Open Innovation University-Industry Collaboration: Student Idea Contests and Exit Strategy in Japan

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Abstract

Open Innovation in the University-Industry Collaboration (OI-UNIC) is increasingly important globally for researchers and practitioners. As a coupled-type OI, students contests have become one of the most important elements for the creation of regional business in Japan. OI-UNIC, lab teams of university students from all over Japan, use patents from large firms, exchange knowledge, brush the ideas up with the help of SMEs and regional institutions, and compete to commercialize their product. However, the existing literature has not revealed how the collaborative team stakeholders can promote an "exit strategy" and commercialization through knowledge exchange channels. This study fills in the gaps. Applying creative problem solution theory, intellectual property management, patent management, and exit strategy methods, this study extends the concept of OI to the research frame. The survey method is a qualitative analysis based on observations by the author, reflections by the students, and interviews with the stakeholders. The research result shows that the team that commercialized their product had properly used the multiple channels adequately, but the teams that created only prototypes, while they understood the importance of the channels, did not take full advantage of them. The main conclusion of this study is formulated as a hypothesis and suggests further study of the effectiveness of innovation education and the possibility of small-scale innovation of regional revitalization.

Keywords:
Open Innovation University-Industry Collaboration, Creative problem solving, Patent, Exit strategy, Student idea contest

(1) Introduction and Overview

1. Open Innovation University–Industry Collaboration

Open Innovation University–Industry Collaboration (OI-UNIC), which is oriented toward student contests, is recognized as one of the most important elements for the creation of regional business in Japan. Many relevant initiatives and knowledge channels that support innovative activities in various ways have been developed. The student idea contest (2015/2016),"Fostering student' ideas using published patents and the OI platform,"[1] aimed to develop a physical and virtual environment for generating, developing, and commercializing university students' innovative ideas through relevant training and mentoring. Following the entrepreneurial or open innovation route, it fosters collaboration between universities and enterprises, enhances the employment potential of graduates and promotes innovation in companies.

2. The rising role of university in the

[1] Detail information: http://opi.innovations-i.com /idea/report/

knowledge–based society[2]

As Peter Drucker noted about innovation and entrepreneurship[3] in the mid-1980s, the pervasiveness of information and communication technologies, globalization, and the development of knowledge society have led to the growth of knowledge and its redistribution and supply of knowledge-absorbing worker. In the era of continuous development of the knowledge–based society, where the value of university-industry collaboration (UNIC) gained a greater recognition[4], the UNIC consequently became a more significant subject of study[5].

For large sized firms that are looking to enhance and maintain their competitiveness, knowledge has become a decisive factor. The foundation of competitiveness in the world is now more dependent on valuable knowledge resources that are widely distributed across the globe, across the value chains, across R&D and across individuals with high knowledge absorption in multi organizations. Against this situation, the paradigm of open innovation (OI) has emerged as a new response to manage the increased amount of boundary–knowledge flows both in and out of the innovation process.

To overcome the limitations of closed innovation processes, such as increasing R&D costs, insufficient resources, and unsatisfactory levels of competence, companies may choose to outsource their innovation work and invite external contributors to develop ideas or solutions to specific, predefined problems.

3. Dilemma of innovation education and corporate strategy in Japan

Japanese regional open innovation is the results of a complex interaction of various actors and institution. Universities (students' idea), large firms (licenser), SMEs (licensee), City industry policy divisions and financial institutions ("Shinkin" credit bank or local bank) play crucial roles in accelerating innovation. Technological innovation is a result of interaction and feedback among all elements within the system, rather than an occurrence in a complete linear system (OECD, 1977)[6].

The core of the UNIC system is corporations and universities, which manages and organizes knowledge channels accessing the source of external knowledge. However, several factors can lead to the failure of collaboration projects. Universities emphasizes not only research, but also human resource development and the significance of knowledge transfer and application to a large extent. Corporations, however, emphasize patent exit strategies.

However, while many innovation education programs have focused on proposing creative ideas, the methodology of innovation education in an "OI" is still controversial. Innovation education plays a crucial role in developing "creative problem-solving skills[7]" and "collaborative behaviors[8]"for students to create a new path towards a desirable future.

On the other hand, companies evaluate utility that is intended to create profits rather than education. Japanese firms have external novelty and fresh knowledge sources for their IP exit strategy. According to the Survey on R&D Collaboration by RIETI[9], the share of firms with R&D collaboration with other firms, universities, or public research institutions have increased in the past five years, and is expected to increase in future as well. (RIETI, 2004)[10].

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[2] P.F.Drucker(1985).*Innovation and Entrepreneurship Principles and Practices*, pp.58-80.

[3] Ibid.

[4] Studies increased in development of industry academic society, Japan Society for Intellectual Production, etc.

[5] Region creation policy by METI, etc.

[6] OECD, 1977 innovation report.

[7] This skill is manifest in what the Ministry of Economy, Trade and Industry refers to as fundamental competencies for working persons and what the Ministry of Education Culture, Sports, Science and Technology refers to as bachelor's competencies and "21st century skill.

[8] Ibid.

[9] RIETI Research Institute of Economy, Trade and Industry)

[10] Motohashi (2011), p16, p.23.

The study of open innovation has primarily focused on the benefits and consequences of inbound or outbound innovation exchange between firms; however, increasingly firms may be engaged in simultaneous inbound and outbound exchange forming a "coupled[11]" approach.

Furthermore, firms increasingly collaborate with university and regional SMEs as sources of innovation, but how does such coupled open innovation affect idea create, information flows, commercialization? Is a coupled open innovation applicable as a formal university education program?

