Knowledge Management of University-Industry Collaboration in the Learning Economy

Irina-Emily Hansen, Ola Jon Mork
Department of Ocean Operations and Civil Engineering
Norwegian University of Science and Technology
Aalesund, Norway
irina-emily.hansen@ntnu.no, ola.j.mork@ntnu.no

Torgeir Welo
Department of Mechanical and Industrial Engineering
Norwegian University of Science and Technology
Trondheim, Norway
torgeir.welo@ntnu.no

***Abstract*— Rapid transformation of technologies and markets challenge organizations to build structures and norms that promote learning and innovation. Up until now, however, knowledge management has not been a common subject for investigation of university-industry collaboration in innovation projects. The few known studies have concentrated on the numbers of patents, spillovers and publications, or institutional set-up on the success of collaboration. The scientific community has paid little attention on how to leverage learning and knowledge creation in university-industry innovation projects, thus increasing their innovation impact on both organizations and society. This article addresses knowledge management collaborative university-industry projects and proposes a relevant knowledge perspective to stimulate outcomes.**

Keywords-knowledge management; learning organization; organizational memory; university industry collaboration; innovation projects

I. INTRODUCTION

To generate new products, processes or technologies, companies are looking for ideas outside their organizational boundaries [1]. Collaboration with universities allows companies to acquire new knowledge that can improve their organizational performance and competitiveness [2][1]. Research projects, technology transfer, research consultancies are all different forms of university-industry collaboration (UIC). When using external knowledge for internal innovation, organizations have to absorb the new knowledge. Knowledge becomes obsolete much faster than before, which emphasizes the need to learn and to create new knowledge in a fast pace, challenging knowledge management to build organizational forms that promote learning and innovation [3].

The role of individual capabilities and interdependence between individual and organizational components is a key factor in innovation processes, meaning that organizational practices should support individuals to become more effective innovators [4] [5] [6]. When it comes to knowledge management of UIC projects, there is a lack of practical guidance to support individuals from different 'worlds' in co-creation of knowledge and innovation, thereby developing the absorption capacity of both organizations [7] [8] [9].

The other issue motivating more research is the importance of incremental innovation that takes place in university-industry collaborative projects. The majority of the research done on university-industry partnerships has concentrated on the so-called STI mode of innovation, where innovation is a result of industrial integration of universities' scientific technological knowledge. The importance of DUI mode—innovation based on doing, using and interaction—has been underestimated [10] [11]. This kind of innovation is typical for operators when dealing with problems in their daily operations. It is mostly undertaken in applied research and development and has incremental character. However, it happens more often than radical innovation grounded in basic research, and has a significant impact on the growth of the whole economy [12].

To answer the research questions posted in this article, we performed a literature review seeking to find evidence on (best-) practices in collaborative university-industry innovation projects. Such a literature review establishes the current state of the art in the field while highlighting potential issues that require more research. Thus, this paper addresses the identified need of studying how to more efficiently and effectively manage innovation processes in collaborative research projects. The paper comes with the research objectives aiming to design a practical approach for management of UIC projects with knowledge transformation in focus.

To enrich the understanding of the aspects that need investigation, next sections will present the challenges faced by university and industry in innovation projects. Each challenge is deliberated from the knowledge perspective. The research questions and a brief outline of the research plan are introduced in the last section along with a discussion.

Table I summarizes the challenges, questions and focus areas of the invoked research on university-industry collaboration from the knowledge management perspective.

TABLE I. CHALLENGES, QUESTIONS AND FOCUS AREAS OF THE INVOKED RESEARCH ON UNIVERSITY-INDUSTRY COLLABORATION FROM THE KNOWLEDGE MANAGEMENT PERSPECTIVE

