Knowledge Reconstruction in R&D through Interactions among Six Lenses

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Abstract

A process model is described for reconstructing an individual's knowledge during the research and development of new technology by using six-lens interaction activities and management actions promoting it. It has a nested, or transformational, structure and three stages: awareness of issues, development of solutions, and "dialogical practice" of solutions. The second stage transcends and includes the first stage, and the third stage transcends and includes the first and second stages. Three interactions are evident in the third stage: between the subject lens and object lens, between the past lens and future lens, and between the analog lens and digital lens.

The model was tested through a case study of a research team working for a Japanese electronics manufacturer. A modified grounded theory approach revealed five knowledge reconstruction factors, four lens functions for activating dialogical practice, and six management actions for promoting knowledge reconstruction.

Two knowledge reconstruction factors are evident in the first stage: producing conflict and/or contradiction and resetting subject boundary. In addition, managers tend to create chaos in order to produce conflict and/or contradiction. Managers also tend to encourage heterogeneous information sharing, road-mapping, organizing and networking with other research and business teams, and assessing the potential of the technology in order to reset the subject boundary.

Three additional knowledge reconstruction factors are evident in the second stage: expansion of viewing field, creation of new connection among technological concepts, and transformation of individual beliefs. Managers tend to present research goals abstractly to promote expansion of the viewing field. They also tend to encourage heterogeneous information sharing to promote the creation of new connection among technological concepts.

All the knowledge reconstruction factors are evident in the third stage. In addition, an activation object lens comprising the team members and a past lens within future consciousness were evident. In contrast, the subject lens and digital lens had broken down. Managers tend to share heterogeneous information and expand the viewing field in order to activate the object lens comprising the research team colleagues.

Keywords: Six-lenses model, Knowledge reconstruction process, Management of knowledge reconstruction

1 Introduction

While there have been numerous studies on the innovation process in the management field It, there It has been some criticism of their tendency to focus on only developmental changes in technology. For example, Pavitt (2005) proposed an agenda for future studies on the innovation process: coordinating and integrating specialized knowledge and learning under conditions of uncertainty [1]. These proposals indicate the growing importance of focusing on the developmental changes in the perspectives of researchers and developers that precede developmental changes in technology.

In line with this agenda, in this paper we discuss the developmental change, or transformation process, of people researching and developing new technologies. We also discuss management policies promoting the transformation process.

We regard this transformation as "knowledge reconstruction." Knowledge reconstruction is defined as the interaction between "knowledge" and "frame of reference" It in problem-setting and problem-solution situations (see figure 1).

We assume that knowledge comprises two factors: point of view and conceptual system. According to Mezirow (2000) [2], point of view comprises clusters of meaning schemes, such as expectations, viewing field, and beliefs (p.18). In addition, a conceptual system is defined as an information cluster, which is connection among concepts.

Frame of reference also comprises two factors: habit of mind and point of view (Mezirow, 2000) [2]. Habit of mind is defined as a set of assumptions, such as vision and values (p.17).

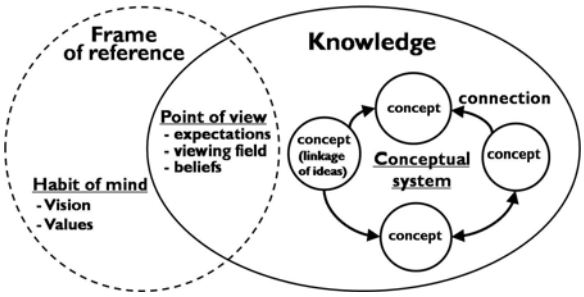

Figure 1. Relationship between knowledge and frame of reference

In addition, following Wilber (1995) [3] and Watzlawick et al. (1974) [4], we assume that the transformation process has a nested structure. In other words, developed knowledge includes and transcends precedent knowledge. Using this assumption, we clarify the knowledge reconstruction process.