Through an exploratory study of student idea contest, this paper shows how this approach incorporates not only the patent and idea but also the provision of technology and market information using multiple knowledge channels.

For the above reasons, the author believes that incorporating the practice of collaborations between Japanese universities and industries into the open innovation literature is important from the aspect of firm patent exit strategies and the aspects of university education for innovation, both theoretically and practically can lead to regional economic development.

Section 2 of this paper reviews the relevant literature about the concept of outbound, inbound and coupled types of OI, success factors, university-industry collaboration, and patent exit strategy. Section 3 presents an analytical framework of the OI-UNIC. Understanding the knowledge channels in the UNIC context of the entire innovation process requires a framework for understanding the structure of team's innovation activities. Section 4 explains the methodology: A) CPS project; and B) OI-UNIC project with qualitative analysis of knowledge channels. Finally, this paper conclude and discusses the managerial and educational implications.

(2) Literature review

In this section, I briefly review the literature on the open innovation evolutionary approach, the success factors, the openness of intellectual property, and collaborative innovation

1. Open innovation evolutionary approach

Innovation[12] is defined here as "creating new value by adding values through new ideas, methods, directions, opportunities, and solutions that meet new needs through more effective products, processes, services, and business models up to commercialization[13]". Innovation also, means not only conventional technology-driven innovation, but also "human-driven[14]" innovation, which focuses on creating products that people want to use.

The concept of "open innovation" is defined as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation and expand the markets for external use of innovation, respectively" (Chesbrough, 2003, p1; Chesbrough, 2006a)[15]. Open innovators have a specific mindset and disposition to co-evolve ideas and co-create new products and services in elaborate innovation ecosystems (Chesbrough, Vanhaverbeke and West, 2014)[16]. Open innovation requires a supportive environment. (Salter, Crscuolo, and Ter Wal, 2014)[17]. It was observed that, although an organization may encourage its staff to be more open, individuals often shy away from these efforts (Salter, Crscuolo, and Ter Wal, 2014). In addition, a recent em-

[11] One of Open innovation modes. Section 2 discusses more details.

[12] Schumpeter presented the following five types as innovation, rather than innovation, (neue Kombination)"new combination" in the first edition of his great classic, The Theory of Economic Development (1911).

[13] The definition here means an innovation is the result of the successful commercialization of an invention.

[14] One of the core of the innovation approach, and it focuses on human experience.

[15] Chesbrough(2003).Open Innovation: The new imperative for creating and profiting from technology.

[16] Chesbrough, Vanhaverbeke and West(2014)

[17] Salter, Crscuolo, and Ter Wal (2014)

pirical research implies that students theoretically understand the advantage of openness, but do not apply it to their own behavior (Oganisjana, 2015)[18].

Following these initial insights, more research from different settings arose, causing the definition of OI to be refined. Following the original and more recent conceptualizations (Chesbrough, 2003 p.43, 2006a; Gassmann and Enkel, 2004; Dahlander and Gann, 2010; West and Bogers, 2014), Chesbrough and Bogers (2014) define OI as a distributed innovation process based on purposively managed knowledge flows across organizational boundaries, using pecuniary and non-pecuniary mechanisms in line with the organization's business model. These flows of knowledge may involve knowledge inflows to the focal organization (leveraging external knowledge sources through internal processes), knowledge outflows from a focal organization (leveraging internal knowledge through external commercialization processes), or both (coupling external knowledge sources and commercialization activities). The latter perspective of coupled OI has recently been used to also connect the literature on OI with research on user innovation (Piller and West, 2014), a stream in the literature focusing on the contributions of users and customers for the innovation process.

Open innovation means that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well. This approach places external ideas and external paths to market on the same level of importance as that reserved for internal ideas and paths (Chesbrough, 2006, p.1).

2. Three types of OI

Figure 1 shows the three archetypes of open OI.

As firms collaborate with universities, there are three different ways in which they may engage with them—which the open innovation literature has termed inbound, outbound, and coupled processes. (West and Gallagher, 2006a; West and Lakhani 2008; Vanhaverbeke et al., 2008; Enkel et al., 2009; Tucci et al., 2016).

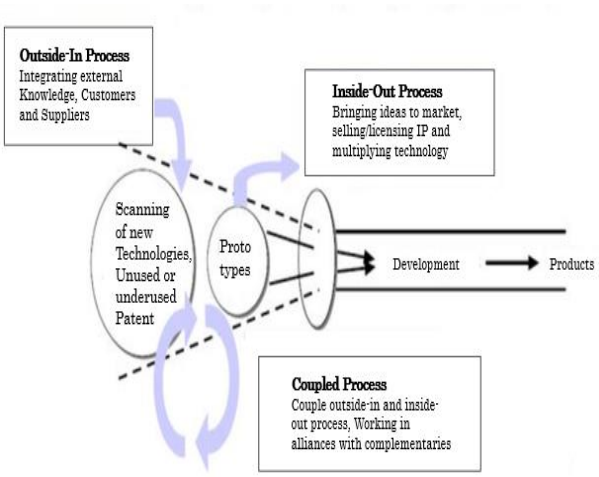

Figure 1. Three Archetypes of Open innovation processes[19]

Source: Towards a Theory of Open Innovation: Three Core Process Archetypes by Gassmann & Enkel (2004), author applied

Through the inbound process, firms import external knowledge or resources to develop internal innovations. This is, the most commonly researched process (West and Bogers, 2014) building on related bodies of work such as absorptive capacity (Cohen and Levinthal, 1990). In the outbound process, firms' patent license or transfer internally developed innovations outside the firm (Chesbrough, 2003). Finally, the coupled process is defined as "coupling the inbound and outbound processes by working in alliances with complementary partners" (Gassmann and Enkel, 2004). That is, it has been assumed students idea contest assumed as Coupled innovation mode.