Challenge	Research Questions	Research Focus
1. University-industry collaboration strategies and objectives	How to define a strategy for UIC in innovation projects such that collaboration will continually boost the knowledge base of both partners in a long-term perspective?	• Allocation of the resources, skills and efforts of the people, in the organizational learning process. • How to encourage individuals to believe in the values of collaborative research efforts, and boost social and emotional ties between people.
	How to define project objectives such that they meet both academic and industrial requirements while facilitating innovation?	Define the projects objectives and the results in terms of new knowledge acquired and the degree of implementation in industry.
2. Facilitating university-industry innovation projects	How to facilitate projects to enable knowledge creation and innovation?	Structural and social conditions that support interactive learning externally, across organizations, and internally, across organizational levels. The areas that research should concentrate on: a) UI boundary management: how to trigger and coordinate knowledge creation process and how to disseminate knowledge between organizations and across organizational levels. b) Creating the learning environment that will: • Increase individual creativity. • Provide common language and build trust and commitment. • Support interactions between tacit and explicit knowledge, between individual and collective learning.
3. Accelerating the rate of learning from project to project	How to accelerate the rate of learning from each UIC innovation project?	Investigate managerial mechanisms that are needed to organize organizational memory such that people in UI project teams are able to acquire, store and retrieve knowledge.

II. CHALLENGE 1: UNIVERSITY-INDUSTRY COLLABORATION STRATEGIES AND OBJECTIVES

The challenge to manage university-industry (UI) innovation projects is rooted in fundamental differences of partners' logics. Universities' openness contradicts with the protective attitude of companies and creates problems in regards to intellectual property rights [13] [9]. Another factor is conflicting objectives of collaboration and different time horizons, where industry is looking for tangible short-term outcomes and academia is interested in publishing.

This paper argues that research on UIC innovation projects should turn its focus on how to support the processes of learning and knowledge creation in all phases of innovation project—rather than measuring the inputs such as motivation factors for collaboration, or outputs such as number of patents and the like. This will optimize knowledge exchange and co-creation processes in projects and intensify their innovation impact.

When university and industry collaborate in an innovation project, they create a collaborative unit that can be considered as one innovative enterprise with its own 'strategic control' and 'organizational integration' as some of the key social concepts. Here the 'strategic control' means a set of relations that gives executives the power to allocate resources to confront uncertainty of innovation [3] [5]. Allocation of resources implies 'organizational integration' of the skills and efforts of the people in the organizational learning process [3]. Hence, the study should explore how the university and company can align their research strategies and allocate resources to innovation such that collaboration will continually boost the knowledge base of both partners in a long-term perspective.

The innovation is uncertain and it is difficult to be sure about the results of innovation processes [5] [3]. It is thus challenging to define the UIC project objectives especially when partners have distinct interests. Both academic and industrial benefits should be derived from the project. Nonetheless, innovation is a dynamic process with learning as outcome, and it is of common interest for both partners [3]. Therefore, the research should investigate if the UIC innovation project objectives and the results can be defined in terms of new knowledge acquired and the degree of implementation in industry (See Table I).

III. CHALLENGE 2: FACILITATING UNIVERSITY-INDUSTRY INNOVATION PROJECTS

It is proven that structural conditions, formal and informal incentive systems, norms for internal and external collaboration are crucial for learning and innovation processes [14].

Different forms of collaboration between university and industry require different support structures and motivation mechanisms [9]. Therefore, we introduce the context of the research that this article stresses.

The research will find place at Norwegian University of Science and Technology, campus Aalesund, which is located at the west cost of Norway. Marine and maritime industries are dominating in this area, but there are also other industries

represented. Shipbuilding companies, fish factories, furniture and food producers are some examples of industries present.

The study will investigate how the university cooperates with local companies in innovation projects, limited to 3 year duration period and restricted to mechanical engineering and industrial design. The incremental innovation typically undertaken in applied research and development is of research interest rather than radical innovation that is more common in basic research [12]. The two types of innovation have their origin in different types of knowledge, tacit and explicit. This will be explained and clarified in the following section.

A. *Tacit and Explicit Knowledge*

The traditional definition of knowledge is 'justified true belief'. He or she creates knowledge by making sense of the information in the given situation. This individual knowledge creation process is anchored in personal beliefs and perceptions of the world.

Knowledge can be explicit and tacit [15] [16]. Knowledge becomes explicit, or codified, when it communicated to others in the forms of sentences, documents, drawings and as such. Tacit knowledge is not easy to convey because it is tied to personal physical and emotional experiences, such as skills in bodily movement, intuitions and life values [17]. Individual creativity, which is a key factor for innovation, is connected to tacit knowledge [4] [18]. Tacit knowledge of operators is often critical for incremental innovations [12] [11]. Due to the nature of tacit knowledge, it represents a challenge for management to capture, transform and (re)use.

