Knowledge Value Chain Development: Cross-Field Open Team Knowledge Integration

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***Abstract*--To reflect the growing importance of networking beyond disciplinary and organizational boundaries toward an open R&D system with the commercialization aim, in Taiwan Engineering Section of the National Science Council in October 2009, began to support the "Promoting Program for Cross-Field Creative Scenario Value-adding". This promoting program aims to facilitate the formation and cooperation of the interdisciplinary open teams toward developing one specific knowledge integration process for innovative R&D, method from "creative idea", "feasibility assessment", "prototyping", to commercialization bridging. We reflect upon the outcomes of primary and supportive activities performed in the knowledge value chain that has been proposed to explore based on the value-based commercialization framework. The subsequent empirical parts have been presented here based on the activities developed since 2009 and extensive case studies of 9 open teams that undertook all knowledge value creation activities designed by the project office in the first year. In the last section, this study aims to discuss the issues of how to make these interdisciplinary open team participants work together as one innovation system as well as one specific interdisciplinary team in an integrated knowledge value chain. Implications and further research for such a peer mentoring process are provided.**

I. INTRODUCTION

According to the OECD survey in 2006 [1], universities perform approximately 17% of research and development activities in its member countries and are an important source of innovations that may create new technologies of commercial significance [2]. Since universities are not in the business manufacturing products and services based on these innovations [3], in Taiwan regardless of the rich stock of R&D outputs generated by the domestic research institutes and academic systems, the successful cases of the commercial application of these research results are few and far below the endeavors input. There is an enhanced mission that universities are increasingly expected to take on in addition to teaching and research with respect to commercialization of their research results [4]. Also, the emerging extra-campus role of universities [5] in socio-economic development through knowledge networking has driven many governments in developed and developing countries to establish a range of mechanisms and channels that would encourage and prompt the strong linkages between universities, industry and other institutional and organizational actors. Among the diverse channels available to establish these links, the commercialization of academic knowledge is considered a key example for generating academic impact because it brings immediate, measurable market acceptance for outputs of academic research [6].

It requires the transfer of knowledge and intellectual property rights across organizational boundaries for converting the innovation from the academic world to the commercial world [7]. In addition to that, factors including the quality of management available to direct the commercialization effort and the availability of financial capital needed to commit, which might affect the process of commercializing these academic innovations [8][3]. In Taiwan, although many universities have established specialized structures to support commercialization, such as technology transfer offices (TTOs) and incubators, there two missing links have been examined during the executing process of these research projects. Firstly, due to lack of the knowledge of potential industrial demands, the research efforts were directed toward a very specifically limited innovation-end bounded by the R&D resources already committed by an individual researcher or the project units. Secondly, due to the limited commercialization capacity, it encompassed the bridging difficulties between the R&D outputs and the industrial practices and failed in contributing the synergy from academic research and development to the industrial economy. Recently, being stimulated by Chesbrough’s open innovation [2][9][10] proposal on aiming to traverse the firm’s boundaries during innovation process, science and technology is undergoing a critical transformation from only one discipline orientated research into a totally new paradigm where a cross-disciplinary orientation gradually shapes the innovative focus [11]. In addition to that, investigations of commercialization activities at university tend to focus on describing infrastructure reforms and institutional innovations that create a culture of entrepreneurship within the institution [12], or on examining specific initiates and policies aiming to increase commercialization of university research [13]. Yet, very few studies have shed light on how universities would take a more direct role as promoters [14] in regional and economic development based on open innovation paradigm, to initiate interdisciplinary knowledge networking, promote cross-field open team collaboration, and finally restructure the process of commercializing university innovation; not to mention the percentage that research efforts ever made to explore an integrated knowledge value chain model for commercialization of academic research.

The research described in this study attempts to address the above issues by exploring specific initiates and activities aiming to increase the commercialization of university research. Further, we analyze how researchers from different university could be networked with each other and integrated into one knowledge value chain through open team innovation process which constitutes an innovation commercialization system. Finally, we reflect upon the outcomes of primary and supportive activities performed in the knowledge value chain that has been proposed to explore based on the value-based commercialization framework supported by Engineering Section of the National Science Council in Taiwan (2009). By investigating evidence from the case studies in the first year and from semi-structured field interviews of participants involved in the cross-field open teams, this study summarized all value activities of the promoting program. In the following section, this study takes a closer look at the initiatives for the "Promoting Program”. And the merits of knowledge value chain model development for commercialization in a university setting on the basis of interdisciplinary open team process with activities have been discussed. The subsequent empirical parts have been presented here based on the activities developed since 2009 and extensive case studies of 9 open teams that undertook all knowledge value creation activities designed by the project office in the first year. In the last section, this study aims to discuss the issues of how to make these interdisciplinary open team participants work together as one innovation system as well as one specific interdisciplinary team in an integrated knowledge value chain. Implications and further research for such a peer mentoring process are provided.