3. Success factors of OI

Systematically reviewed the success factors of the open innovation process as

[18] Oganisjana (2015).A study at Riga Technical University in Latvia, p.1.

[19] Gassmann & Enkel(2004), p7. Gassmann & Enkel (2001). According to the research 'Towards a Theory of Open Innovation: Three Core Process Archetypes' done by Gassmann and Enkel, University of St. Gallen, Switzerland.

derived from the empirical research literature (2003-2012)[20]. These success factors are grouped into nine factors: 1) the people involved in the process, 2) partners relationship aspect, 3) facilitators, 4) supplies and equations of resources, 5) Leadership, 6) process management, 7) culture, 8) governance, 9) IP patent management.

4. Discussion on published patents for exit strategy

Intellectual property rights[21] (IPRs) are generally designed to exclude others from using a firm's ideas and inventions. Hall (2010) argued that, at first glance, open innovation and IPR protection are irreconcilable. Open innovation implies a willingness to allow knowledge produced within the firm to spill over to others (possibly with the expectation of receiving knowledge spillovers from others in return) whereas IPR protection enables a firm to exclude others from using that knowledge (Hall 2010, p1).

Despite this contradiction, some of Japan's largest patent holders, including Fujitsu, Panasonic, and Osaka Gas, have embraced the open innovation model. Motohashi (2006)[22] investigated the role of patent system in innovation at the firm level, and found that open strategy firm with active licensing spends more on R&D.

Some SMEs doubt that the IP being given up by these large firms is very valuable to them. Indeed, the technology they offer to the OI will not be their most valuable. Instead, it will be a technology for which they have no further development plans but that they think can be developed by others in a manner that may ultimately benefit them via knowledge spillovers or increased demand for the firm's own goods and services.

Intellectual property managing can be used in two ways to help manage open innovation. First, the necessary codification of an invention or technology which occurs when a patent application is successful, helps to structure collaboration agreements (Hall, 2010, p.4). Although, uncertainty and imprecision are inherent in the definition and scope of any piece of knowledge or technology that is to be licensed to another party, this imprecision can be mitigated if the description is already subject to the standards imposed by patent offices. In addition, because the patent is a legal document, in principle the language of the document is already suitable for use referenced in a different legal document, such as a license. Second, IP rights can be used defensively to negotiate cross-licenses with others in the industry that hold complementary technologies, thus avoiding mutual litigation. Many firms in the semiconductor and computing hardware/software industries pursue this strategy (Hall, 2010, p.5).

5. Creative Problem Solving[23]and Analogical Thinking[24]

Fisher argued that creative problem solving is a proven model for driving innovation when implemented as an organization wide business process (Basadur, 2001; Basadur & Gelade, 2003). Figure 4 is an adaptation of Basadur's Simplex model[25] (Basadur, 2001). In the Simplex framework, creative problem solving follows three distinct phases: problem formulation, solution find

[20] To determine the current research status and answer the research question, the criteria for inclusion and exclusion was selected. The inclusions were published in 2006-2017 as empirical papers and peer reviewed ProQuest ABI/Inform, Web of Science and EBSCO were accessed, and searched for materials using the keywords "open innovation process," "open innovation activities" "open innovation," combined with "University–Industry collaboration" or patent". This was done from June 2016 to January 2017.

[21] Source: Japan Paten Office Asia-Pacific Industrial Property Center, JII

[22] Motohashi (2006), p.1.

[23] Fisher (2011),p.71

[24] Kima &Horiia (2016). A Study on an Assessment Framework for the Novelty of Ideas Generated by Analogical Thinking. Their research method was three workshops and a questionnaire survey.

[25] This model has been used successfully in hundreds of innovation workshops at Procter & Gamble's innovation studio; the GYM.

ing, and execution (Fisher, 2010).

Figure 2. Creative Problem Solving
Source: Basadur, Basadur's Simplex model 2001. Adapted by author.

Each phase includes a divergent step (in which all options are explored) followed by a convergent step (in which the most promising options are carried forward to the next step in the process). Basadur's research shows that organizations with a culture of continuous problem finding, problem solving, and implementation — along with requisite attitudinal, behavioral, and cognitive skills — have the greatest long-term innovation success (Basadur and Gelade, 2003). Kima and Horiia argued that as an ideation tool, analogical thinking enables conceptual change, which is seen as a crucial aspect of creativity. In this regard, the use of analogy can be an important instrument to facilitate novel idea generation (Kima and Horiia, 2016, p.201).

6. Research questions

Previous theoretical and experimental literature lead the following questions.

- To what degree do university students use knowledge channels of collaboration in OI-UNIC? OI? (Knowledge channels are places where internal or external ideas or knowledge flow)
- To what degree do the students think knowledge channels of collaboration in OI-UNIC are valuable for innovation elaboration with open innovation?

The goal of this research was to determine if certain teaching and learning methods and approaches-students not only create ideas and write business plans but also make prototypes of new products, and test the prototypes with potential business partners-can be applied to university study practices.