B. *Social and Structural Conditions for Innovation*

The actual learning process is the relation between tacit and explicit knowledge, between individual and organizational capabilities [3]. Management's task is to create appropriate structural and social conditions that would support these interactions [5]. The different phases of an innovation process demands appropriate conditions. Kanter has pointed out four innovation phases: "(1) idea generation and activation of the drivers of the innovation…; (2) coalition building and acquisition of the power necessary to move the idea into reality; (3) idea realization and innovation production…; (4) transfer or diffusion, … the commercialization of the product, the adoption of the idea" [5]. Kanter suggested structural arrangements and social patters that organization can apply to facilitate each of the phases. These suggestions imply interaction between people with different knowledge, skills and capabilities to perform successfully each innovation task. Kanter's recommendations are applicable to a company with a commercial mindset, but they should be adjusted for the use in the setting of UIC in innovation projects.

The barriers to successful innovation in university-industry research projects are similar to those that large firms face. Different divisions of a large company are like different 'thought worlds' where individuals organize their thinking and actions in relation to innovation in their own way, so called 'interpretive schemes' [19]. The same situation is relevant for UIC, where academics and industry think in distinct different ways. It brings us to the idea of creating the context—or environment that can support interaction between to different worlds—between tacit and explicit knowledge, between individual and collective learning.

C. *Knowledge Enabling Context for University-Industry Innovation Projects*

The idea of the context, or 'ba', came from Japan and stands for shared space that fosters knowledge creation. It can be physical, virtual and even mental meeting places where people share their personal values and beliefs; where they exchange and co-create knowledge. Social informal meetings, face-to-face discussions of the product's concepts or building a physical or virtual prototype are examples of knowledge enabling context [20] [21]. The essence is that knowledge needs a place to be created because knowledge is dynamic and is formed in continuous interaction between people and organizations and, thus, relying on the situation and people involved [18] [17].

When new ideas are generated by some of the members of UI project team, they must be shared with other project team members and, sometimes, to people outside of the project team. To be assessed by others, the ideas must be translated into the form others would understand [6]. In this case, for example, physical or virtual prototypes can provide a common language [22].

Social face-to-face meetings between individuals involved in a project contribute to trust building, which in turn has positive effect on interactive learning and risk taking, which are crucial components of creativity and innovation [23] [24] [25].

Hence, management of UI innovation projects should think appropriate learning contexts, or learning environments that will increase individual creativity. This context should provide a common language and build trust and commitment, which are the preconditions of the successful collaboration (See Table I).

D. *University-Industry Boundary Management*

The project manager of innovation projects between industry and university is usually a person from the company. A representative from the university has also a responsibility for managing the project on behalf of the university. Both managers act as 'gatekeepers' between the UI project team and their organizations, including departments directly involved in the project and other departments across organizations. Other industrial and/or academic partners are often involved in the project in order to contribute with their expert knowledge. Therefore, managers have to cope with many relations. In practice, there is always a challenge for companies to devote personnel to manage alliances. Especially projects that involve tacit knowledge require considerable managerial resources [12].

From the knowledge perspective, the two managers have the tasks to trigger and coordinate knowledge-creation process. They act as 'scouts' that have responsibility to mobilize broader participation both in generation and justification of the concepts [26] [5]. The managers have to ensure that internal users of the new solution are involved such that they feel an ownership to the project and thus contribute to the development and adaption of the idea [27].

Managers must be also ‘ambassadors’ that transmit knowledge to others outside the project team [26] [5]. Globalization, or dissemination of knowledge across many organization levels, is instrumental in inducing of organizational learning [17].

The diversity of external and internal participants, tightness of the relationships and cultural norms within these networks are the contextual characteristics that are likely to influence innovation processes and learning capabilities of partners involved [28].

These arguments call for research on the social and structural conditions that management of UIC innovation projects should provide to facilitate interactive learning across organizations and enhance absorptive capacity of the partners [7] [5] [8] [9].

It is also important to investigate the social conditions in relation to strategy of UIC innovation projects. Specifically, the researcher has to look into how to encourage individuals to believe in the values of collaborative research efforts, and boost social and emotional ties between people [5] (See Table I).

IV. Challenge 3: Accelerating the Rate of Learning from Project to Project

Learning from project to project means not only storing the knowledge about previous projects, but also transforming, generalizing and making it accessible to others and being able to retrieve it in new projects.