II. INITIATIVES FOR PROMOTING COMMERCIALIZATION THROUGH INTERDISCIPLINARY COLLABORATION

The conversion of university innovation into products or services is a difficult process. A transforming process involving the integration of both technological and market knowledge is required to develop commercially potential new products and services based on these new innovations [15]. The process includes a broad series of activities from technology R&D, product design and development, to business plan development which directs the commercial application end of these new technologies [7]. These would include manufacturing, distribution, marketing, and selling capabilities of the innovation process [16]. As universities generally do not have the capacity to perform all of these activities, the open innovation paradigm provides an avenue to commercial end for university research by networking diverse knowledge communities. Furthermore, according to the value-based commercialization framework developed by Jolly [17] to guide the stages of technology commercialization, innovation process can be segmented into 5 sub-processes of imaging, incubating, demonstrating, promoting, and sustaining, and that each sub-process represents multifunctional input, different types of research, and commercial outcomes. In turn, it suggests that the cross-field open team innovation process can be structured in a way to represent an independent sub-process of value creation that requires mobilizing researchers for a commercial mission during the “mind to market” process [17].

To reflect the growing importance of networking beyond disciplinary and organizational boundaries toward an open R&D system with the commercialization aim, Engineering Section of the National Science Council in October 2009, began to support the "Promoting Program for Cross-Field Creative Scenario Value-adding". This promoting program aims to facilitate the formation and cooperation of the interdisciplinary open teams toward developing one specific knowledge integration process for innovative R&D, method [18] from "creative idea", "feasibility assessment", "prototyping", to commercialization bridging (Figure1).

This promoting program is implemented on the basis of stage-by-stage design to guide the innovation process as the commercialization process, but through the cross-field open innovation team setting. As each segmented process represents a series of knowledge integration activities in commercialization chain, it provides a new way to rethink how R&D has been organized and evaluated in this knowledge value chain, and to reconsider the link between R&D and business-market strategies during innovation process. The stage-by-stage measures are particularly important for knowledge value creation and technology commercialization programs, as value creation can be measured by the process effectiveness indices with value-based outcome generated at each stage.

A. Exploring Supportive activities of the Knowledge Value Chain

The knowledge value chain model has been advanced to understand linkages between knowledge activities and organizational performance [19][20]. In this study, we aim to propose the knowledge value chain model and to explore the specific activities as focal points to enhance the effectiveness of the interdisciplinary open innovation process based on the activities initiated in this promoting program. We have consolidated these activities into supportive and primary activity type and organize them into 2 supportive activity

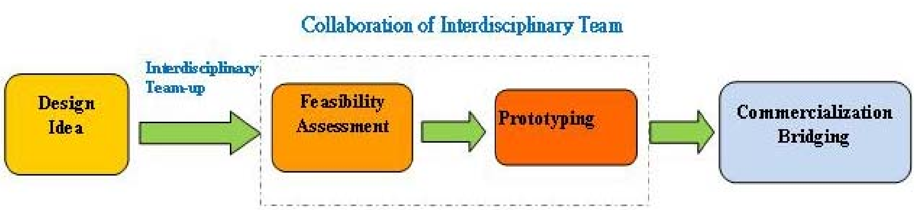

Figure1. Collaboration of Interdisciplinary Team

classes and 3 primary stage activities. The result is a more in-depth version of the knowledge value chain that provides better guidance to academic researchers and practitioners in assessing current technology commercialization initiative across the academic boundaries. The supportive activities are characterized as those activities held to develop a multi-level innovation community by promotors and contributors to enhance community networking for open innovation [14].

1) Activities in Developing Innovation Communities as Network of Promotors

To trigger the process of cross-field collaboration [21], the multi-level innovation communities has aimed to develop by the project office as promotors to support development of "an integrated model of innovative knowledge value chain", and that provides mechanism to link market knowledge into each stage of innovation process, through performing a series of cross-field product value-adding programs related to the emerging green and orange technology development. We have adopted the construct of innovation communities to draw on the concept of multi-level innovation system, because it helps to clarify and structure cross-field relationships and allows systematic connections to the researchers on the interdisciplinary structure of open innovation systems [14].