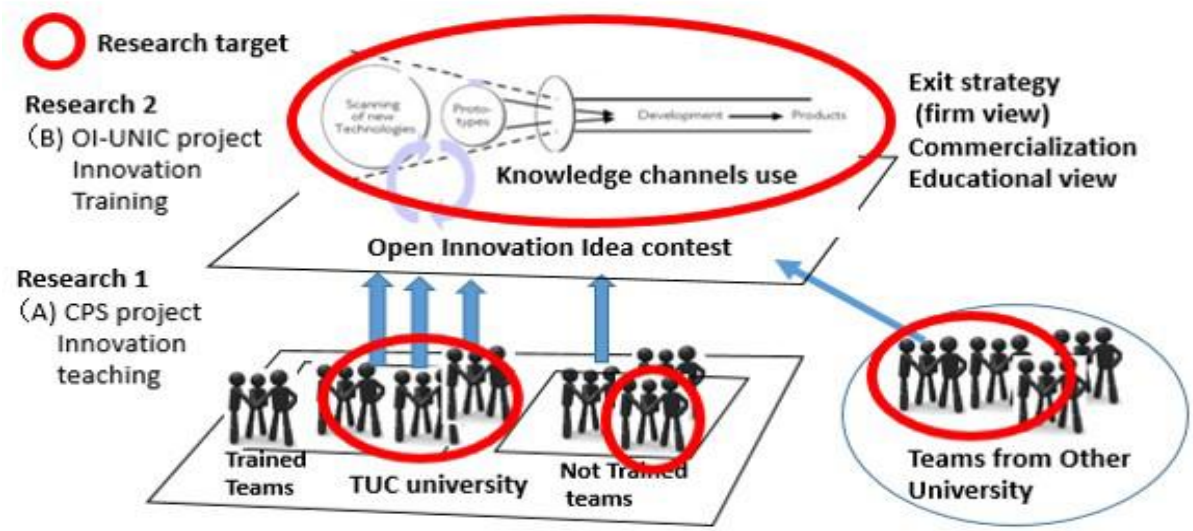

Figure 3. Research framework
Source: Author illustrated and adapted the concept of coupled type innovation to the student idea contest. "Three Archetypes of Open innovation processes" (Gassmann & Enkel, 2004) and Chesbrough's Open Innovation Model (2003a, 2003b,2006) to the OI-UNIC.

(3) Research framework

Figure 3 shows the research framework for study of the knowledge exchange channels between students and collaborators.

Japanese regional open innovation is the results of a complex interaction of various actors and institutions. Universities (students) large firms (licenser), SMEs (licensee), City industry policy divisions, and financial institutions ("Shinkin" credit bank or local bank) play crucial roles in accelerating innovation. Human-driven innovation using ICT and patent is a result of interaction and feedback among all elements within the system rather than an occurrence in a complete linear system (OECD, 1977). Project (A) 2015-2016: University –Industry collaboration was an innovation teaching including creative problem solving and analogical thinking. Then Project (B) 2015/2016: Open Innovation- University–Industries collaboration was an innovation training: knowledge channels, performance exit strategy and commercialization

(4) CPS Project 2013-2016[26]

1. Overview

The CPS project was implemented from 2013 to 2016 under the theme "Welfare business and ICT[27]". The CPS project provided training in innovating the design of products, services and other systems using the Creative Problem Solving model, analogical thinking, and innovation management approaches developed collaboratively TUC University and private companies or public institutions.

2. How CPS series work[28] 2016

CPSs began with class instruction (1 class), followed by lectures about ICT (4 lectures), CPS lectures and workshops using the Active Learning method (10 lectures/workshops). The participants were Sophomore enrolled in TUC and auditors.

The CPSs operated as follow:

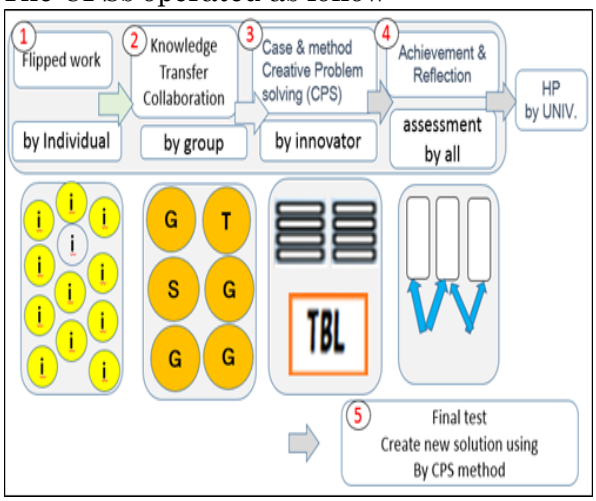

Figure 4. The 5 steps of CPS
Source: Author (2016,p.74)

Step 1: A pre-task given to participants one week before. The pre-task consisted of answering questions about a current issue related to the innovator's business mode, viewing YouTube videos and searching for information on websites.

Step2: During group discussions about the business mechanism, small teams of students (five or six students) absorbed information and opinions from others.

Step 3: The innovation tried to visualize the sophisticated complex issues inherent in their business and explained the path to solutions incorporating the viewpoints of various users. A method of designing a product or service system with the latest technical system that provides new functions from creative problem solvers were presented. In some classes, the Innovation Project Leader explained the management of complex and medium-sized projects with the stakeholders. In order to cope with uncertainty and high-liquidity environment and social problems, innovative business system development was explained.

Step 4: After each lecture, the students

[26] "CPS" project started in 2013 and ran for 4 years.
[27] ICT means Information Communication Technologies
[28] The CPSs implemented at the Takasaki University of Commerce, during the months of April-July in the years 2013-2016 (Number of Participants were including auditor of class who registered from high school etc. N=80 in 2013, N=80 in 2014, N=190 in 2015, N=160 in 2016). 2 credit course, 15 hours classes for 2nd year students and above.

submitted self-assessment and reflection sheets.

Step 5: As a final assessment, students selected one topic, identified the problem, and proposed a new business utilizing the CPS method and analogical thinking.

