

# Case Study on Spatial Occupancy and Knowledge-Creation Processes in Project-Based Research Groups

○Azizah Md Ajis<sup>\*1</sup> Shin Muramatsu<sup>\*2</sup>  
Ryusuke Naka<sup>\*3</sup>

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## 1. Introduction

### 1.1 Research Background

With the new millennium, the “knowledge-based” economy has become the world’s preeminent economy by having benefitted from organizational creativity, knowledge, and information in creating wealth and business growth. This has led to the emergence of the knowledge-based society, whose “knowledge productivity” remains a subject of discussion in management in terms of keeping abreast of business agility and competitiveness. Various models and diverse definitions have been developed in an attempt to understand the concept of knowledge productivity. Some studies suggest that knowledge productivity can be defined as the process of acquiring knowledge and using it to develop new skills, new knowledge, and creativity; thus, it applies to innovative services and work processes [1]. These processes are compatible with the functions of the knowledge-creation process of the SECI Model [2]. Developed by Nonaka and Takeuchi, the SECI Model explains two types of knowledge: tacit knowledge, which is hard to formalize and difficult to transfer, and explicit knowledge—knowledge that has been articulated and is transferable through formal methods. They mutually interact with each other and continually rise in a dynamic spiral shape—ontologically from the low levels of the individual to the high levels of the organization—and are presented as four modes knowledge conversion: socialization, externalization, combination, and internalization.

The concept of knowledge creation in organizational and knowledge productivity has driven researchers to explore the relationships between humans within organizations, including their physical settings and conditions [3], [4]. However, shaping the office layout for such activities must consider the links between them—face-to-face communication among workers [5]–[7]. Communication among workers encourages information exchange and can reduce uncertainty in helping organizations implement ways to achieve optimal productivity and efficiency.

### 1.2 Research Aim

Several authors have investigated the effects of physical

settings on face-to-face communication—including the quality of communication, work activities, cohesiveness, environmental stress, and collaboration—by looking into office spatial constructs such as privacy, territory, proximity, and visibility [8]–[10]. Their findings mostly elaborate on worker satisfaction regarding either communication or office spatial settings. Further, these investigations are mostly conducted in large organizations and study that look into knowledge creation process using SECI behaviors from empirical evidence in knowledge-based organization like research institution is quite limited in the field.

Therefore, the scarcity in these studies drives the aim of the present research to investigate the effects of physical office spaces on knowledge-creation processes [11], based on the amount of communication among workers, by considering spatial occupancy in a small-scale office when performing these processes. Spatial occupancy has a great potential to show the role of space utilization in understanding space-planning concepts for organizational knowledge creation.

For this research, we hypothesized that spatial occupancy based on the amount of communication can contribute toward determining the optimal spatial characteristics for knowledge-creation processes in small scale office layout. In particular, we focused on knowledge-creation behaviors—12 SECI behaviors and communication content were considered as parameters that might influence the process.

## 2. Methodology and Data

Studying the relationship between knowledge creation and the amount of communication links within a project-based research group could provide rich empirical evidence presently lacking in the field. Therefore, this qualitative study adopted a case-study approach using three project-based research groups at the same institution—in this case, a research institution located in Japan with different office spatial settings. Each office layout was designed independently. The locations of each office are shown in Figure 1.

## 2.1 Research Design

The study adopted an ethnographic method where each project group employed similar approaches by using both primary and secondary data-collection methods:

a) The primary method of gathering raw data entailed semi-structured face-to-face interviews regarding knowledge-creation activities, the amount of communication, communication patterns, and spatiality. The three project groups consisted of 9–12 full-time researchers assigned in each office. Six volunteered for the interview sessions, of which three were the project leaders with the rest being researchers. The interviews took 45–90 minutes per person.

b) Secondary data collection used the research institution's documents and archival records to support the above analysis.

c) Site observation was conducted to gain real-time perspectives on the researchers' behavioral movements while performing SECI activities and spatial occupancy when communication occurred. Observation was conducted using overt observational research; the test subjects (in this case, researchers at a research institution) were informed about the study, and the purpose of the observation was explained. Although the behaviors of the test subjects might have changed due to the presence of the observers, the advantage of this technique is that the data could be openly recorded. Observation was conducted for five days for each group during office hours from 9:30 a.m. until 5:00 p.m. A total of 112.5 hours were spent collecting the data with 600 communication occurrences recorded.