These innovation communities are characterized as promotor networks or as informal personal networks of innovators, which emphasizes the role of communities in creating, shaping and disseminating innovations. Intermediation in the promoting program comprises a broad variety of functions, such as technology foresight, roadmapping, information scanning, matchmaking (team-up bridging), brokering (commercialization bridging, etc.. In this study, we would summarize organizations like technology brokers (venture capitalists), industry associations, government organizations (NSC) or national R&D organizations (ITRI) as framing and linking organizations that enable cross-field teams to innovate. As shown in Figure 2, the multi-level framework of promotors [14] has been summarized as a comprehensive concept of the quality of interaction within innovation communities, to signify the role of promotors play from framing and linking level, knowledge value chain level, to individual team level in promoting knowledge value creation. Especially their close and informal co-operation across disciplines and organizational boundaries, would enhance the value-adding innovation process on the basis of the established public funded research capacities.

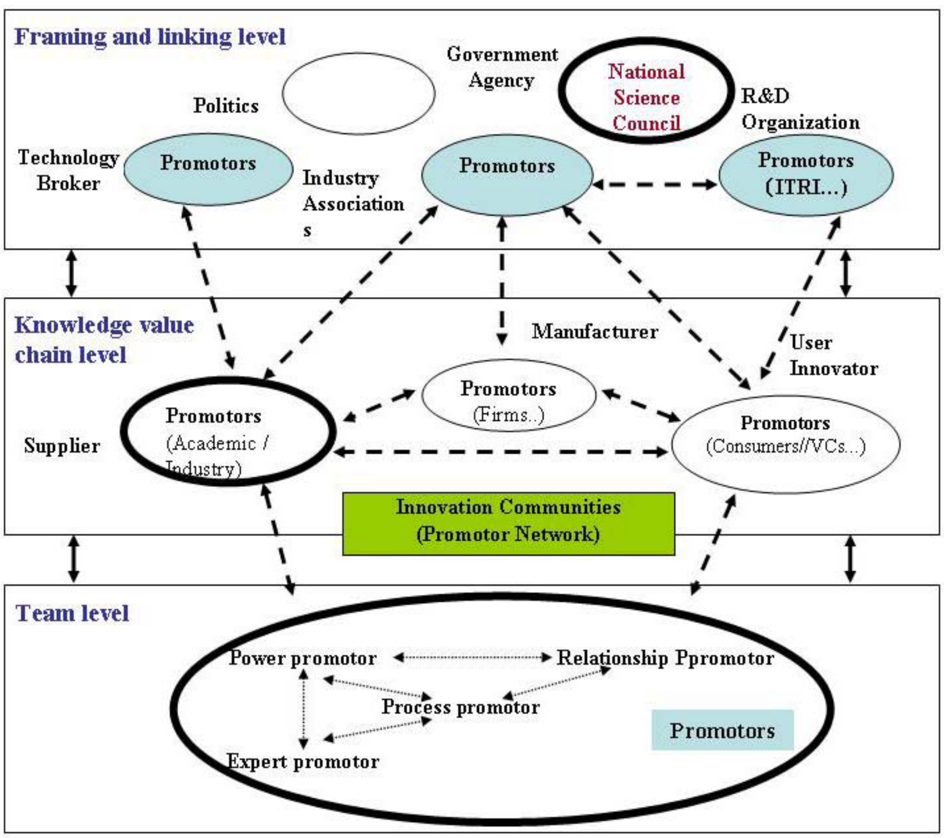

Figure 2: Innovation Communities as Network of Promotors
Note. This figure is adapted from Figure 1 in Fichter [14].

2) Activities in Enhancing Community Networking

In order to develop the successful paradigms of commercialization through performing the cross-field product value-adding R&D teamwork program, a series of community development and networking activities have been initiated and implemented. By observing the requirement of market knowledge, open innovation team-up experience and diverse interdisciplinary knowledge input during the innovation process[22][23], the project office has examined the evolution process of this innovation community to redesign activities needed to improve performance at each stage.