3. Proposal of a new business solution by analogical thinking

As shown in Table 1., CPS examined innovation examples in three area: 1) products and processes (anti-aging cosmetics, pharmaceuticals, automobiles and equipment, AED, biotechnology, etc.); 2) operation system (efficient production management by tablet, cabin service, smartphone security); and 3) social issues (such as disaster / emergency medical care, tablet education, entertainment, communication, and food in space development, forest management, etc.).The final task for the students was to apply analogical thinking, creative problem solving skills, and the proposed business solutions. Data was collected from the 60 to 80 participants who participated in this study.

4. Method and results

Data was collected from the student's reflection sheets and final test according to the 5-steps. The qualitative contents analysis was based on the CPS learning model (Figure 4).

The following four questions were used to evaluate the students in the course.

・Did you fully understand the issue?

・Did you improve your ability to find and resolve problems?

・Did you actively work on the CPS task?

・Did you create an idea using information technology?

The student reflection papers received high scores (4 or 5 on a 5-point scale). However, they chose problems that were closely related to everyday life experiences because it was difficult to apply an analogy to business problems in areas where they lacked

Table 1. Innovators/Themes/ 2015-2016[29]

2016	Innovators	Theme
May 9	IPA, Mr. Komon	Smartphone security
May 18	Nomura HD, Mr.Sakai	Net equity investment
May 23	Dentsu PR ,Dr.Kitami	Digital PR& Social Media Flames
May 30	System alfa, Mr.Okada	Cognitive elderly wandering with GPS
Jun 6	Nihon Kohden, Mr.Tanaka	Automatic external defibrillator R&D
Jun 13	Yomiuri, Mr. Orita	Newspaper new Technology
Jun 20	JAXA, Dr.Nakazara	Space food & Satellite Communication
Jun 27	Maebashi red cross hospital, Dr.Nakamura	Disaster, Life Saving by Doctor Heli
July 4	Fujitsu, Mr. Mizutani	Sensor system in automobile
July 11	ANA, Ms.Kawamoto	Cabin Service
2015	Innovators	Theme
May 11	Cyber Police agt. expert	Cyber Criminal
May 18	Senior Life Association, Mr.Hirai	Web platform of Senior Life
May 25	Gain, Mr.Miura	Internet Business risk & chance
Jun 1	Panasonic, Mr.Takeyasu	New Business Model
Jun 8	Shiseido, Dr. Amano	Anti-aging cosmetics
Jun 15	NARO, Mr. Hayashi	Automated Agriculture Machine with GIS
Jun 22	LINE Mr. Eguchi	Communication & security
Jun 29	Maebashi red cross hospital, Dr.Nakamura	Emergency, Life Saving by Doctor Heli
July 6	Fujitsu, Mr. Kouketsu	Leaner centric education
July 13	Mitsubishi UFJ Lease & Cyubu Forest Management, Mr.Kizuka et al.	Forest Business

Source: Author.

[29] Themes in the past: 2014 Cases: Regeneration of regional economy by comedy project of "Yoshimoto Kogyo". A robust solution for cybercriminal by IPA. Promotion of local souvenirs by "International Tourism Association". "NARO" solution of agricultural business with GPS equipped agricultural machines, World Heritage and tourism policy of Tomioka City. Doshisha University exercise for anti-aging. Medical efficiency by SAP Japan. Tourism insight solution by "social media analysis" by "NTT Comware".
2013 Cases: TV commercial data transfer system by "IMD Japan", Operation of doctor helicopter in case of disaster. Hospital network system by NEC, user experience value products by "LION Corp.", production management with WIFI tablet by EXE, large-scale data analysis of smart society by OKI, information security system of Canon MJ, regenerative medicine of Advanced Medical Ltd. etc.

business knowledge and experience.

(5) OI-UNIC 2015/2016

1. Overview

Open innovation in the university–industry collaboration is one of the most important elements for fostering innovation in regional economies. Many initiatives exist to support these activities in different ways. This section presents OI–UNIC cases in Japan, in 2015 and 2016. It presents the idea, published patent, multiple channels of knowledge flows and first results in open collaborative innovation particularly those related to student' contests.

2. Innovation's-i[30]" idea platform

The core idea behind the idea contest project is to create innovative ideas by proactively exploiting the company's published patents and the student's intellectual potential. "Innovations-i" office launched the Open Innovation Gateway (OIG) for the Student Idea Contest on the website in 2015. The OIG is a platform where organizations as patent license), student' teams (as idea creators), and SMEs (as entrepreneurs) utilize patent information and applied product.

3. Interview with Fujitsu mission and patent division exit strategy

Author: What is the mission of Fujitsu, specifically, the patent division?
Fujitsu: Through the OIG, Fujitsu Inc.[31] works to activate innovative drivers faster, both inside and outside the company, and, based on collaborations between internal and external partners, verifies and transforms them into practical businesses. We are promoting 'co-innovation' using our open patents selected among from own holding approximately 95,000 patents[32] to support new businesses through the SMEs"[33].

Author: What is the significance of using patents?
Fujitsu: The mission of the Fujitsu Limited Business Development Department is to develop the business of the SMEs through patent licenses as an published patent that are not utilized within our company, or newly use her own business model.[34]

Author: How far can you offer support?
Fujitsu: Even without introducing new technologies, small businesses can create highly competitive products and services in the market with innovative concepts. Nonetheless, the use of new technology increases the possibility of creating innovative products and services that are not in the world, and if the new technology is patented as a patent, the market competitiveness of the product is markedly improved. Therefore, it is possible to prevent a competitor from entering the market in an uncontrollable way[35]"

Author: What is different from technology transfer?
Fujitsu: We consistently support what we need for commercialization until commercialization. Such a technology transfer method is distinguished from an act of simply selling patent licenses and placing a list of published patents on the public shelf[36].