2 Hypothetical Model

Our approach to building a hypothetical model is to extend the knowledge reconstruction process (KRP) model based on six-lens interaction (Yoshinaga and Toyama, 2006) [5]. The KRP model includes three stages: awareness of issues, generation of solutions, and practice of solutions. Six-lens interaction is based on the "six-lenses" model, which has three axes and six viewpoints: (1) subject lens and object lens, (2) future lens and past lens, and (3) analog lens and digital lens (Hayashi, 1999 [6], 2001 [7], 2004 [8]). The "six-lenses" model is illustrated in figure 2. There are 15 interaction patterns among the lenses. Here we focus on only three—those along the three axes: between the subject lens and object lens, between the future lens and past lens, and between the analog lens and digital lens.

- In the first pattern, the subject lens refers to self-identity, and the object lens refers to outside the self-identity (Hayashi, 2004) [8].
- In the second pattern, the future lens refers to desirable visions, goals, targets, and ideal situations for the self-identity, and the past lens refers to the memory of past experiences about the self-identity (Hayashi, 2004) [8].
- In the third pattern, both the analog lens and digital lens are styles of perception, judgment, and communication. The analog lens refers to perception by feeling and intuition, judgment by affect and mood, and communication by context and metaphor. The digital lens refers to perception by definition and categorization, judgment by analysis and logic, and communication by discussion (Hayashi, 2004) [8].

In addition, these lenses also work on another consciousness on the same axis (see figure 2). For example, the analog lens works within both analog and digital consciousness. These six types of lenses are significant concepts for understanding interaction with heterogeneity, a factor in innovative activities.

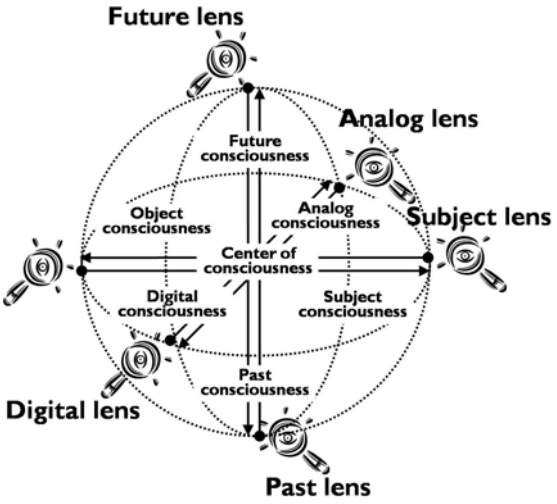

Figure 2. "Six-lenses" model [7]

To correlate the KRP model to the "six-lenses" model, we consider the correlation between "practice" and "dialogue." Practice is defined as proactive and repetitive action to object, while dialogue is defined as an interaction between

subject lens and object lens. Critical review of previous research on learning theories for adult education (Kolb, 1984 [9]; Mezirow, 1991 [10], 2000 [2]; Schön, 1983 [11]), learning organization theories for management (Nonaka and Takeuchi, 1995 [12]; Nonaka and Konno, 2003 [13]; Nonaka and Toyama, 2003 [14], 2005 [15]; Engeström, 1987 [16], 2001 [17], 2004 [18]; Weick, 1995 [19]) revealed that integration of practice and dialogue is a key concept in work interaction between subject lens and object lens and between analog lens and digital lens. Thus, we propose a new concept—"dialogical practice"—for expressing the state of integration and simultaneous occurrence between practice (Schön, 1983 [11]) and dialogue (Bohm, 1990 [20]). This concept replaces the third stage of the KRP model, "practice solutions".

We constructed a hypothetical model (see figure 2) based on these propositions and findings for the knowledge reconstruction process. It comprises three stages: awareness of issues, development of solutions, and dialogical practice of solutions.