Community networking [24] has been the major efforts made by the promoting program. Figure 3 shows how the cross-field value adding community has been evolved. Based on the ITRI's framework of Innovation Beehive, activities and workshops have been designed to prompt the networking mechanisms. Initially, through team mediating conferences, participants from different fields of specialization in universities are formed into an initial innovation team in 2009. This community network has been enlarged and broadened by periodically holding activities such as community workshops, outcome review conferences, exhibition and show [25] during team innovation process. From time T1 to T3, it shows that both direct and indirect connections contribute to the development of such an open innovation community for commercialization, especially the experience sharing across the different time periods associated with the project teams. Trusts within the interdisciplinary teams in the innovation team process [26] are strengthened through these ties of connection and create successful outcomes for these cross-field value adding innovation teams.

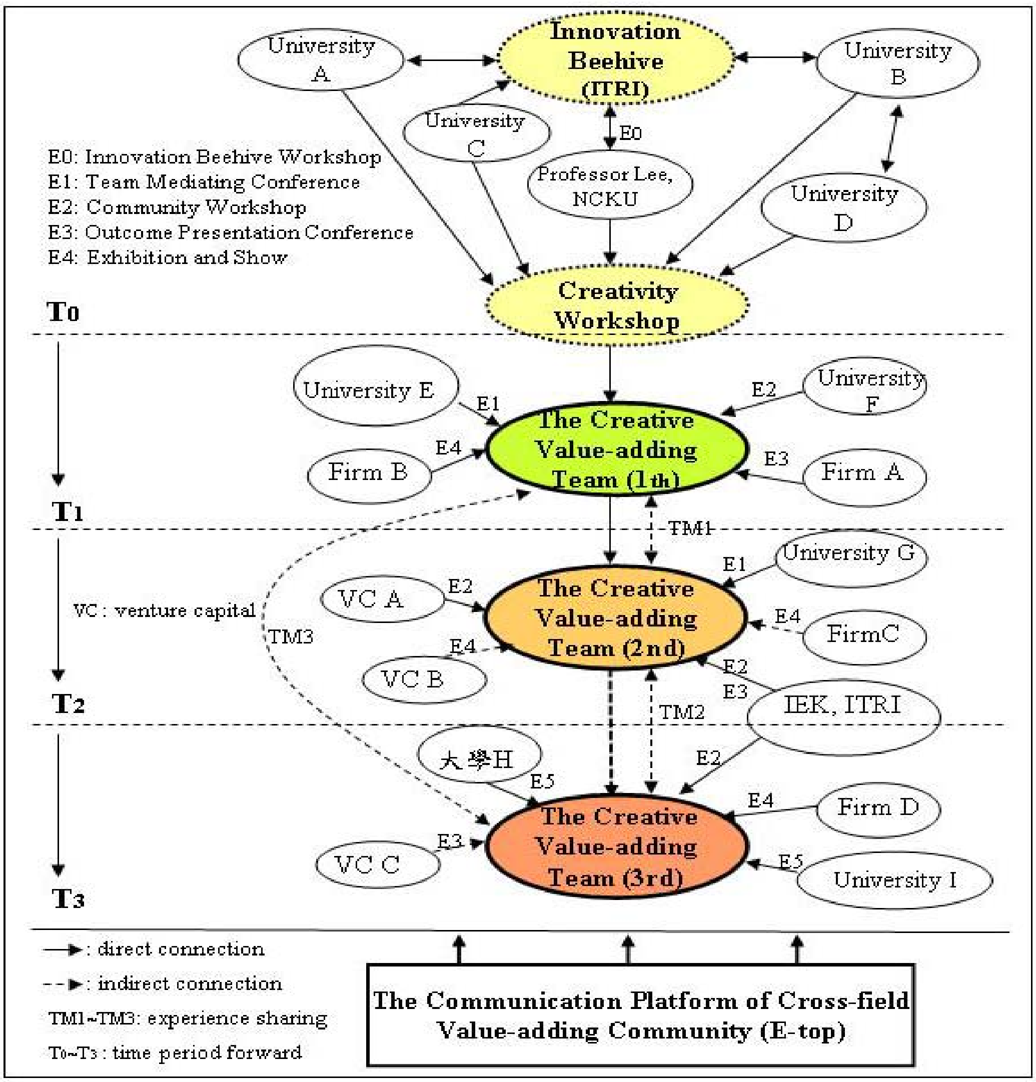

Figure 3. Evolution map of the Cross-Field Value Adding Innovation Community

B. Exploring Primary activities of the Knowledge Value Chain

In this study, we have explored primary activities of the knowledge value chain by examining the case study of the Floating Bay project team. The knowledge value created at each stage has summarized in Figure 4. This project calls for team up in searching of solutions by its owner based on the scenario design. The team participants would contribute the knowledge required to work out technical feasibility with business plan and finish the real prototype development for commercialization end. After initial team-up, the technical report and real prototype development would be aimed to generate. These team sub-processes represent stage-by-stage knowledge value chain of an integrated process for commercializing university research outputs.