Author: Can the business plans of university students be commercialized?
Fujitsu: Business proposals and consistent

[30] Its' role was context organizer and intermediary. Interview with Mr. Kudo, innovation director (January, 4, 2017)

[31] Fujitsu Inc. headquarter is located in Kawasaki city, is a leading ICT total-solution company in Japan that provided a published patent. Fujitsu Ltd. launched Open Innovation Gateway (OIG) in Kawasaki city in Japan. It is a platform to connect and grow ideas, and based on the collaboration of internal and external partners, to verify and transform them into practical businesses.

[32] Intellectual Property Report for FY 2014.

[33] Author Interviewed Masatoshi Nishida, Vice President, (January 4, 2017) Intellectual Property innovation Division, Headquarters of Fujitsu Legal, Compliance and Intellectual Property Unit.

[34] Ibid.

[35] Author Interviewed Masatoshi Nishida, Vice President, (January 4, 2017)

[36] Ibid.

support are products rather than patent licenses. By utilizing Fujitsu's patents to create a business plan for university students, universities, local governments, financial institutions jointly create a place to create new businesses that are not bound by existing concepts. I believe that human resources can be raised through social learning.[37]"

4. Contest start

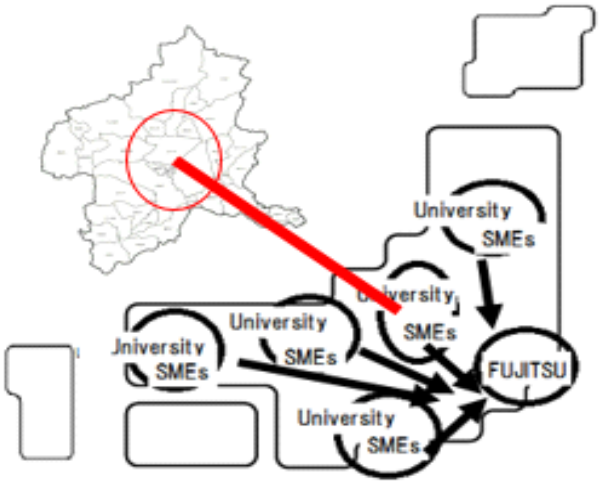

Figure 5. Participants Location of the Open-UNIC 2016
Source: The author edited data from http://opi.innovations-i.com/idea/purport/

Figure 5 shows images of the location of participants and the TUC University, SMEs in Maebashi City of Gunma Prefecture in the northern Kantō region of Japan.

5. Rules of contest

Six requirements and problems to solve were given to each team.

1) To create idea from the viewpoint that you want to purchase yourself, or you want to use (useful / interesting / surprised).

2) To identify differentiation from similar products.

3) To add ideas as patents are a part of the information on some products and services.

4) To propose the following related ideas leading to the business of the SMEs. *Product or service must be related to: a) Revitalization support. b)Tokyo Olympic Games, Paralympic Games 2020. c) To contribute to the regional economy.

5) To utilize one of the six Fujitsu patents.

6) To assume an annual turnover of about 10 million yen to 100 million yen.

6. Type of patent

The OI-UNIC 2015 began in June with a total of 71 student teams from around Japan and 12 types of published patents offered by three organizations (JAXA, NHK E.S., and Fujitsu[38]), and finished the national competition in January of the following year. The OI- UNIC 2016 project started in June with19 types of published patents offered by five organizations (Fujitsu, NHK E.S., AIST, Fujitsu-ten, and Panasonic[39],and ended in December 2017 in Tokyo. Table 2 and Table 3 list the available types of patent and team selections.

7. OI gate, knowledge route and knowledge exchange channels

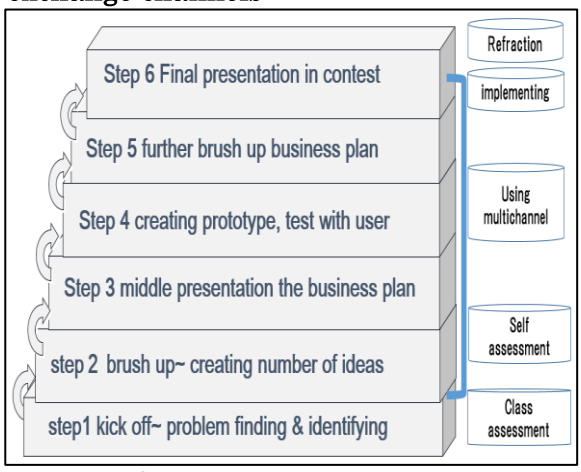

Figure 6. OI 6 gate and assessments
Source: Author.

Figure 6 describes the gates and assessment of the OI. During the kick-off mee-

[37] Ibid

[38] Formal name is as follows. Fujitsu = Fujitsu Limited, HKE E.S.= NHK Engineering System Inc., JAXA= Japan Aerospace Exploration Agency

[39] AIST =National Institute of Advanced Industrial Science and Technology.