## 2.2 The Dimensions

The dimensions investigated in the observation can be divided into two parts: first, investigation of the spatial settings, and second, investigation of communication content

during communication events.

The investigated office layouts were composed of the following: (1) one's own workstation—the test subject's personal workstation; (2) the opponent's workstation—the communication partner's workstation; (3) the circulation area; (4) the discussion area; and (5) other areas (areas outside the office territory). Meanwhile, the investigation of communication content looked at the information exchanged during communication occurrences. The composition included the variables shown in Table 1.

Table 1 Communication content measured during observation

Variable	Description
1 Knowledge / Information	A process involving thoughts, participation, understanding, and intuition
2 Rule of thumb / know-how	Developing skill and learning about difficulties and challenging techniques
3 Generating ideas	Generating inspiration, opinion, conception, imagination, and thought
4 Chatting	Informal communication where people talk casually about a wide range of topics
5 Resolving problems / making decisions	Drawing conclusions and finding agreement; it tends toward new directions and determination
6 Other	Greetings, instructions with very limited communication exchange

## 2.3 Data Collection

The procedures during observation were as follows: (1) all test subjects were given a briefing about the purpose of the study and the type of information that would be collected during observation; (2) observers stood at one objective point to ensure the test subjects and the situation in the field settings could be seen and grasped relatively; (3) test subjects were given a survey sheet after a communication occurrence ended to grasp the content of the conversation, spatial occupancy, and the duration of the communication event; and (4) to grasp the movement of people, presence rate of people in the office, and density, video recordings and snapshots were taken during the observations.

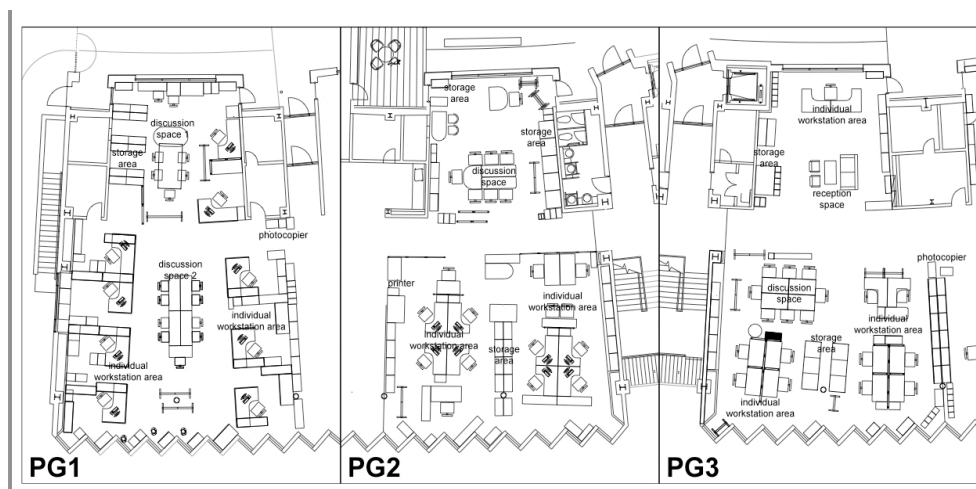


Figure 1 Office layout of each project research group

Table 2 Summary of 12 SECI behaviors of researchers identified through content analysis