1) Value Creation at the Stage of Feasibility Analysis

The Floating Bay project is a scenario designed to develop a solar energy supporting snorkeling vehicle, also value creation for the green navigating leisure industry has been proposed. The interdisciplinary participants have been teamed up to solve the problems, such as the structure strength of the floating vehicle frame, the electronic instrument and GPS navigated system, the solar powered system, and the green label certificating process for the floating vehicle.

After integration of cross-field knowledge to finish feasibility assessment, the team would define the technical report of structure specification with strength coefficient, stability analysis for the floating vehicle in navigation, analysis of solar powered and electronic structure, GPS and sensors for navigation. And the knowledge value created by feasibility analysis can be measured by solar power exploitation of the snorkeling vehicle, process technology and development for the floating vehicle, water proof technology development for the floating vehicle, business model exploitation of the floating vehicle.

Paper Prototype →		Business and Technical Feasibility →		Prototype Development	
Title of Design Scenario	The Floating Bay	**Pending Problem and Feasibility Analysis**	1. Target market and user needs 2. Technical feasibility for integration solar power and the snorkeling vehicle	**Specification for Prototype Design**	1. The real Floating Bay prototype design 2. The specification definition for components and systems
Value Proposition	1. The Solar Energy Supporting Snorkeling Vehicle 2. Green Technology Exploitation 3. The Green Navigating Leisure Economy	**Cross-Field Knowledge Needs and Technical Solutions**	1. The solar energy knowledge exploitation 2. The structure strength knowledge for the floating vehicle frame 3. The water-proof navigation system knowledge for the solar powered vehicle 4. The knowledge of consumer and market potential for industry of snorkeling and navigation leisure	**Process Knowledge Needed and Manufacturing Solutions**	1. The process knowledge exploitation for the solar powered cell system 2. The process knowledge exploitation for the electronic instrument control system 3. The process knowledge exploitation for the navigation system 4. The manufacturing process exploitation for the vehicle frame
Technical Solutions call for	1. The structure strength of the floating vehicle frame 2. The electronic instrument and GPS navigated system 3. The solar powered system 4. The Green Label certificating process for the floating vehicle	**System Development through Open Team Knowledge Integration**	1. U-shape streamlined structure system and strength of frame design 2. Solar powered structure and design 3. The unique integrated navigation system	**Prototype Development through Open Team Process**	1. The solar powered system development 2. The navigation instrument control system development 3. The navigation frame development
Cross-Field Open Team-up	1. Electronic Instrument Engineering 2. Navigation Engineering 3. Engineering in solar technology 4. Business and Management	**Feasibility Report after Integration**	1. Structure specification with strength coefficient 2. Stability analysis for the floating vehicle in navigation 3. Solar powered and electronic structure analysis 4. GPS and sensors for navigation	**Real Prototype Developed after Integration**	The solar powered GPS navigated floating vehicle
Cross-Field Team Aims to Collaborate and Work out	1. U-shape streamlined structure 2. The water-proof operating environment for the solar powered vehicle 3. The operation Environment for GPS and electronic instrument in navigation	**Knowledge Value Created through Feasibility Analysis**	1. Solar power exploitation of the snorkeling vehicle 2. Process technology and development in the floating vehicle 3. Water proof technology development for the floating vehicle 4. Business model exploitation of the floating vehicle	**Knowledge Value Created through Prototyping Process**	1. System integration and assembly knowledge exploitation 2. Component and sub-system supply chain development 3. Cost evaluation 4. Market exploration

Figure 4. Primary Activities of the Knowledge Value Chain

2) Value Creation at the Stage of Prototype Development

At the stage of prototype development, the team has aimed to work out the development of the solar powered system, the navigation instrument control system, and the navigation frame for real prototype development of the solar powered GPS navigated floating vehicle. And the knowledge value created at the stage can be measured by system integration and assembly knowledge exploitation, component and sub-system supply chain development, cost evaluation, and market exploration for commercializing the solar powered GPS navigated floating vehicle.