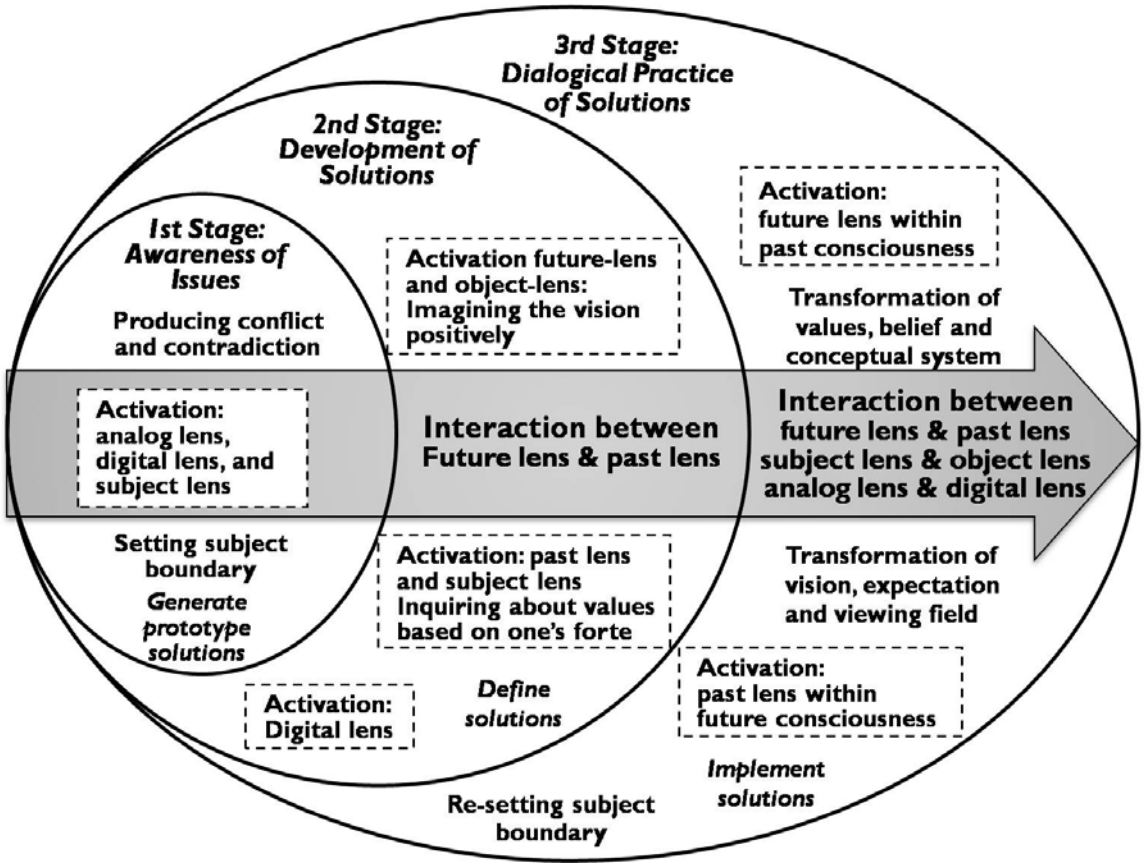

Figure 3. Hypothetical model based on knowledge reconstruction process model

3 Evaluation

3.1 Fieldwork and Interviews

We tested our hypothetical model by using the case of a research team (research team A) at a Japanese electronics manufacturer with a prestigious history (M Corp.). See figure 4. The research team is studying advanced software production engineering for a particular business area that M Corp. has recently targeted. The team is part of the MD research institute, which focuses on basic research. The research headquarters, which manages several research institutes, provides funds to various teams to promote basic research activities. Team A also receives funds from sponsoring marketing and development divisions and from a related company to promote applied research and development.

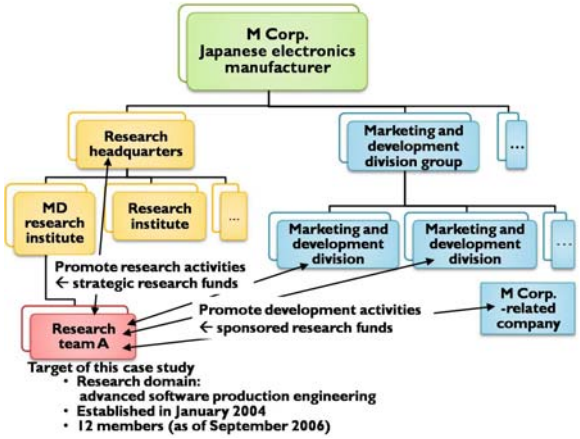

Figure 4. Position of research team A

We spent 27 months, from July 2004 to September 2006, observing the activities of the team firsthand. We interviewed 10 of the 12 members, including the senior manager, from 1 to 6 times each for a total of 28 interviews (see table 1). The 11th and 12th members were not interviewed due to their personal reasons. Because they joined the team from April 2006, we assume that they had not started activities for their knowledge reconstruction yet.