SECI Mode	SECI Code	SECI Behavior Code	Activities	Comm. Type	Communication Network
Socialization <i>tacit - tacit</i>	stimulating	walk around	most activities in this behavior showed that researchers needed to make a contact with a related person involved in their research project. They also needed to get information on the actual conditions of their research subject by visiting the site, seeing the activities of local people, collecting specimens, meeting counterpart researchers, etc. These activities did not necessarily occur during the early stages of the research process; they were performed whenever the information was required.	Face-to-face Telephone	Focus Group Local People Research Counterpart
		to make contact with			
		to feel-see-seen			
Externalization <i>tacit - explicit</i>	idea	light talk	generating ideas from the collected data; receiving advice regarding technical matters; alternative solutions for data collection; brainstorming ideas, methods, or concepts; extracting data from samples/specimens/site measurements; and visualizing raw data into figures, pictures, and words	Face-to-face Email	Project Leader Project Researcher
		brainstorm			
		to illustrate / similize			
Combination <i>explicit - explicit</i>	finalizing	to investigate, analyze, edit, and accumulate	investigating, analyzing, editing, and accumulating data; active discussion, examination, or listening. Activities that fall under this behavior include the following: • Desk work such as writing documents, organizing and summarizing data, finalizing accumulated data, establishing data from experiments, analyzing images, and so forth • Discussions about finalizing data; Q&A on the discussed theme; and debating with other researchers about the theme, appropriate methodology, and analysis method • Presenting the research output and being examined at the periodical group meeting, academic conferences, research seminars, special seminars, or reserved lectures	Face-to-face Email Telephone	Project Leader Project Researcher Remote Project Researcher
		aggressively discuss			
		being examined / listened to			
Internalization <i>explicit - tacit</i>	improve understanding	make a trial	knowledge-creation activities that require researchers to improve their skills, knowledge, and understanding as well as spread the knowledge to others, such as students and the community. Activities include speaking at an academic conference, publishing a booklet or book, performing on-site experiments through trial-and-error testing on the invented method, performing a small-scale demonstration test to transfer potential technology, and attending research seminars and colloquiums for further research understanding	Face-to-face	Community Academician / Researchers
		practice / perform			
		self - improve			

## 2.4 Data Analysis

This research intended to look at – 1) activities in knowledge-based organization that imply the knowledge creation process contemplating SECI behavior, 2) communication pattern practiced by workers in relations to knowledge creation activities (contents and amount), 3) spatial used by workers during communication occurrence while performing their knowledge creation activities.

Data extracted from the interviews were transcribed and analyzed using content analysis. Content consisting of knowledge-creation activities was classified into four SECI dimensions: socialization, externalization, combination, and internalization. To analyze the behavior of the researchers, knowledge-creation activities were codified according to 12 SECI behavioral codes. The 12 SECI behaviors came from an extended study by Nonaka and Takeuchi on the SECI Model. Meanwhile, site observation data were analyzed using descriptive statistics. The analysis considered three factors: 1) the behaviors, 2) the amount of communication patterns that included social networking and communication content, and 3) spatial occupancy during the SECI activities.

### 3.1 Knowledge-Creation Behavior

The content analysis of the interviews and secondary sources sought to identify knowledge-creation behavior in the organization. By understanding the nature of the researchers' work, spatial occupancy can be predicted and thus indicate

the spatial characteristics needed for this type of work. Due to huge data obtained, the result shown in Table 2 presents the summary of the work activities that were codified into SECI behavior codes. The SECI behaviors were classified into the same four codes used by NOPA in a creative office study [12]; however, the activities in this study referred to activities in the said organization.

### 3.2 The Amount of Communication Patterns in the Knowledge-Creation Process

Why should studies examine the amount of communication (AOC) among researchers? Some researchers claim that the amount of communication is important for reducing uncertainty and ambiguity in the information transferred or shared among them. Hence, greater AOC encourages information exchange and reduces uncertainty, improving information quality and communication satisfaction while also improving knowledge sharing, information absorption, social networking productivity, and capability- and knowledge-based work. It is specific to non-routine tasks that require the engagement of people, such as collaborative work, services, innovation, and creative work. Therefore, to enhance the intellectual productivity of researchers in this context, we proposed examining AOC factors and space occupancy during communication occurrences. The following items were calculated to examine the AOC:

1. Duration rate: the proportion of the duration when each

worker verbally communicated on average in each communication event

2. Frequency: how frequently each worker verbally communicated on average

The AOC pattern was analyzed by looking at content and space occupancy during the communication occurrence. Table 3 shows the average AOC that occurred over five days for each project group. For all groups, most of the communication was in the range of one to five minutes. For PG1 and PG2, it occurred as a result of being visited or called by someone; for PG3, it occurred mostly as a result of researchers needing to talk to someone. Communication occurrences of less than one minute occurred for PG1 as a result of ad hoc or accidental communication; PG2 and PG3 had less communication of more than 30 minutes resulting from scheduled communications, such as scheduled meetings.

Communication content was measured to examine the type of information exchanged in knowledge-creation processes at the studied institution. Table 4 shows the AOC by measuring the mean value of communication occurrences while performing knowledge-creation activities. It shows that almost all the research groups had a significant AOC when communicating about knowledge and information. The observation was conducted during the phase of collecting information for their research project; this could be the reason why this type of information exchange among the researchers had a high mean value for AOC.