Table 2. Number of Team and Published Patents in 2015

.	Type of published patent	License Provider	Numbers of Teams
1	Sales support technology using transmission type liquid crystal and half mirror	Fujitsu	9
2	Screen display control technology of vending machines according to users	Fujitsu	5
3	Product suggestion technology considering remaining budget	Fujitsu	11
4	Capture and play equipment technology	Fujitsu	8
5	Article inspection technology by hammering analysis	Fujitsu	8
6	Contact sensor technology using air bag	Fujitsu	6
7	Metallic coloring technology without paint	Fujitsu	14
8	CG character control technology	NHK E.S.	1
9	Image retrieval technology by drawing requested image using image elements in database	NHK E.S.	1
10	Tactile presentation technology to convey diagrams and graphs	NHK E.S.	0
11	Flexible solar cell	JAXA	5
12	Two-dimensional actuator	JAXA	3
	Total	3	71

Source: Author edited data from http://opi.innovations-i.com/idea/purport/

Table 3. Number of team & Published Patents in 2016

	Type of published patent	License Provider	Numbers of Teams
1	Code embedding technology using light emitting diode: LED	Fujitsu	28
2	Gaze detection technology	Fujitsu	24
3	Behavior state detection technology	Fujitsu	11
4	Direction guidance technology	Fujitsu	5
5	Temperature difference power generation technology	Fujitsu	11
6	Advertisement related technology	Fujitsu	19
7	Three-dimensional sound reproduction technology with headphones	NHK E.S.	0
8	Television system applying the AR (Augmented Reality) technology "Augmented TV"	NHK E.S.	0
9	CG character animation production technology	NHK E.S.	0
10	Inflection conversion technology	NHK E.S.	0
11	Two-dimensional code easy to understand with dot picture	AIST	1
12	Two-dimensional actuator	AIST	3
13	Switchable light control mirror with gas	AIST	0
14	Photo synthesis system considering size	AIST	1
15	Electric switched dimmer mirror	AIST	1
16	Door auto-lock technology	Fujitsu-ten	0
17	Door unlock warning technology	Fujitsu-ten	0
18	Mike picking up tweets	Panasonic	0
19	Super directional speaker	Panasonic	3
	Total	3	107

Source: Author edited data from http://opi.innovations-i.com/idea/purport/

ting (Gate 1) the team carefully chose a published patent, defined the current problem, created and brushed up an idea (Gate 2), proposed a business model (Gate 3), created a prototype and tested it with users (Gate 4), further brushed up the idea (Gate 5), and presented their plan in the business contest (Gate 6). The team can work with their collaborators through multiple knowledge

route (Figure 7) based on their business model through the project.

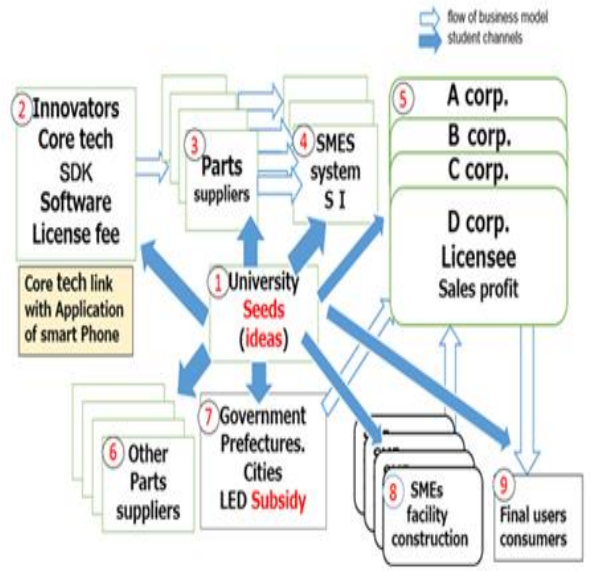

Figure 7. Kowledge Route with Collaborators
Source: Author.

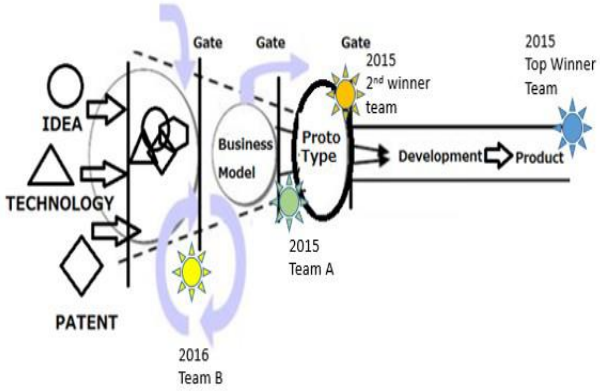

Figure 8. OI- UNIC licensing 2016
Source: Author illustrated (2016) and adapted Chesbrough's Open Innovation Model (2003a, 2003b,2006) to the OI-UNIC students idea contest.

Figure 8 ilustrates team innovation performance on OI process. Blue marked team ~ Top Winner team has exit.

8. Methods and results

8.1. RQ 1 methods and results

The first research question, "To what degree do university students use multiple channels of collaboration in OI-UNIC?" was explored based on qualitative analyses (author's observations, student reflection papers, and interviews with potential partners

Table 4. Knowledge Exchange Channels

	Knowledge multi-channel	Type of collaboration (Ba)
1	within team	Kick off, brushing up, selecting published property. Students divided their responsibilities for product concept, design, solution, finance, market research by exchanging findings and discussing further activities with their teammate.
2	student-teacher	Teacher open to discuss, advice and facilitate students learning theory and practice both at individual and team level. (encourage)
3	team other-team	Kick off, brush up, intermediate phase. Team present their idea done and discuss the challenges faced with the other teams.
4	team-mentor coordinator outside	Coordinator visiting, telephoning, or meeting at city office, recommending particular SMEs to realize and need specific experience and knowledge.
5	team-firm 1 engineer	Presentation, discuss, advice regarding hardware
6	team-firm 2 engineer	presentation, discuss, advice regarding software
8	team-firm 3 partner	Presentation, discuss, advice regarding business model, marketing
9	team-staff-licenser	Brash up, intermediate phase, Team present their idea done and discussed the challenges faced with the license
10	team-staff city administrator	Advice regarding contact to SMEs, scheduling.
11	team-staff investor	Advice regarding financial information
12	team-final users	Interview, questionnaire, observation

Source: Author's observations[40] (2016)

[40] Author researched type of collaboration channels are researched, revised, and modified based on the work of Oganisjana (2015).

outside the university), according to the knowledge exchange channels (Table 4), OI-UNIC steps (Figure 6) and the knowledge route (Figure 7). Figure 8 compares winner team.