Depending on the situation at the time, we used the active interview method (Holstein and Gubrium, 1995) [21], the PAC analysis method (Naito, 1997/2002 [22], Yoshinaga and Toyama, 2005 [23]), the life-story interview method (Sakurai and Kobayashi eds., 2005 [24]), or the retrospective interview method (Weick, 1995 [19]). We attempted to extract intersubjective understanding between the interviewee and the interviewer. The interviews were recorded and transcribed.

Table 1. Team member attributes and interview framework

Participant code	Position	Years of experience at M Corp.	Profession	No. of interviews	Interview dates	Interview timing
RM-W	Senior manager	Over 20	Researcher	1	December 27, 2004	First stage
RL-G	Team manager (senior member)	16	Researcher	6	July 28, 2004 August 5, 2004 September 15, 2005 March 22, 2006 April 4, 2006 September 29, 2006	First stage First stage Second stage Third stage Third stage Third stage
R-J	Researcher (senior member)	10	Researcher	5	August 3, 2004 September 9, 2005 March 24, 2006 March 24, 2006 September 29, 2006	First stage Second stage Third stage Third stage Third stage
R-D	Researcher (senior member)	8	Researcher	5	November 16, 2004 September 9, 2005 March 24, 2006 March 24, 2006 September 7, 2006	First stage Second stage Third stage Third stage Third stage
R-X	Researcher	3	Researcher	2	March 23, 2006 September 2006	Third stage Third stage
R-S	Researcher (senior member)	3 (transferee from other company)	Researcher	2	April 2006 September 2006	Third stage Third stage
R-T	Researcher (joined late)	2	Researcher	2	March 2006 September 2006	Third stage Third stage
R- U	Researcher (joined late)	13	Engineer	2	April 2006 September 2006	Third stage Third stage
R- V	Researcher (joined late)	1 (transferee from other company)	Engineer	2	April 2006 September 2006	Third stage Third stage
R-W	Researcher (joined late)	10	Engineer	1	September 2006	Third stage

3.2 Analytic procedure

We analyzed the data collected from the interviews in three steps.

1. Analysis of developmental process of team activities based on expansive learning cycle model (Engeström, 2001) [17] in order to match interview data to the three stages in our model.
2. Generation of concepts and categories, which are clusters of concepts, related to our hypothetical model based on the modified grounded theory approach (Kinoshita, 1999 [25], 2003 [26]; see figure 5) which was developed from the original grounded theory approach by Glaser and Strauss (1967) [27].
3. Identify relationships between simultaneous occurrences among concepts and categories.

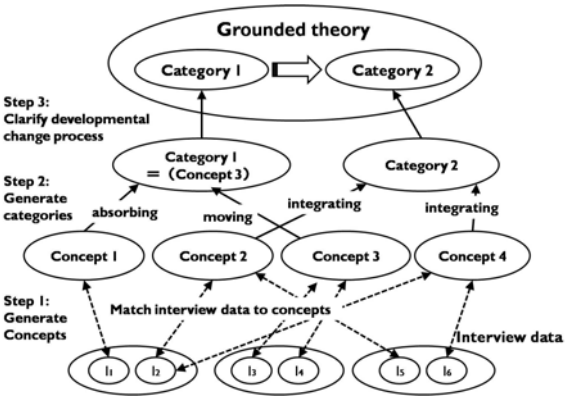

Figure 5. Modified grounded theory approach [26]

For the second and third steps, we used the MAXQDA 2007 text analysis package [28], qualitative data analysis software developed by VERBI Software Consult. Sozialforschung. GmbH (see figure 6). Using MAXQDA 2007, we generated and browsed "analytical work sheets" (Kinoshita, 2003 [26]). Analytical work sheets are core tools for the modified grounded theory approach. They contained the name of the concept, the definition of the concept, the list of text corresponding to the concept, and the memorandum for the concept. Using the code relation browser function, we generated a cross tabulation showing the number of simultaneous occurrence among concepts and categories. Using this cross tabulation, we qualitatively identified interrelated effects among concepts and categories. Through these steps, we constructed a modified grounded theory (see figure 5).