Table 3 The amount of communication for each project group

		PG1	PG2	PG3
communication frequency		60.00 (19.59)	30.14 (19.59)	41.71 (23.47)
duration	< 1 minute	2.17 (3.18)	6.20 (3.66)	6.20 (2.92)
	1 - 5 minutes	18.83 (4.45)	31.00 (17.17)	38.40 (11.94)
	6 - 30 minutes	5.66 (1.25)	4.20 (3.06)	9.60 (5.89)
	> 30 minutes	3.33 (1.37)	0.40 (0.49)	4.20 (3.31)

PG1 N=3, PG2 N=7, PG3 N=7, (standard deviation in parentheses)

Table 4 Frequency mean value of communication content in knowledge creation

		knowledge / information	rule of thumb / know how	idea	chatting	resolving problem / decision making	other
PG1	S	0.60 (0.45)	0.17(0.27)	0	0.23 (0.07)	0.11 (0.09)	0.09 (0.09)
	E	0.14 (0.23)	0.11 (0.28)	0.11 (0.15)	0	0.03 (0.06)	0
	C	1.29 (1.21)	0.42 (0.58)	0.06 (0.14)	0.57 (0.09)	2.03 (1.62)	0.03 (0.07)
	I	0.34 (0.43)	0.03 (0.07)	0	0	0.29 (0.50)	0
	OTHER	0.43 (0.74)	0.03 (0.07)	0	0.66 (0.35)	0.69 (0.92)	0.20 (0.15)
PG2	S	0.34 (0.58)	0	0.11 (0.21)	0.17 (0.16)	0.37 (0.34)	0.03 (0.06)
	E	0.23 (0.55)	0.03 (0.07)	0.20 (0.41)	0	0.09 (0.21)	0
	C	0.37 (0.36)	0.03 (0.07)	0.06 (0.09)	0.06 (0.09)	1.46 (1.24)	0.03 (0.06)
	I	0.31 (0.23)	0	0.06 (0.09)	0.03 (0.07)	0.14 (0.35)	0
	OTHER	1.00 (2.05)	0	0.03 (0.06)	0.14 (0.14)	0.60 (1.01)	0.11 (0.14)
PG3	S	1.22 (0.08)	0.17 (0.13)	0.17 (0.14)	0.72 (0.39)	0	0
	E	0.28 (0.28)	0.06 (0.07)	0.22 (0.31)	0.06 (0.07)	0.11 (0.15)	0.11 (0.15)
	C	0.50 (0.6)	0.11 (0.15)	0.17 (0.24)	0	0.28 (0.20)	0
	I	0.78 (0.28)	0.17 (0.13)	0	0	0.11 (0.07)	0.11 (0.07)
	OTHER	0.72 (0.55)	0.06 (0.07)	0	1.17 (0.70)	1.28 (1.46)	2.00 (2.16)

PG1 N=3, PG2 N=7, PG3 N=7, (standard deviation in parentheses)  
 indicate low mean value - frequency of communication  
 indicate high mean value - frequency of communication

### 3.3 AOC Distribution of Knowledge-Creation Behavior in the Office Layout

Analyzing the AOC distribution in the office layout when performing SECI behaviors provides insight into spatial occupancy for each group's physical settings. With such an analysis, optimal spatial designs can be proposed based on the nature of the institution's work. Figure 3 shows the higher AOC occurrences based on the type of SECI behavior. To determine spatial and physical settings characteristics from this analysis, we looked into several attributes—1) Visibility – each office layout has different setting of workstation type. PG1 settings were cubicle workstation with low partition in the front per researcher, and it allowed them to see each other faces from the front but not from their side. Therefore, high AOC occurred mostly at open space like discussion space and circulation area especially for “stimulating” and “improving understanding” behavior. In contrary, PG2 and PG3 have island type workstation with low partition for PG2 and high partition for PG3. However, the settings of workstations were closed to each other, and as a result, high AOC mostly occurred at workstation area. This especially can be seen at “finalizing” behavior. 2) Proximity – high AOC occurred