Hargadon and Sutton studied one of the largest and successful product design firm in United States, IDEO. Researchers defined IDEO as a technological broker, implying that the success of the firm depends on the firm’s network position and organizational memory that allows acquiring, retaining, and retrieving new combination of knowledge obtained through its position in a network [29] [14].

Hargadon and Sutton claim that the organizational memory relies on individual actions and organizational routines in recognizing, storing, blending and transforming knowledge. IDEO deliberately employs workers that have working experience and hobbies different from background to other designers who already work in the company. IDEO’s organizational norms proclaim that personal knowledge of designers has to be accessible to others in order to be retrieved for new solutions. Displaying individual knowledge in physical objects and prototypes, participating in the routine brainstorming, having open-office lay outs are some of the methods company has integrated in order that everyone in the company knows what the others are experts in and can dynamically co-create new products and technological solutions [14].

Future research on UIC innovation projects can use the IDEO-perspective of organizational memory to investigate how UIC can accelerate learning in both organizations from project to project. The study should focus on what managerial mechanisms are needed to organize organizational memory such that people in UI project teams are able to acquire, store and retrieve knowledge (See Table I).

V. Discussion

This situation invokes the research on innovation projects between university and industry targeting the following research questions:

- How to define a strategy for UIC in innovation projects such that collaboration will continually boost the knowledge base of both partners in a long-term perspective?
- How to define project objectives such that they meet both academic and industrial requirements while facilitating innovation?
- How to facilitate projects to enable knowledge creation and innovation?
- How to accelerate the rate of learning from each UIC innovation project?

The article has defined the areas that research should focus on in order to answer those questions from the knowledge management perspective (See Table I). Both academic managers and company managers with experience in university-industry collaboration will be consulted for interviews. Their opinions and suggestions should provide the solutions to the challenges presented in the article [30]. The research plan consists of three steps:

- Semi- structured and informal interviews of managers and academics on how they experience collaboration and how they would like it to be.
- Analyze interviews and synthesize the results in practical guidelines for managing the UIC innovation projects.
- Test practical guidelines via interviews or workshops with participants from university and industry.

The presented research is relevant for academics, industrial companies and policy-makers. Policy- makers are interested in increasing the innovation impact of academic research on industry. For industry, collaboration with academics is different from collaboration with customers, suppliers, or other business companies. Entering partnership with academics, the industry has to consider the need of academic outcomes. Therefore, policy-makers should establish a set of guidelines helping academic and industrial partners to execute innovation research projects in a way that brings innovative outcomes and strengthens the ‘knowledge-based’ society [9].

When the management—either of universities or industrial companies—is equipped by practical tools to conduct innovation projects more efficiently, it is more willing to engage in more projects and is thus capable of developing skills in managing collaborations, as well as increased awareness of new projects and reputation as a valuable partner [31]. In addition, the positive outcome of innovation projects will most likely trigger new projects with the same partners, because it is easier to mobilize people and resources in a cohesive network where it is greater trust and already functioning norms and processes for collaboration [25].

References

[1] H. Chesbrough, “The logic of open innovation: managing

intellectual property," *Calif. Manage. Rev.*, vol. 45, no. 3, pp. 33–58, 2003.

[2] A. B. Jaffe, "Real effects of academic research," *Am. Econ. Rev.*, pp. 957–970, 1989.

[3] W. Lazonick, "The innovative firm," in *The Oxford handbook of innovation*, Oxford University Press: New York, 2005, pp. 29–55.

[4] T. M. Amabile, "A model of creativity and innovation in organizations," *Res. Organ. Behav.*, vol. 10, no. 1, pp. 123–167, 1988.

[5] R. M. Kanter, "When a thousand flowers bloom: Structural, collective, and social conditions for innovation in organization," 2000.

[6] A. Salter, P. Criscuolo, and A. L. J. Ter Wal, "Coping with Open Innovation," *Calif. Manage. Rev.*, vol. 56, no. 2, pp. 77–94, 2014.

[7] W. M. Cohen and D. A. Levinthal, "Absorptive Capacity: A New Perspective on Learning and Innovation," *Adm. Sci. Q.*, vol. 35, no. 1, p. 128, 1990.

[8] M. Perkmann and K. Walsh, "University–industry relationships and open innovation: Towards a research agenda," *Int. J. Manag. Rev.*, vol. 9, no. 4, pp. 259–280, 2007.