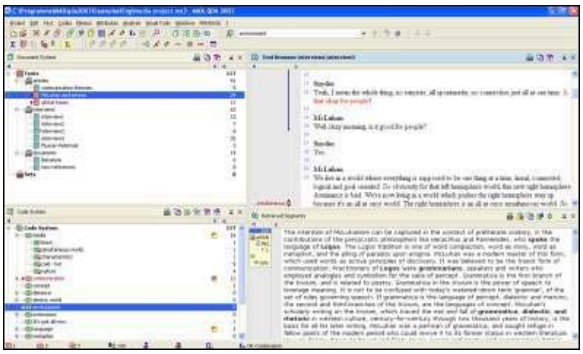

Figure 6. Interface of MAXQDA 2007 [28]

4 Results and Discussions

The first step in the analytic procedure above showed that the first stage lasted from June 2003 to December 2004, the second stage lasted from December 2004 to September 2005, and the third stage lasted from October 2005 to the present (September 2006). From this, we categorized the interview data into three stages (see table 1).

The second step generated 9 categories with 48 concepts: (1) 3 activities for knowledge reconstruction (awareness of issues, development of solutions, and dialogical practice of solutions), (2) 6 factors for knowledge reconstruction: resetting subject boundary, producing conflict, producing contradiction, expanding viewing field, creating new connections among technological concepts, and transforming individual beliefs, (3) 11 management actions for promoting knowledge reconstruction, (4) 4 activities for subject lens, (5) 9 activities for object lens, (6) 4 activities for past lens, (7) 3 activities for future lens, (8) 4 activities for analog lens, and (9) 4 activities for digital lens.

The third step revealed a nested structure in the knowledge reconstruction process through simultaneous occurrences between the three stages and its proper activities. In the first stage, the only activities were related to awareness of issues. In the second stage, the activities were related to development of solutions as well as awareness of issues. In the third stage, the activities were related to all three stages (see figure 7).

The three stages had unique characteristics. In the first stage, interactions between subject lens and object lens and between future lens and past lens worked well, and two knowledge reconstruction factors were evident: producing conflict

and/or contradiction and resetting subject boundary. In addition, the managers tended to create chaos in order to produce conflict and/or contradiction. They also tended to encourage heterogeneous information sharing, road-mapping, organizing and networking with other research and business teams, and assessing the potential of the technology in order to promote resetting the subject boundary (see figure 7).

In the second stage, interactions between future lens and past lens and between subject lens and object lens worked well, and three additional knowledge reconstruction factors became evident: expansion of viewing field, creation of new connection among technological concepts, and transformation of individual beliefs. Managers tended to represent the research goal abstractly to promote expansion of the viewing field. They also tended to encourage heterogeneous information sharing to promote the creation of new connections among technological concepts (see figure 7).

In the third stage, the interactions among all six lenses worked well, and all knowledge reconstruction factors were evident. In addition, an activation object lens comprising the team members and a past lens within future consciousness were evident. In contrast, the subject lens and digital lens had broken down. The managers tended to share heterogeneous information and expand the viewing field to activate the object lens comprising the research team colleagues. On the basis of these findings, we rebuilt our hypothetical model of the knowledge reconstruction process as a grounded theory model (see figure 7).