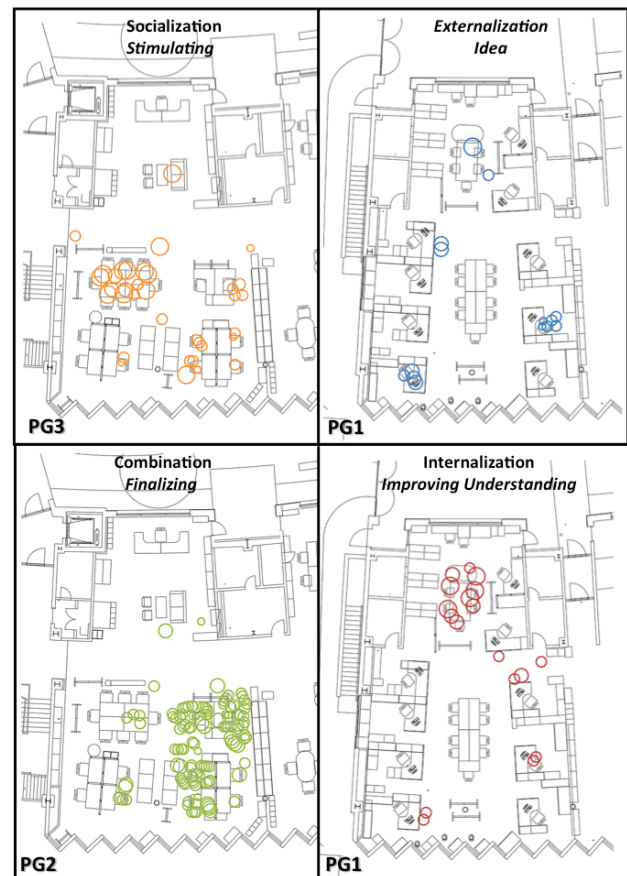


Figure 2 Four SECI Behavior that had high AOC with the distribution of communication occurrences in the layout

with more than 30 minutes in “stimulating” behavior when discussion space allocated adjacent to workstation as shown at PG1 and PG3, compared to PG2, which allocated far from workstation area. The number of people involved in this behavior always more than 2 person. 3) Circulation – various support settings allocated along with the circulation area such as storage filing cabinet, pantry, print and photocopier area. Non-SECI communication by accident or ad hoc frequently occurred with low AOC.

Table 5 summarizes the overall spatial occupancy of each SECI behavior based on AOC occurrences and from this table, we can predicted what SECI activities performed at such spaces for this organization by referring to SECI activities outlined in Table 2.

Table 5 Analysis summary of spatial occupancy based on SECI behavior

SECI Code	Project Group	AOC	Spatial Occupancy	SECI Activity
S	PG1	high moderate low	discussion space individual workstation circulation area	refer to table 2
	PG2	high moderate low	individual workstation circulation area, discussion space printer area	
	PG3	high moderate low	discussion space circulation area, individual workstation reception space	
E	PG1	high moderate low	nil individual workstation circulation area, discussion space	
	PG2	high moderate low	nil circulation area individual workstation	
	PG3	high moderate low	nil nil discussion space, individual workstation, circulation area	
C	PG1	high moderate low	nil discussion space, individual workstation, circulation area nil	
	PG2	high moderate low	individual workstation circulation area nil	
	PG3	high moderate low	individual workstation, circulation area nil discussion space	
I	PG1	high moderate low	discussion space circulation area individual workstation	
	PG2	high moderate low	individual workstation nil printer area	
	PG3	high moderate low	individual workstation discussion space circulation area	

※high AOC > 15 occurrences, moderate AOC 5<x<15 occurrences, low AOC <5 occurrences

## 5. Conclusion

This study analyzed how AOC and work behavior—in this case, knowledge creation—are influenced by the physical settings of the office. Spatial occupancy during communication occurrences related to knowledge-creation activities can be summarized as follows:

- For “stimulating” behaviors, most communication occurrences happened in discussion areas.
- Communication related to “finalizing” behaviors mostly occurred at individual workstations. This was especially true for PG2 and PG3.
- Communication related to “generating ideas” behaviors

occurred randomly at all places.

- Communication on “improving understanding” occurred mostly at workstations for PG2 and PG3, and mostly at discussion areas for PG1. The findings for PG2 and PG3 show that most researchers displayed this behavior at senior researchers’ workstations.

This study on the relationship between AOC and SECI behaviors showed that spatial occupancy can be used as a factor to determine the optimal spaces for knowledge creation in a small scale office layout. Future research should use the same method of investigation in different types of organizations. Such research should aim to determine whether the behaviors and AOC are similar by looking at the nature of the work practiced by the profession and the culture of the organization.

