy interfaces (seek certain base than toys)
- **Intuition**: Good artistic sense (graduated Art Univ.)
- **Skills**: Good programming skills
- **Successful experience**: Implementation of spring algorithm (in Lecture by ***B***)

Figure 7: Factors for *A*'s foreknowledge

Once we get the organizational network, remembering contexts and environment becomes easier. Contexts and environment is the most essential factors for research projects. Ichikawa's *analog route* and Polanyi's *tacit foreknowledge* are conceptually almost similar. Foreknowing is most important for the project. Factors for *A*'s foreknowledge is listed in Figure 7. An analog route is intuitively found where fresh feeling is important.

A digital route is logically constructed step by step where coordinating and experienced experts are important. Figure 8 shows the whole process of the project where we can recognize evidences of basic concepts of the existing KC theories in own experience.

In the steps from *Social network* to *Knowledge exchange*, what we have recognized is summarized as follows:

Ten people and six organizations were related. Six persons are collaborators. They did not overlap through the project. Seven phases can be identified and SECI modes also can be identified based on the phases. Knowledge from the outside of KS Lab should be noted. In the Formalization phase, explicit declarative knowledge was supplied from the outside. *A*'s ideas (foreknowledge) are most important for the project. *A* was stimulated on leaf to another organization. The coordination role of *B* and his explicit knowledge and experience, and social network are important for coordinating the entire of the project.

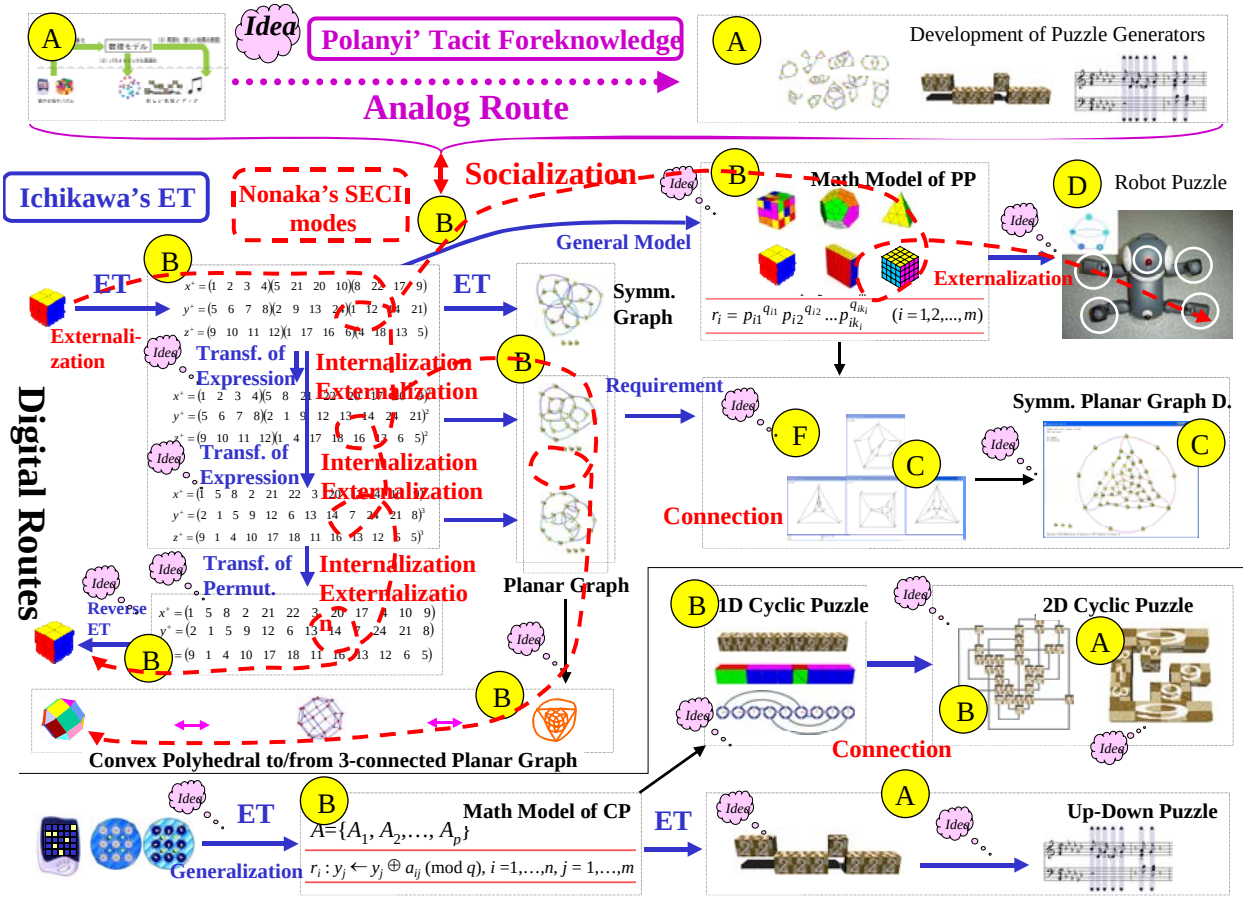

Figure 8: The whole process of the *puzzle generation* project and basic KC concepts

In the steps from *Analog route* to *Knowledge creation model*, important recognized things are as follows:

A tacit foreknowledge of yet undiscovered things is clearly seen. Both analog and digital routes are clearly seen. *Socialization* is clearly identified. The branching of Equivalent Transformations is important in the digital route and clearly seen. Articulation and categorization of individual knowledge are difficult practically. Coordination or leadership of getting specialized knowledge and securing manpower is important. *Ba* (shared context) is important especially in the stage of Socialization.

4. DIFFERENCES BETWEEN PROJECTS

We analyze the other project *Cyber-IRORI* and compare its results with those of the first project.

(1) In the second project, the equivalence transformation is clearly seen like the first project. Metaphor of *irori* is employed in the second project while analogy of Rubik's cube in the first project. Though an analog route in the first project are remarkable, it progresses step by step in the second project. In other words, the final goal cannot be foreseen clearly at the beginning in the second project.
(2) Knowledge from the outside is not so important in the second project while very important in the first project. This reason seems that more formal knowledge was required for the first project.
(3) Roles of idea creator and coordinator can be clearly identified. Collaborations with them are indispensable to accomplish the project.

5. CONCLUSIONS

A workflow for KC process analyses has been proposed. The analysis of KC processes of two projects has been carried out precisely.

The use of fine granular analysis is threefold. Firstly, the project supervisor realizes that it is more than knowledge of facts that contributes to the outcome of a project. Secondly, combined with cross-tables for inter-individual knowledge exchange, knowledge flows within and without the project can be analyzed on a deeper level. Thirdly, this analysis can reveal potentials for future improvements. For example, if a project fails and at the post-project analysis can reveal a lack of individual non-explicit knowledge use or exchange, this could be an indicator for areas of improvement in future projects.

We conclude that the workflow model has been successfully employed in the analysis of a scientific research project and that we have recognized evidence of the concepts. It is also stated that further research in form of the analysis of further cases is desirable.

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