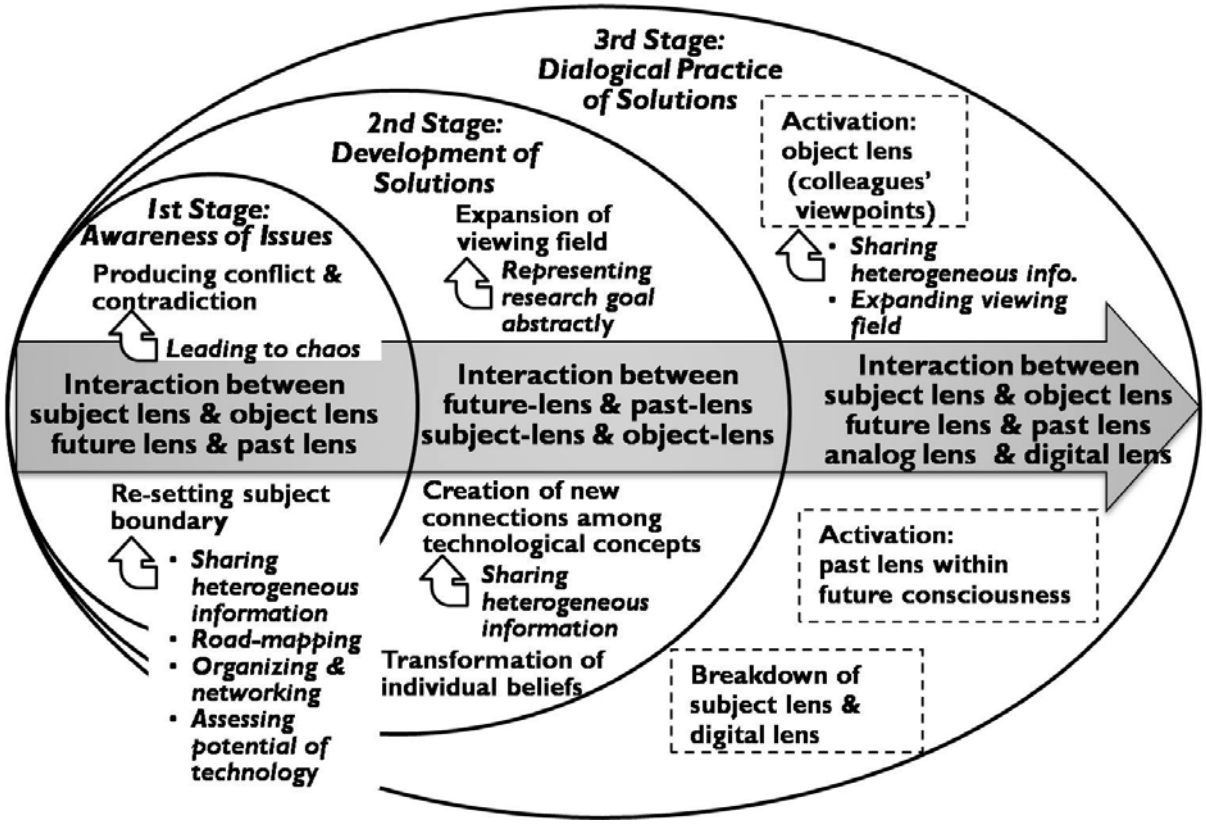

Figure 7. Modified knowledge reconstruction process and management model

5 Conclusion

We tested our process model for reconstructing an individual's knowledge during the research and development of new technology through a case study of a research team at a Japanese electronics manufacturer. Using the modified grounded theory approach, we identified five knowledge reconstruction factors, four lenses for activating dialogical practice, and six manage-

ment actions for promoting knowledge reconstruction.

Our modified knowledge reconstruction model has three theoretical implications for organizational knowledge creation theory (Nonaka & Takeuchi, 1995 [12]): (1) given its nested structure, this model indicates that knowledge creation also has a linear and interactive structure, (2) given its six lenses, this model can eye not only knowledge, but also perception and communication, (3) concrete activity on integration between practice (Schön, 1983 [11]) corresponding to "internalization mode" [12] and dialogue (Bohm, 1990 [20]) corresponding to "externalization mode."

In addition, our model also has three implications for the "six-lenses" model (Hayashi, 1999 [6], 2001[7], 2004[8]). (1) There is interaction among all six-lenses in the third stage, (2) Breaking down the subject lens and the digital lens is effective for knowledge reconstruction in the third stage. (3) There are five knowledge reconstruction factors corresponding to the six lenses and consciousness.

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