[9] M. Perkmann *et al.*, "Academic engagement and commercialisation: A review of the literature on university–industry relations," *Res. Policy*, vol. 42, no. 2, pp. 423–442, 2013.

[10] B.-A. Lundvall, "Knowledge management in the learning economy," *Danish Res. Unit Ind. Dyn. Work. Pap. Work. Pap.*, no. 06–6, pp. 3–5, 2006.

[11] B. Lundvall, *Innovation System Research. Where it came from and where it might go*. 2007.

[12] R. Narula, "R&D collaboration by SMEs: new opportunities and limitations in the face of globalisation," *Technovation*, vol. 24, no. 2, pp. 153–161, 2004.

[13] E. Sjoer, B. Nørgaard, and M. Goossens, "Implementing Tailor-Made CEE in theory and in practice: The Knowledge Triangle as a Conceptual Tool," *1st World Eng. Educ. Flash*, 2013.

[14] A. Hargadon and R. I. Sutton, "Technology brokering and innovation in a product development firm," *Adm. Sci. Q.*, pp. 716–749, 1997.

[15] M. Polanyi, "Tacit knowledge: Toward a post-critical philosophy." Chicago: The University of Chicago Press, 1958.

[16] M. Polanyi, "The logic of tacit inference," *Philosophy*, vol. 41, no. 155, pp. 1–18, 1966.

[17] G. von Krogh, K. Ichijo, and I. Nonaka, *Enabling Knowledge Creation*. 2000.

[18] G. R. Oldham and A. Cummings, "Employee creativity: Personal and contextual factors at work," *Acad. Manag. J.*, vol. 39, no. 3, pp. 607–634, 1996.

[19] D. Dougherty, "Interpretive barriers to successful product innovation in large firms," *Organ. Sci.*, vol. 3, no. 2, pp. 179–202, 1992.

[20] I. Nonaka, "A dynamic theory of organizational knowledge creation," *Organ. Sci.*, vol. 1, no. 5, pp. 14–37, 1994.

[21] I. Nonaka, R. Toyama, and N. Konno, "SECI, Ba and Leadership: a Unified Model of Dynamic Knowledge Creation," *Long Range Plann.*, vol. 33, no. 1, pp. 5–34, 2000.

[22] O. J. Mork, I. E. Hansen, K. Strand, L. A. Giske, and P. S. Kleppe, "Manufacturing Education- Facilitating the Collaborative Learning Environment for Industry and University," in *Procedia CIRP*, 2016, vol. 54, pp. 59–64.

[23] F. J. Milliken, C. A. Bartel, and T. R. Kurtzberg, "Diversity and creativity in work groups," *Gr. Creat. Innov. through Collab.*, pp. 32–62, 2003.

[24] T. M. Amabile, S. G. Barsade, J. S. Mueller, and B. M. Staw, "Affect and creativity at work," *Adm. Sci. Q.*, vol. 50, no. 3, pp. 367–403, 2005.

[25] L. Fleming, S. Mingo, and D. Chen, "Collaborative brokerage, generative creativity, and creative success," *Adm. Sci. Q.*, vol. 52, no. 3, pp. 443–475, 2007.

[26] D. Gladstein and D. Caldwell, "Boundary Management in New Product Teams.," in *Academy of Management Proceedings*, 1985, vol. 1985, no. 1, pp. 161–165.

[27] J. A. Pertuzé, E. S. Calder, M. Edward, and W. A. Lucas, "Best Practices for Collaboration Best Practices for Industry," *MIT Sloan Manag. Rev.*, vol. 51, no. 4, pp. 83–90, 2010.

[28] J. E. Perry-Smith and C. E. Shalley, "The social side of creativity: A static and dynamic social network perspective," *Acad. Manag. Rev.*, vol. 28, no. 1, pp. 89–106, 2003.

[29] J. P. Walsh and G. R. Ungson, "Organizational memory," *Acad. Manag. Rev.*, vol. 16, no. 1, pp. 57–91, 1991.

[30] R. K. Yin, *Qualitative research from start to finish*. 2015.

[31] W. W. Powell, K. W. Koput, and L. Smith-Doerr, "Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology," *Adm. Sci. Q.*, pp. 116–145, 1996.