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\*1 Doctoral Program, Design Engineering, Kyoto Institute of Technology, MSc

\*2 Project Leader, RIHN, PhD

\*3 Prof., Dept. of Design Engineering & Management, Kyoto Institute of Technology, PhD

# プロジェクトベースの研究グループにおける空間占有と知識創造行動に関するケーススタディ

○アジザ マド アジス\*<sup>1</sup> 村松伸\*<sup>2</sup>  
仲隆介\*<sup>3</sup>

キーワード：SECI モデル ワークプレイス コミュニケーション量 オフィス空間

## 1. 研究背景と目的

近年、組織ビジネスにおいて知識創造的な業務の割合が増えている。そのためワーカーの知識創造生産性を上昇させる重要性が高まっている。そのような業務では、ワーカー間のコミュニケーションを活性化させることが必要であると同時に、そのコミュニケーションを支援する環境が求められる。これまでのコミュニケーションとオフィス環境の研究は、プライバシー空間、領土、近接、可視性などのインデックスに基づくコミュニケーションに対するオフィス環境の効果をコミュニケーション品質、環境ストレス、作業活動、コラボレーション、凝集性等の要因に着目して行われてきた。しかし、知識創造行動によるコミュニケーション量に特化した空間占有に関する研究例は少ない。本研究では、コミュニケーションを刺激するまたは妨げるオフィス空間の空間特性を把握するため、知識創造行動によるコミュニケーションに着目して調査分析を行った。なお、知識創造行動は SECI モデルを採択した。

## 2. 調査の概要

調査事例として、某研究所における3つのプロジェクトベースの研究グループのオフィスレイアウトを各グループ PG1, PG2, PG3 にエスノグラフィ調査を行った。まず、知識創造の行動を把握するため、ヒアリングを行った。ヒアリング内容はどんな活動でどこの空間また誰とコミュニケーションをするのか記録した。ヒアリングのデータは内容分析方法で知識創造行動を抽出した。次に、各オフィスで観察調査を5日間行った。観察調査では、知識創造行動によって発生したコミュニケーションの時間、頻度、空間占有、コミュニケーション内容を記録した。分析に関しては知識創造の行動において発生するコミュニケーションの内容と空間占有について行った。また、空間占有の特徴を抽出するため、コミュニケーション量分布図を用いてさらに分析した。この分析により、知識創造行動におけるコミュニケーション内容や実際に占有する空間の状況が明らかとなり、オフィス環境構築のための重要な知見を得た。

## 3. 結果とまとめ

本研究では、実際の知識ベースのオフィスで行われている知識創造活動の実態を明らかにした。そして、知識創造活動のコミュニケーション量における実際の空間占有によりオフィス空間特徴をいくつかを把握する事ができた。具体的には以下の4つの点にまとめる。

- ①「刺激し合う」行動のコミュニケーション量による空間占有は、全オフィスのほとんどがディスカッションスペースで起こる事を示している。このような知識創造活動の例は研究プロジェクトの現地情報を得るため関係者の相談、意思決定等を行う、カウンターパートの研究者と会う等が挙げられる。
- ②「アイデアを表に出す」行動のコミュニケーションによる空間占有は、全オフィス全てのオフィス空間でランダムにコミュニケーションが発生した。知識創造活動の例としては、情報収集からアイデアを作り出すこと、技術的な項目についてアドバイス・意見を求めること、アイデア・方法やコンセプトをブレインストーミングすること等がある。
- ③「まとめる」行動によってコミュニケーション量は主に個人ワークステーションで発生した。特にグループ PG2 と PG3 で目立った。活動例としては3つに分けられ、i) デスクジョブ-データ整理、画像解析、書類執筆等、ii) 相談-データ最終決定、適切な方法論・分析の議論、テーマの Q&A 等、iii) 評価-定期的なグループ会議などである。
- ④「自分のものにする」行動は PG2 と PG3 では個人ワークステーションで多く発生し、PG1 ではディスカッションエリアでコミュニケーション量が多く発生した。特に先輩の研究者が在席するワークステーションで発生し、活動例では研究者の知識やスキルを向上させるためのセミナー、試行錯誤の実験等がみられた。

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\*1 京都工芸繊維大学設計工学専攻 博士後期課程.修士

\*2 RIHN、プロジェクトリーダー、博士

\*3 京都工芸繊維大学デザイン経営工学部門、教授 博士(学術)