III. DISCUSSION

The knowledge value chain model which has been explored above provides a new paradigm of interdisciplinary collaboration activity through open team process in university. The interdisciplinary team process would connect researchers in different fields to cooperate, and contribute knowledge needed specifically to implement those scenario projects. Their knowledge inputs have to be coordinated based on the paper prototype designed in a way that the proposal of the specialists in one field (e.g. engineering, management) should be compatible with the solutions contributed by the specialists from other fields (e.g. customer segment served, materials, supply chain). Especially, at the stage of feasibility analysis, the business model [2] in terms of the market segment, user acceptance, supply chain availability has been considered as inputs and also been converted into technical report with economic potential considerations. The integration process has shown to be time-consuming, dynamic, and iterative in nature, yet knowledge exploitation after going through each stage (Figure 5) makes the process payoff. During such an innovation process, knowledge from different fields have been integrated based on the paper prototype design and going through a series of complex and iterated feedback processes to make a real prototype. Knowledge exchange has been triggered when problems are encountered during integration testing. The exchange processes have taken the form of a collective solution of the problems.

It is different from many researchers who have assumed that intensive cross-learning between specialists during knowledge integration process [27], most participants of this program reflect that only few and short cross-learning occurs between academicians during the open team process. As it lacks formal support mechanisms, design scenario has served as the integration platform to link one field to the other. They also have reported the formal meetings [27] and project deadlines as the major coordination platforms. Also, the team vision has been shared by most participants plays as the key mechanism to motivate the cross-field open team to perform those activities required in the knowledge value-chain.

In 2010, the promoting Program has included "Orange Technology" in the theme. Through this program the awareness has been made among people to know more about the trend from Green Technology to Orange Technology. These creative ideas from different domains are humanism, management, engineering, bio-techs, etc. There have been 104 out of 181 designs adopted in Orange Technology and 30 Orange Designs have shown executable potential. Among the interdisciplinary teams, 14 projects have shown actual technology feasibility evaluation, and 9 projects have finished their prototyping. This promoting program is still ongoing and entering its fourth projecting year in 2013 and the project office has been promoting these processes by the way of learning. It has shown that an evolving knowledge society requires a continuous renewal of its knowledge base and the academic supporting system [28].

Each interdisciplinary open team consists of sub-teams having a professor along with a group of students from design, engineering and management. The sub-teams from different fields have to collaborate with each other to achieve the project goal. Substantial communication among these teams leads to new knowledge exploitation in the form of new system or product development. The project executing process has contributed to a new learning organization development, in which a unique learning model has been created. During the process, one variation from a sub-team

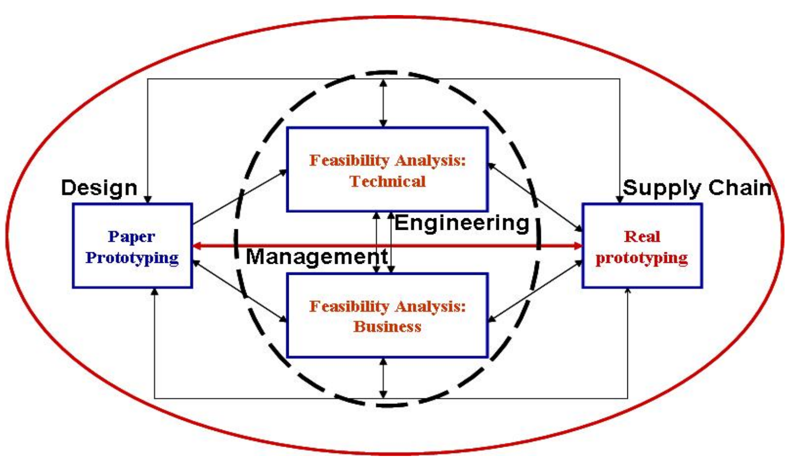

Figure 5. Knowledge Integration loop in Cross-Field Open Team

might trigger a collective change movement apart from the original design. While the established disciplinary systems may be good at promoting high quality research within existing boundaries, they are often less effective in supporting new knowledge exploitation that challenges those very boundaries [28]. The promoting program has been supported to facilitate the cross-field open collaboration to tackle the boundary limited challenge. The heuristic learning nature of such a cross-disciplinary knowledge integration process is different from the lab or project specific mentor advising traditions, and calls for further discussions.

ACKNOWLEDGEMENTS

The research reported in this paper has been supported by the National Science Council under Grant NSC98-2218-E-006-246 to the project team of National Cheng Kung University. The author acknowledges the contributions of all co-researchers leading by Professor Rong Shean Lee, Department of Mech. Engineering, NCKU.

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