Results of R1: Partly applicable but not all (Table 5). The proposed assessment framework for collaborative behavior is inapplicable to the "one size fits all" type of students. It does overcome some of the limitations of current evaluation methods.

Table 5. RQ1: Result [41]2015 and 2016

	collaboration channel	2015 Team A N=16	2016 Team B N=12	2015 Top Winner Team	2015 2nd Winner Team
1	within team	100	60	-	-
2	students-teacher	100	60	-	-
3	team-team	5	5	-	-
4	team-mentor coordinator outside	50	10	-	-
5	team-firm 1 engineer	50	5	license contract	than 11 partners
6	team-firm 2 engineer	20	5		
7	team-firm 1 partner	20	5		
8	team-firm 2 partner	40	10		
9	team-staff licenser	60	0		
10	team-staff city administrator	40	5	-	-
11	team-staff investor	10	0	contract	high
12	team-final users	200	10	full use	-

Source: Author's observations[42] (2016).

8.2. RQ 2 methods and results

The second research question, "To what degree do the students think multiple channels of collaboration have value for their practical studies of OI," was explored according to the Value List (Table 6).

Unlike in previous studies (Oganisjana, 2015), the author considered technical information about the published patent. Although Oganisjana (2015) categorized (IN, OUT, IN-OUT-IN) as a "fragment of the qualitative content analysis and labeling of the categories," the author included technology information about the published patent and redesigned the study.

Table 6. Value Lists and Categories

	Value List	2015 Team A, N=16			2016 Team B, N=12		
		category			category		
		in	out	in-out -in	in	out	in-out -in
1	Experience		40		45		
2	Knowledge		30		39		
3	Othr idea		30		12		
4	Advice		5		30		
5	Problem solving		3		7		1
6	User view			4	16		
7	Motivation	3	3	30	6	6	14
8	Creating	9	9	30	9	4	12
9	Support	4	4		7	4	
10	Business thinking	16			12		
11	New opportunities	16			12		
12	Critical thinking	6	2	4		6	
13	Creating	12			8		
14	Information patent	16	8	4	11		

Source: Author (2016)[43].

The qualitative content analyses accounted for the three possible categories of action.

A) IN (inflow): students get an idea (they judge useful) from collaboration partners related to the category.
B) OUT (outflow): students give an idea (they judge useful) to collaboration partners related to the category.
C) IN-OUT-IN (inflow–outflow): students exchange ideas (they judge useful) with collaboration partners related to the category. The student reflection papers and

[41] The 2015 top winner was Showa Women's University team-"Small Drone Gate Passing Game supported by Showa Shinkin (Tokyo). Team A created a prototype and just won at regional stage. http://opi.innovations-i.com/feature/idea/re/20151217/.
The 2016 top winner was university of Shizuoka team-"Spot with spots!" supported by Seishin Shinkin. http://opi.innovations-i.com/idea/report/.
Team B lost game at the regional competition.

[42] Type of collaboration channels revised and modified the work of Oganisjana (2015).

[43] Compared Team A (prize) with Team B (no prize). Team A was participated in CPS Project (innovation training), value information patent, and critical thinking more than team B.

the author's observations of student behaviors revealed that the students highly value the potential for intergenerational collaboration outside formal university frames.

However, the student reflection also revealed that while some students are aware of the value of studying in collaboration channels, they did not active and full use the open channels.

(6) Findings

In this section, we present the findings from the systematic review.

Management point of view:

① Reliable goals and time schedules seem necessary to build the credibility of the collaboration.

② Initial ideas don't generate much value in themselves. There needs to be professional guidance for creative problem solving and discussion of the idea.

③ Companies often have tended to claim openness, while knowingly concealing certain information, such as patents or possible sources of competitive advantage.

④ Clear prizes for innovation challenges are necessary. For example, a career-related reward is much more fulfilling and motivating. Other rewards include internships, monetary prizes, and presenting the winner's name on a website.

⑤ Face-to-face is good for the initial phase where different concepts and processes are tested, but in the long run, online channels are more useful for the entire innovation process.

⑥ Building trust and collaborating on an idea takes times. Financial institutions play a role in building trust.

(7) Conclusion and hypothesis

Although the findings suggest that the proposed method of innovation education is inapplicable to the "one size fits all" type of students, the method does overcome some of the limitations of current evaluation methods. This study shows that universities can play an active role in promoting innovation in an OI activity, as well as shows how study courses and projects can foster greater innovation by students. The study revealed several problems for further research.

The main conclusion of this study formulated as a hypothesis, is that: when clear guidelines for innovation management and indication of innovation performance, in OI are prepared, university students can become more collaborative and motivated to work with potential business partners outside the university, the effect of active learning can be further enhance.

(8) Limitations and future research

This study of innovation education in an OI required students to pose a theoretical framework of innovation education in OI and test it empirically. Future investigations should note the limitations of this study. First, the data source was limited to the author's university students. Second, the research conducted using qualitative content analysis.

Acknowledgements

Project (A) was partly supported by the Telecommunications Advancement Foundation (2013-2016). Project (B) was partly assisted by the Community Center at Takasaki University of Commerce, the Industry Policy Division of Maebashi City and the staff of related organizations and facilities in Gunma. Special Lecture and workshops were assisted by many industries. I deeply appreciate their cooperation.

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(Received: January 31, 2017)
(Accepted: May 23, 1017)